APPENDIX A

Figure R – Rainfall Depth – Intensity 100-yr. 24-hour Storm

Table 1 – Rainfall Data for 6 Locations

NOAA Atlas 14 Internet Printouts for 6 Locations

Figure B-2 – Approximate Geographic Boundaries for SCS Rainfall Distributions

Figure 14 – Depth- Area Curves (NOAA Atlas 2)

AHYMO_97 Output File – Purpose – to Generate the SCS Type II
100-yr. Hyetograph for Input in the SWMM Model

Figure 1 – FR (generic flat residential basin)

Figure 2 – FIC (generic flat 50% commercial / 50% industrial basin)

Figure 3 – SR / SIC (generic basin used for steep residential basin & steep 50% commercial / 50% industrial basin)

Table 2 – Basin Hydrologic Data

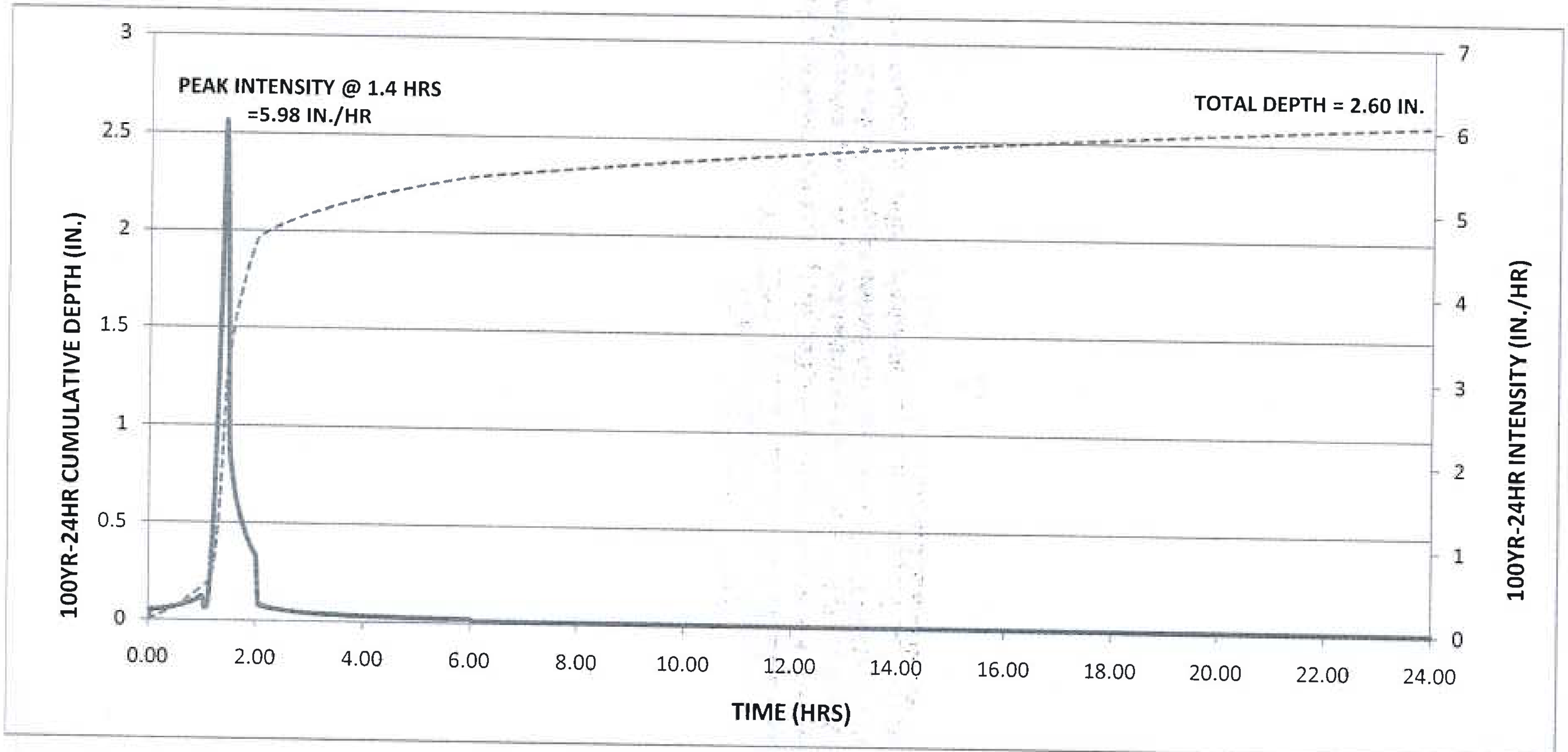
Table 3-1 - Runoff Curve Numbers for Arid and SemiArid Rangelands

Table 3-4 - Runoff Curve Numbers for Urban Areas

NRCS Soils Data for the 3 Generic Basins as Obtained from the NRCS Website

AHYMO_97 SUMMARY TABLE for: (100-yr. 24-hour storm)
For Rainfall Loss Method Comparison between -
Runoff Curve Number Method
and
Land Treatment Method

Chapter 10 – Estimation of Direct Runoff From Storm Rainfall. Part 630 National Engineering Handbook. U.S. Dept. of Agriculture, Natural Resources Conservation Service. Last updated July 2004.



LEGEND	
100YR-24 HR Cumulative Depth (in.)	- - - - - -
100YR-24 HR Intensity (in./hr)	———

Source: NOAA Atlas 14 Point Rainfall Data-internet printouts in Appendix A. Areal reduction factors not applied as total area is relatively small at 4.03 Square miles. See NOAA Atals 2 Vol. IV.New Mexico,1973-Figure 14, Depth-Area Curves as included in Appendix A.(recommended by NOAA Atlas 14 staff)
Rainfall Distribution- Apply the SCS Type II Distribution- See Figure B-2 from SCS in Appendix A

MID VALLEY DRAINAGE MANAGEMENT PLAN FOR THE CITY OF ALBUQUERQUE & ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY
FEBRUARY - 2011
SEC PROJECT NO. 110112
RAINFALL DEPTH -INTENSITY 100YR-24H STORM FIGURE R

TABLE 1

RAINFALL DATA for 6 LOCATIONS

Mid Valley Drainage Management Plan

Location Description	Lattitude	Lattitude	Longitude	Longitude	Return Period	1-Hour Rainfall Depth	6-Hour Rainfall Depth	24-Hour Rainfall Depth
	deg, min, sec	dec. degrees	deg, min, sec	dec. degrees	(year)	(inches)	(inches)	(inches)
						(a)	(a)	(a)
SW corner I-25 & I-40	**035, 06, 12.87**	**35.10358**	**106, 37, 55.20**	**106.63200**	**100**	**1.79**	**2.29**	**2.60**
Rio Grande Blvd. @ I-40	035, 06, 15.73	35.10437	106, 40, 12.50	106.67014	100	1.73	2.23	2.51
Lomas Blvd. & 12th St.	035, 05, 31.73	35.09215	106, 39, 32.65	106.65907	100	1.76	2.24	2.55
Bridge Blvd. at 4th St.	035, 04, 12.42	35.07012	106, 39, 13.87	106.65385	100	1.79	2.24	2.60
Lomas Blvd. @ I-25	035, 05, 28.12	35.09114	106, 38, 4.70	106.64639	100	1.78	2.25	2.58
Laguna Blvd. @ San Pasqualte Ave.	035, 05, 12.70	35.08686	106, 40, 11.60	106.66989	100	1.77	2.23	2.54

CONCLUSION - Rainfall depths are nearly uniform over the Mid Valley Study area, Therefore choose the location with greatest depth (SW corner I-25 & I-40)

FINAL RAINFALL DATA FOR ALL RETURN PERIOD STORMS

SW corner I-25 & I-40	035, 06, 12.87	35.10358	106, 37, 55.20	106.63200	**2**	0.70	0.98	1.22
" "	" "	" "	" "	" "	**10**	1.12	1.49	1.76
" "	" "	" "	" "	" "	**50**	1.57	2.04	2.34
" "	" "	" "	" "	" "	**100**	1.79	2.29	2.60
" "	" "	" "	" "	" "	**500**	2.31	2.92	3.21

(a) NOAA Atlas 14 Point Rainfall Data - internet printouts in Appendix A

Areal reduction factors not applied as total area is relatively small at 4.03 square miles. See NOAA Atlas 2 Vol. IV, New Mexico, 1973 - Figure 14, Depth-Area Curves as included in Appendix A. (recommended by NOAA Atlas 14 staff)

Barelas Basin = 1164 acres, Alacalde Basin = 858 acres, Broadway Basin = 557 acres. Total = 2,579 acres = 4.02969 square miles

Rainfall Distribution - Apply the SCS Type II Distibution - See Figuer B-2 from SCS in Appendix A

MID VALLEY DMP — SW CORNER I-25 & I-40

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

New Mexico 35.10358 N 106.632 W 5022 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006

Extracted: Sat Nov 20 2010

Confidence Limits | Seasonality | Related Info | GIS data | Maps | Docs | Return to State Map

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.17	0.26	0.32	0.43	0.54	0.62	0.67	0.78	0.85	0.97	1.01	1.19	1.34	1.48	1.83	2.19	2.69	3.09
2	0.22	0.34	0.42	0.56	0.70	0.80	0.85	0.98	1.08	1.22	1.27	1.47	1.67	1.84	2.27	2.72	3.33	3.81
5	0.30	0.45	0.56	0.76	0.94	1.06	1.11	1.26	1.36	1.52	1.58	1.81	2.03	2.25	2.76	3.27	3.97	4.54
10	0.36	0.54	0.67	0.91	1.12	1.27	1.32	1.49	1.59	1.76	1.82	2.08	2.31	2.58	3.13	3.68	4.42	5.07
25	0.44	0.67	0.83	1.11	1.38	1.56	1.61	1.80	1.90	2.09	2.15	2.43	2.68	3.00	3.59	4.19	4.97	5.70
50	0.50	0.76	0.94	1.27	1.57	1.79	1.85	2.04	2.14	2.34	2.40	2.70	2.96	3.32	3.93	4.55	5.35	6.13
100	0.57	0.86	1.07	1.44	1.79	2.04	2.10	2.29	2.39	2.60	2.66	2.98	3.24	3.64	4.26	4.89	5.69	6.52
200	0.64	0.97	1.20	1.62	2.01	2.30	2.37	2.56	2.64	2.86	2.92	3.25	3.50	3.96	4.57	5.22	6.00	6.87
500	0.73	1.12	1.38	1.86	2.31	2.67	2.74	2.92	2.99	3.21	3.26	3.61	3.85	4.37	4.95	5.61	6.34	7.27
1000	0.81	1.23	1.53	2.06	2.55	2.96	3.04	3.22	3.27	3.49	3.53	3.89	4.11	4.67	5.23	5.88	6.54	7.51

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

* Upper bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.20	0.30	0.38	0.51	0.63	0.75	0.80	0.92	0.98	1.11	1.15	1.32	1.48	1.63	2.03	2.41	2.95	3.40
2	0.26	0.40	0.49	0.66	0.82	0.96	1.01	1.16	1.24	1.39	1.43	1.63	1.83	2.02	2.52	2.98	3.66	4.20
5	0.35	0.53	0.66	0.89	1.10	1.27	1.32	1.49	1.57	1.74	1.78	2.01	2.23	2.47	3.06	3.58	4.35	5.00
10	0.42	0.63	0.79	1.06	1.31	1.51	1.57	1.75	1.83	2.01	2.05	2.30	2.54	2.82	3.46	4.03	4.85	5.58
25	0.51	0.78	0.96	1.30	1.61	1.85	1.91	2.11	2.18	2.38	2.42	2.69	2.94	3.29	3.98	4.58	5.45	6.26
50	0.58	0.89	1.10	1.49	1.84	2.13	2.19	2.39	2.45	2.66	2.70	3.00	3.25	3.64	4.35	4.97	5.88	6.74
100	0.66	1.01	1.25	1.68	2.08	2.42	2.48	2.69	2.73	2.96	2.99	3.30	3.56	4.00	4.71	5.36	6.25	7.18
200	0.74	1.13	1.40	1.89	2.34	2.72	2.80	2.99	3.03	3.25	3.30	3.61	3.86	4.35	5.05	5.71	6.58	7.58
500	0.86	1.30	1.61	2.17	2.69	3.16	3.23	3.42	3.43	3.65	3.69	4.02	4.26	4.81	5.49	6.14	6.96	8.02
1000	0.94	1.44	1.78	2.40	2.97	3.51	3.60	3.78	3.81	3.96	3.99	4.34	4.55	5.15	5.80	6.44	7.19	8.29

* The **upper** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **greater** than.
** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.

Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

* Lower bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.15	0.22	0.28	0.37	0.46	0.53	0.57	0.67	0.74	0.85	0.89	1.07	1.21	1.34	1.65	1.98	2.44	2.80
2	0.19	0.29	0.36	0.48	0.59	0.68	0.72	0.84	0.93	1.06	1.11	1.32	1.50	1.67	2.05	2.45	3.02	3.47
5	0.25	0.39	0.48	0.64	0.80	0.90	0.95	1.09	1.18	1.33	1.39	1.62	1.83	2.04	2.49	2.95	3.59	4.14
10	0.30	0.46	0.57	0.77	0.95	1.07	1.12	1.27	1.38	1.54	1.59	1.85	2.08	2.34	2.82	3.31	3.99	4.61
25	0.37	0.56	0.70	0.94	1.16	1.30	1.36	1.53	1.63	1.81	1.88	2.17	2.40	2.72	3.23	3.77	4.50	5.18

MID VALLEY DMP - RIO GRANDE BLVD. @ I-40

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

New Mexico 35.10437 N 106.67014 W 4957 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006

Extracted: Sat Nov 20 2010

Confidence Limits | Seasonality | Related Info | GIS data | Maps | Docs | Return to State Map

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.16	0.25	0.31	0.42	0.52	0.60	0.65	0.75	0.82	0.94	0.98	1.18	1.33	1.47	1.81	2.16	2.65	3.04
2	0.21	0.32	0.40	0.54	0.67	0.77	0.82	0.95	1.04	1.17	1.22	1.46	1.65	1.82	2.24	2.68	3.27	3.75
5	0.29	0.44	0.54	0.73	0.90	1.02	1.08	1.23	1.32	1.47	1.52	1.78	2.00	2.22	2.71	3.21	3.89	4.46
10	0.34	0.52	0.65	0.87	1.08	1.22	1.28	1.44	1.54	1.70	1.76	2.04	2.27	2.53	3.07	3.60	4.32	4.95
25	0.42	0.64	0.80	1.07	1.33	1.50	1.57	1.74	1.84	2.02	2.08	2.38	2.63	2.94	3.52	4.08	4.84	5.55
50	0.48	0.74	0.92	1.23	1.52	1.73	1.80	1.98	2.07	2.26	2.32	2.64	2.89	3.24	3.84	4.42	5.18	5.95
→ 100	0.55	0.84	1.04	1.40	1.73	1.97	2.05	2.23	2.31	2.51	2.56	2.90	3.14	3.54	4.14	4.74	5.49	6.31
200	0.62	0.94	1.17	1.58	1.95	2.23	2.31	2.48	2.56	2.76	2.81	3.16	3.39	3.84	4.43	5.03	5.75	6.62
500	0.71	1.09	1.35	1.82	2.25	2.59	2.67	2.84	2.89	3.10	3.14	3.49	3.70	4.21	4.78	5.37	6.02	6.95
1000	0.79	1.20	1.49	2.01	2.48	2.88	2.97	3.14	3.17	3.37	3.40	3.75	3.93	4.49	5.02	5.61	6.16	7.13

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

* Upper bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.19	0.29	0.36	0.49	0.60	0.72	0.77	0.88	0.95	1.07	1.10	1.29	1.45	1.60	1.98	2.35	2.88	3.31
2	0.25	0.38	0.47	0.63	0.78	0.92	0.98	1.12	1.20	1.34	1.38	1.60	1.80	1.98	2.46	2.90	3.55	4.08
5	0.34	0.51	0.63	0.85	1.05	1.22	1.28	1.44	1.51	1.67	1.72	1.96	2.18	2.41	2.96	3.48	4.21	4.83
10	0.40	0.61	0.76	1.02	1.26	1.45	1.51	1.69	1.77	1.93	1.98	2.23	2.47	2.74	3.35	3.89	4.67	5.37
25	0.49	0.75	0.93	1.25	1.55	1.78	1.85	2.04	2.10	2.29	2.33	2.60	2.85	3.18	3.83	4.41	5.22	6.01
50	0.56	0.86	1.07	1.44	1.78	2.05	2.12	2.31	2.36	2.56	2.60	2.89	3.13	3.50	4.18	4.77	5.60	6.44
100	0.64	0.98	1.21	1.63	2.02	2.33	2.40	2.60	2.64	2.84	2.88	3.17	3.41	3.83	4.50	5.11	5.92	6.83
200	0.72	1.10	1.36	1.84	2.27	2.63	2.71	2.89	2.92	3.13	3.17	3.45	3.68	4.15	4.81	5.43	6.19	7.17
500	0.83	1.27	1.57	2.12	2.62	3.05	3.14	3.31	3.35	3.52	3.54	3.83	4.02	4.56	5.20	5.79	6.47	7.53
1000	0.92	1.40	1.74	2.34	2.89	3.40	3.50	3.67	3.70	3.82	3.83	4.11	4.28	4.87	5.46	6.05	6.62	7.72

* The **upper** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **greater** than.
** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.

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1	0.14	0.21	0.27	0.36	0.44	0.51	0.56	0.65	0.72	0.82	0.86	1.07	1.22	1.35	1.65	1.98	2.43	2.80
2	0.18	0.28	0.34	0.46	0.57	0.65	0.70	0.82	0.91	1.03	1.08	1.33	1.50	1.67	2.05	2.45	3.01	3.46
5	0.24	0.37	0.46	0.62	0.77	0.86	0.92	1.06	1.15	1.29	1.35	1.62	1.83	2.04	2.48	2.94	3.57	4.11
10	0.29	0.44	0.55	0.74	0.92	1.03	1.09	1.24	1.34	1.49	1.55	1.85	2.07	2.32	2.81	3.29	3.97	4.57
25	0.36	0.54	0.67	0.91	1.12	1.26	1.32	1.49	1.59	1.76	1.83	2.15	2.39	2.69	3.21	3.73	4.45	5.13

MID VALLEY DMP — LOMAS BLVD @ 12TH ST

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

New Mexico 35.09215 N 106.65907 W 4957 feet
from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006
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Confidence Limits | Seasonality | Related Info | GIS data | Maps | Docs | Return to State Map

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.17	0.26	0.32	0.43	0.53	0.61	0.65	0.76	0.84	0.95	0.99	1.17	1.33	1.46	1.81	2.16	2.65	3.04
2	0.22	0.33	0.41	0.56	0.69	0.78	0.83	0.96	1.06	1.20	1.24	1.46	1.65	1.81	2.24	2.67	3.27	3.75
5	0.29	0.45	0.55	0.75	0.92	1.04	1.09	1.24	1.34	1.49	1.55	1.78	2.00	2.22	2.71	3.21	3.88	4.45
10	0.35	0.54	0.66	0.89	1.11	1.24	1.29	1.46	1.56	1.73	1.78	2.04	2.27	2.53	3.07	3.60	4.32	4.96
25	0.43	0.66	0.81	1.10	1.36	1.52	1.58	1.76	1.86	2.05	2.10	2.38	2.62	2.94	3.52	4.08	4.84	5.55
50	0.49	0.75	0.93	1.26	1.56	1.75	1.81	1.99	2.10	2.30	2.35	2.64	2.89	3.24	3.84	4.43	5.19	5.96
→ 100	0.56	0.85	1.06	1.43	1.76	2.00	2.06	2.24	2.34	2.55	2.60	2.90	3.15	3.55	4.15	4.74	5.50	6.32
200	0.63	0.96	1.19	1.60	1.99	2.25	2.32	2.50	2.59	2.81	2.85	3.16	3.39	3.84	4.44	5.04	5.77	6.63
500	0.73	1.10	1.37	1.84	2.28	2.61	2.69	2.86	2.93	3.16	3.19	3.50	3.71	4.22	4.79	5.39	6.05	6.98
1000	0.80	1.22	1.51	2.04	2.52	2.90	2.98	3.15	3.20	3.43	3.45	3.76	3.94	4.50	5.04	5.63	6.20	7.17

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

* Upper bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.20	0.30	0.37	0.50	0.62	0.73	0.77	0.89	0.96	1.09	1.12	1.29	1.45	1.60	1.98	2.35	2.88	3.31
2	0.26	0.39	0.48	0.65	0.80	0.93	0.99	1.13	1.21	1.36	1.40	1.60	1.80	1.98	2.46	2.90	3.55	4.08
5	0.34	0.52	0.65	0.87	1.08	1.23	1.29	1.45	1.53	1.70	1.74	1.95	2.18	2.41	2.96	3.48	4.22	4.84
10	0.41	0.62	0.77	1.04	1.29	1.47	1.53	1.70	1.79	1.97	2.00	2.23	2.47	2.74	3.35	3.90	4.68	5.38
25	0.50	0.77	0.95	1.28	1.58	1.80	1.86	2.05	2.13	2.33	2.36	2.61	2.85	3.18	3.84	4.41	5.24	6.02
50	0.57	0.88	1.08	1.46	1.81	2.07	2.13	2.32	2.39	2.61	2.64	2.89	3.13	3.51	4.19	4.78	5.62	6.46
100	0.65	0.99	1.23	1.66	2.05	2.35	2.42	2.61	2.67	2.90	2.92	3.18	3.42	3.84	4.52	5.13	5.95	6.86
200	0.73	1.11	1.38	1.86	2.30	2.65	2.73	2.91	2.95	3.18	3.21	3.46	3.69	4.17	4.83	5.45	6.24	7.20
500	0.84	1.28	1.59	2.14	2.65	3.07	3.15	3.33	3.35	3.58	3.59	3.84	4.04	4.59	5.22	5.83	6.54	7.58
1000	0.93	1.42	1.76	2.36	2.93	3.42	3.51	3.68	3.72	3.88	3.92	4.13	4.30	4.90	5.49	6.09	6.69	7.79

* The **upper** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **greater** than.
** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

* Lower bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.14	0.22	0.27	0.37	0.46	0.52	0.56	0.66	0.73	0.84	0.88	1.07	1.21	1.34	1.65	1.97	2.43	2.79
2	0.19	0.28	0.35	0.47	0.59	0.67	0.71	0.83	0.92	1.05	1.10	1.32	1.50	1.66	2.04	2.44	3.00	3.45
5	0.25	0.38	0.47	0.64	0.79	0.88	0.94	1.07	1.17	1.31	1.37	1.61	1.82	2.03	2.48	2.93	3.56	4.10
10	0.30	0.46	0.56	0.76	0.94	1.05	1.11	1.26	1.36	1.52	1.58	1.84	2.06	2.31	2.80	3.29	3.96	4.57
25	0.36	0.56	0.69	0.93	1.15	1.28	1.34	1.50	1.61	1.79	1.85	2.15	2.38	2.69	3.21	3.72	4.45	5.12

MID VALLEY DMP – BRIDGE BLVD @ 4TH ST

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

New Mexico 35.07012 N 106.65385 W 4954 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006

Extracted: Sat Nov 20 2010

Confidence Limits | Seasonality | Related Info | GIS data | Maps | Docs | Return to State Map

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.17	0.26	0.33	0.44	0.54	0.62	0.66	0.77	0.85	0.97	1.01	1.18	1.34	1.47	1.83	2.19	2.67	3.07
2	0.22	0.34	0.42	0.57	0.70	0.79	0.84	0.97	1.07	1.22	1.26	1.46	1.66	1.82	2.27	2.71	3.30	3.79
5	0.30	0.46	0.56	0.76	0.94	1.05	1.10	1.25	1.35	1.52	1.57	1.78	2.01	2.23	2.75	3.25	3.93	4.51
10	0.36	0.55	0.68	0.91	1.13	1.26	1.31	1.46	1.58	1.76	1.81	2.04	2.28	2.54	3.11	3.65	4.37	5.02
25	0.44	0.67	0.83	1.12	1.38	1.54	1.60	1.76	1.88	2.09	2.14	2.38	2.64	2.96	3.57	4.15	4.90	5.63
50	0.50	0.76	0.95	1.28	1.58	1.77	1.83	2.00	2.11	2.34	2.38	2.65	2.91	3.27	3.90	4.50	5.26	6.04
→ 100	0.57	0.86	1.07	1.45	1.79	2.01	2.07	2.24	2.36	2.60	2.64	2.91	3.17	3.58	4.22	4.83	5.58	6.42
200	0.64	0.97	1.20	1.62	2.01	2.27	2.34	2.50	2.60	2.86	2.90	3.17	3.42	3.88	4.51	5.13	5.85	6.74
500	0.73	1.11	1.38	1.86	2.30	2.62	2.70	2.86	2.94	3.21	3.24	3.51	3.75	4.26	4.88	5.50	6.15	7.10
1000	0.81	1.23	1.52	2.05	2.54	2.91	2.99	3.15	3.21	3.49	3.50	3.77	3.98	4.55	5.14	5.74	6.31	7.31

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

* Upper bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.20	0.30	0.38	0.51	0.63	0.73	0.78	0.90	0.97	1.10	1.13	1.28	1.45	1.60	2.00	2.36	2.89	3.33
2	0.26	0.40	0.49	0.66	0.82	0.94	0.99	1.13	1.22	1.38	1.42	1.59	1.80	1.98	2.47	2.93	3.57	4.11
5	0.35	0.53	0.66	0.88	1.09	1.24	1.29	1.45	1.54	1.72	1.76	1.95	2.18	2.41	2.99	3.51	4.24	4.87
10	0.41	0.63	0.78	1.05	1.30	1.47	1.53	1.70	1.79	1.99	2.02	2.22	2.48	2.75	3.37	3.94	4.71	5.42
25	0.51	0.77	0.96	1.29	1.60	1.80	1.86	2.04	2.13	2.36	2.38	2.60	2.86	3.19	3.87	4.46	5.27	6.07
50	0.58	0.88	1.09	1.47	1.82	2.07	2.12	2.31	2.40	2.63	2.66	2.88	3.15	3.52	4.22	4.84	5.66	6.51
100	0.66	1.00	1.24	1.67	2.06	2.35	2.41	2.60	2.67	2.92	2.95	3.17	3.44	3.85	4.56	5.19	5.99	6.92
200	0.74	1.12	1.39	1.87	2.31	2.64	2.71	2.89	2.95	3.22	3.24	3.45	3.71	4.18	4.88	5.52	6.29	7.27
500	0.85	1.29	1.59	2.15	2.66	3.06	3.13	3.31	3.35	3.62	3.62	3.83	4.07	4.60	5.28	5.91	6.60	7.66
1000	0.93	1.42	1.76	2.37	2.93	3.40	3.49	3.65	3.66	3.92	3.96	4.12	4.33	4.92	5.56	6.18	6.77	7.88

* The **upper** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **greater** than.
** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.

Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

* Lower bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.15	0.23	0.28	0.38	0.47	0.53	0.57	0.67	0.75	0.86	0.90	1.07	1.23	1.35	1.68	2.01	2.47	2.84
2	0.19	0.29	0.36	0.49	0.61	0.68	0.72	0.84	0.94	1.08	1.12	1.33	1.52	1.68	2.08	2.49	3.05	3.51
5	0.26	0.39	0.48	0.65	0.81	0.90	0.95	1.09	1.19	1.34	1.40	1.62	1.84	2.05	2.52	2.99	3.63	4.18
10	0.31	0.47	0.58	0.78	0.97	1.07	1.12	1.27	1.38	1.56	1.61	1.86	2.09	2.34	2.86	3.36	4.03	4.65
25	0.38	0.57	0.71	0.95	1.18	1.30	1.36	1.52	1.64	1.83	1.90	2.17	2.42	2.72	3.27	3.81	4.53	5.22

MID VALLEY DMP – LOMAS BLVD. @ I-25

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

New Mexico 35.09114 N 106.64639 W 4986 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006

Extracted: Sat Nov 20 2010

Confidence Limits | Seasonality | Related Info | GIS data | Maps | Docs | Return to State Map

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.17	0.26	0.32	0.43	0.54	0.62	0.66	0.77	0.84	0.96	1.00	1.18	1.33	1.47	1.81	2.17	2.66	3.05
2	0.22	0.34	0.42	0.56	0.69	0.79	0.84	0.96	1.06	1.21	1.25	1.46	1.65	1.82	2.25	2.68	3.28	3.76
5	0.30	0.45	0.56	0.75	0.93	1.04	1.10	1.25	1.35	1.51	1.56	1.79	2.00	2.22	2.72	3.22	3.91	4.47
10	0.35	0.54	0.67	0.90	1.11	1.25	1.30	1.47	1.57	1.75	1.80	2.05	2.28	2.54	3.08	3.62	4.34	4.98
25	0.43	0.66	0.82	1.10	1.37	1.53	1.59	1.77	1.88	2.07	2.12	2.39	2.64	2.95	3.53	4.11	4.88	5.59
50	0.50	0.76	0.94	1.26	1.57	1.77	1.83	2.00	2.11	2.32	2.37	2.66	2.91	3.26	3.86	4.46	5.24	6.00
100	0.56	0.86	1.07	1.44	1.78	2.01	2.07	2.25	2.35	2.58	2.62	2.92	3.17	3.57	4.18	4.78	5.56	6.38
200	0.64	0.97	1.20	1.61	2.00	2.27	2.34	2.51	2.60	2.84	2.88	3.18	3.42	3.87	4.47	5.09	5.83	6.70
500	0.73	1.11	1.38	1.85	2.29	2.63	2.70	2.88	2.94	3.19	3.21	3.53	3.75	4.26	4.83	5.45	6.13	7.05
1000	0.81	1.23	1.52	2.05	2.53	2.92	3.00	3.17	3.22	3.46	3.47	3.79	3.99	4.55	5.09	5.69	6.30	7.26

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

* Upper bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.20	0.30	0.38	0.51	0.62	0.73	0.78	0.90	0.97	1.10	1.13	1.29	1.46	1.61	1.99	2.36	2.89	3.33
2	0.26	0.39	0.49	0.65	0.81	0.94	0.99	1.14	1.22	1.38	1.41	1.61	1.80	1.99	2.47	2.92	3.58	4.11
5	0.35	0.53	0.65	0.88	1.09	1.25	1.30	1.46	1.54	1.72	1.75	1.97	2.19	2.42	2.99	3.50	4.25	4.88
10	0.41	0.63	0.78	1.05	1.30	1.48	1.54	1.72	1.80	1.99	2.02	2.25	2.48	2.76	3.37	3.93	4.72	5.43
25	0.51	0.77	0.95	1.29	1.59	1.82	1.88	2.07	2.14	2.36	2.38	2.63	2.87	3.21	3.87	4.46	5.30	6.08
50	0.58	0.88	1.09	1.47	1.82	2.09	2.15	2.34	2.41	2.63	2.66	2.92	3.16	3.54	4.23	4.83	5.69	6.53
100	0.66	1.00	1.24	1.67	2.06	2.37	2.43	2.63	2.69	2.92	2.94	3.21	3.46	3.88	4.57	5.18	6.03	6.94
200	0.74	1.12	1.39	1.87	2.32	2.67	2.74	2.93	2.97	3.21	3.24	3.50	3.73	4.21	4.88	5.51	6.33	7.29
500	0.85	1.29	1.60	2.15	2.67	3.09	3.17	3.35	3.37	3.61	3.62	3.89	4.10	4.64	5.29	5.91	6.65	7.69
1000	0.94	1.42	1.76	2.38	2.94	3.44	3.53	3.70	3.74	3.92	3.92	4.18	4.37	4.96	5.57	6.18	6.83	7.92

* The upper bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are greater than.
** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

* Lower bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.15	0.22	0.28	0.37	0.46	0.53	0.57	0.66	0.74	0.85	0.88	1.07	1.21	1.34	1.65	1.97	2.43	2.79
2	0.19	0.29	0.36	0.48	0.59	0.67	0.72	0.83	0.93	1.06	1.10	1.32	1.50	1.66	2.04	2.44	3.01	3.45
5	0.25	0.38	0.48	0.64	0.79	0.89	0.94	1.08	1.17	1.32	1.38	1.61	1.82	2.03	2.48	2.93	3.57	4.11
10	0.30	0.46	0.57	0.77	0.95	1.06	1.11	1.26	1.37	1.53	1.58	1.85	2.07	2.32	2.80	3.29	3.97	4.58
25	0.37	0.56	0.69	0.94	1.16	1.29	1.35	1.51	1.62	1.81	1.86	2.15	2.39	2.70	3.21	3.73	4.46	5.13

MID VALLEY DMP – LAGUNA BLVD. @ SAN PASQUALE AVE

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

New Mexico 35.08686 N 106.66989 W 4950 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006
Extracted: Sat Nov 20 2010

Confidence Limits | Seasonality | Related Info | GIS data | Maps | Docs | Return to State Map

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.17	0.26	0.32	0.43	0.53	0.61	0.65	0.76	0.83	0.95	0.99	1.17	1.33	1.46	1.81	2.16	2.64	3.03
2	0.22	0.33	0.41	0.56	0.69	0.78	0.83	0.95	1.05	1.19	1.24	1.45	1.64	1.81	2.24	2.67	3.26	3.74
5	0.29	0.45	0.56	0.75	0.93	1.03	1.08	1.23	1.34	1.49	1.54	1.77	1.99	2.21	2.71	3.20	3.87	4.44
10	0.35	0.54	0.67	0.90	1.11	1.23	1.29	1.45	1.56	1.73	1.78	2.03	2.26	2.52	3.06	3.59	4.30	4.94
25	0.43	0.66	0.82	1.10	1.36	1.52	1.58	1.75	1.86	2.04	2.10	2.37	2.61	2.92	3.51	4.07	4.82	5.54
50	0.49	0.75	0.93	1.26	1.56	1.74	1.81	1.98	2.09	2.29	2.34	2.62	2.87	3.23	3.83	4.41	5.16	5.93
100	0.56	0.85	1.06	1.43	1.77	1.99	2.05	2.23	2.33	2.54	2.59	2.88	3.13	3.53	4.14	4.73	5.47	6.30
200	0.63	0.96	1.19	1.60	1.99	2.24	2.31	2.48	2.58	2.80	2.84	3.14	3.37	3.82	4.42	5.02	5.72	6.60
500	0.73	1.10	1.37	1.84	2.28	2.60	2.67	2.84	2.92	3.15	3.17	3.47	3.68	4.20	4.77	5.36	5.99	6.94
1000	0.80	1.22	1.51	2.04	2.52	2.89	2.97	3.13	3.19	3.42	3.43	3.72	3.91	4.47	5.01	5.60	6.14	7.12

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

* Upper bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.20	0.30	0.37	0.50	0.62	0.72	0.77	0.89	0.96	1.08	1.11	1.28	1.45	1.59	1.97	2.34	2.86	3.29
2	0.26	0.39	0.48	0.65	0.80	0.93	0.98	1.12	1.21	1.35	1.39	1.59	1.79	1.97	2.44	2.89	3.53	4.06
5	0.34	0.52	0.65	0.87	1.08	1.22	1.28	1.44	1.53	1.69	1.73	1.94	2.17	2.39	2.95	3.46	4.19	4.81
10	0.41	0.62	0.77	1.04	1.29	1.45	1.52	1.69	1.78	1.96	1.99	2.21	2.46	2.73	3.33	3.88	4.65	5.34
25	0.50	0.77	0.95	1.28	1.58	1.78	1.85	2.03	2.12	2.32	2.35	2.58	2.83	3.16	3.81	4.39	5.20	5.98
50	0.57	0.88	1.08	1.46	1.81	2.05	2.11	2.30	2.38	2.59	2.62	2.87	3.11	3.48	4.16	4.75	5.57	6.41
100	0.65	0.99	1.23	1.66	2.05	2.33	2.40	2.59	2.65	2.88	2.90	3.15	3.39	3.81	4.48	5.09	5.89	6.80
200	0.73	1.11	1.38	1.86	2.30	2.62	2.71	2.88	2.94	3.17	3.18	3.43	3.66	4.13	4.79	5.41	6.17	7.13
500	0.84	1.28	1.59	2.14	2.65	3.04	3.13	3.30	3.33	3.56	3.56	3.80	4.00	4.54	5.17	5.78	6.45	7.50
1000	0.93	1.41	1.75	2.36	2.92	3.39	3.48	3.65	3.65	3.86	3.90	4.08	4.25	4.84	5.44	6.03	6.60	7.69

* The upper bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **greater** than.
** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

* Lower bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.14	0.22	0.27	0.37	0.46	0.52	0.56	0.66	0.73	0.84	0.88	1.07	1.21	1.34	1.65	1.98	2.43	2.79
2	0.19	0.29	0.35	0.48	0.59	0.66	0.71	0.83	0.92	1.05	1.10	1.32	1.50	1.66	2.05	2.44	3.00	3.45
5	0.25	0.38	0.47	0.64	0.79	0.88	0.93	1.07	1.17	1.31	1.37	1.61	1.82	2.03	2.48	2.93	3.56	4.10
10	0.30	0.46	0.57	0.76	0.94	1.04	1.10	1.25	1.36	1.52	1.57	1.84	2.06	2.31	2.80	3.29	3.96	4.57
25	0.37	0.56	0.69	0.93	1.15	1.27	1.33	1.50	1.61	1.79	1.85	2.15	2.39	2.68	3.21	3.73	4.44	5.12

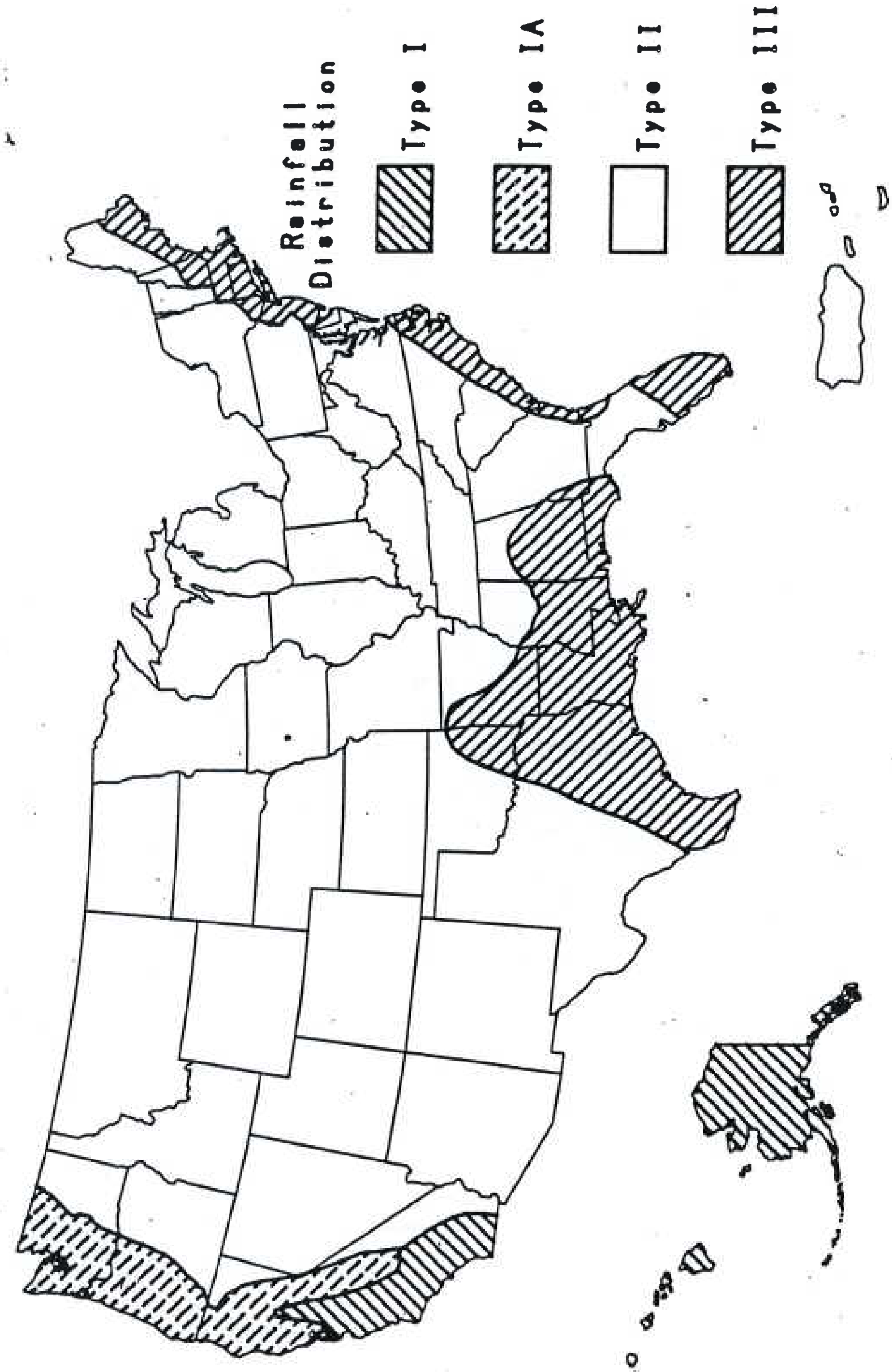


Figure B-2.—Approximate geographic boundaries for SCS rainfall distributions.

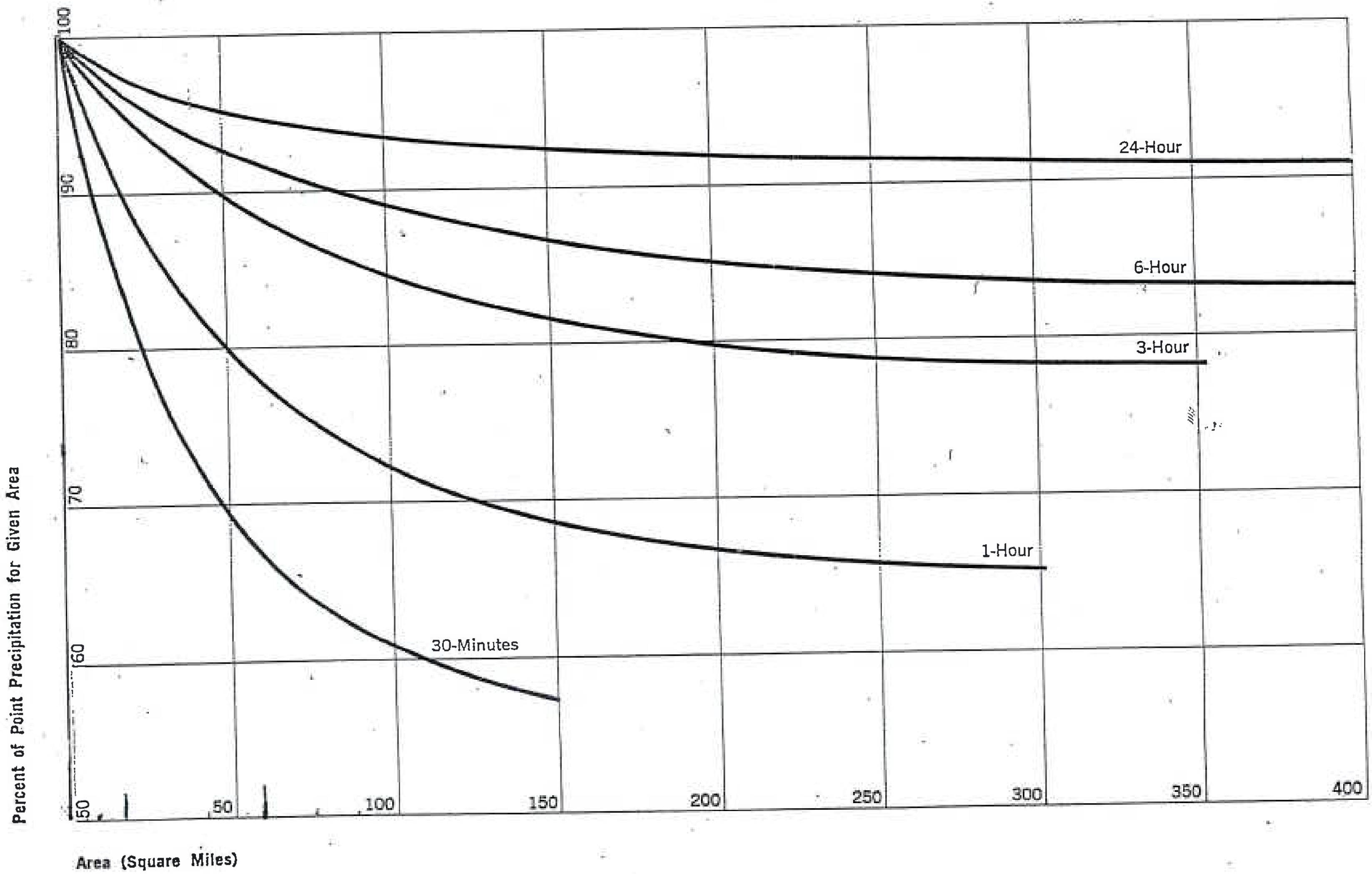


Figure 14. *Depth-Area curves.*
SOURCE:
NOAA Atlas 2, Vol. IV, New Mexico
Precipitation Frequency Atlas of the Western United States
U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration
National Weather Service. Silver Spring MD, 1973.

PURPOSE OF THIS AHYMO_97 OUTPUT FILE :

THIS IS THE FINAL 100-yr. 24-hour RAINFALL HYETOGRAPH as GENERATED BY AHYMO_97

For SCS TYPE II RAINFALL DISTRIBUTION AND NOAA ATLAS 14 POINT RAINFALL DEPTHS

THIS RAINFALL HYETOGRAPH WILL BE USED IN THE SWMM Model

```
AHYMO PROGRAM (AHYMO_97) -                          - Version:  1997.02c
     RUN DATE (MON/DAY/YR) = 11/20/2010
     START TIME (HR:MIN:SEC) = 09:08:29      USER NO.= AHYMO-S-9702c01SEC01A-AH
     INPUT FILE = Q:\SEOCVM~P\2FKWN6~Q\13AYKU~8\DDRU20~D\ABIJZX~P\AIQZF9~Z\AP3KME~G.TXT

START                 TIME=0.0  PUNCH CODE=0 PRINT CODE=0
*S
*S PROJECT NAME - MID VALLEY DRAINAGE MANAGEMENT PLAN
*S
*S   MODEL PURPOSE - TO COMPARE AHYMO_97 BASIN HYDROGRAPH RESULTS
*S                   TO SWMM V.0.021     BASIN HYDROGRAPH RESULTS
*S
*S
*S  MODEL DEVELOPMENT CONDITIONS AND ASSUMPTIONS
*S
*S        MODEL DESCRIPTION -
*S
*S   1.   EXISTING BASIN DEVELOPMENT CONDITIONS -
*S
*S   2.   NO SEDIMENT BULKING APPLIED
*S
*S   3.   USE PROCEDURES FROM City of Albuquerque
*S        Development Process Manual DPM SECTION 22
*S
*S PREPARED BY :  Pat Stovall, PE, CFM,      Felix Carles, PE, CFM
*S
*S  input file name :          ahymo97test1.txt          100-YR. 24-HR. STORM
*S  summary table file name :  ahymo97test1sm.doc         "                  "
*S  output file name :         ahymo97test1ot.doc         "                  "
*S
*S Prepared for  :   City of Albuquerque
*S
*S
*S  NOAA ATLAS 14 Rainfall Data for various return period
*S               24-hour storms follows:
*S   return period   1-hr. depth(in.)   6-hr. depth(in.)   24-hr. depth(in.)
*S      100-yr.           1.79               2.29               2.60
*S      500-yr.           2.31               2.92               3.21
*S       50-yr.           1.57               2.04               2.34
*S       10-yr.           1.12               1.49               1.76
*S        2-yr.           0.70               0.98               1.22
*S
*S 100-yr. 24-hr. rainfall   (DT = 0.05 hours = 3 minutes as time interval)
*S
```

RAINFALL TYPE=2 RAIN QUARTER=0.0 ONE=1.79 IN
SIX=2.29 IN DAY=2.60 IN DT=0.05 HOURS

COMPUTED 24-HOUR RAINFALL DISTRIBUTION BASED ON NOAA ATLAS 2 - PEAK AT 1.40 HR.
DT = .050000 HOURS END TIME = 24.000000 HOURS

.0000	.0057	.0116	.0177	.0240	.0305	.0373
.0443	.0515	.0590	.0669	.0751	.0837	.0927
.1022	.1122	.1227	.1340	.1460	.1590	.1730
.1805	.1889	.2130	.2701	.3683	.5201	.7387
1.0376	1.2733	1.3798	1.4688	1.5467	1.6163	1.6794
1.7369	1.7897	1.8383	1.8832	1.9246	1.9630	1.9726
1.9816	1.9902	1.9982	2.0059	2.0133	2.0203	2.0271
2.0336	2.0399	2.0460	2.0519	2.0577	2.0633	2.0687
2.0740	2.0792	2.0842	2.0892	2.0940	2.0987	2.1034
2.1079	2.1124	2.1168	2.1211	2.1253	2.1295	2.1335
2.1376	2.1415	2.1454	2.1493	2.1531	2.1568	2.1605
2.1642	2.1678	2.1713	2.1748	2.1783	2.1817	2.1851
2.1884	2.1917	2.1950	2.1982	2.2014	2.2046	2.2077
2.2108	2.2139	2.2170	2.2200	2.2230	2.2259	2.2288
2.2317	2.2346	2.2375	2.2403	2.2431	2.2459	2.2486
2.2514	2.2541	2.2568	2.2594	2.2621	2.2647	2.2673
2.2699	2.2725	2.2751	2.2776	2.2801	2.2826	2.2851
2.2876	2.2900	2.2913	2.2927	2.2940	2.2954	2.2967
2.2980	2.2993	2.3007	2.3020	2.3033	2.3046	2.3059
2.3071	2.3084	2.3097	2.3110	2.3123	2.3135	2.3148
2.3161	2.3173	2.3186	2.3198	2.3210	2.3223	2.3235
2.3247	2.3260	2.3272	2.3284	2.3296	2.3308	2.3320
2.3332	2.3344	2.3356	2.3368	2.3380	2.3392	2.3403
2.3415	2.3427	2.3439	2.3450	2.3462	2.3473	2.3485
2.3496	2.3508	2.3519	2.3530	2.3542	2.3553	2.3564
2.3576	2.3587	2.3598	2.3609	2.3620	2.3631	2.3642
2.3653	2.3664	2.3675	2.3686	2.3697	2.3708	2.3718
2.3729	2.3740	2.3751	2.3761	2.3772	2.3782	2.3793
2.3804	2.3814	2.3825	2.3835	2.3845	2.3856	2.3866
2.3877	2.3887	2.3897	2.3907	2.3918	2.3928	2.3938
2.3948	2.3958	2.3968	2.3978	2.3988	2.3998	2.4008
2.4018	2.4028	2.4038	2.4048	2.4058	2.4067	2.4077
2.4087	2.4097	2.4106	2.4116	2.4126	2.4135	2.4145
2.4155	2.4164	2.4174	2.4183	2.4193	2.4202	2.4212
2.4221	2.4230	2.4240	2.4249	2.4258	2.4268	2.4277
2.4286	2.4295	2.4305	2.4314	2.4323	2.4332	2.4341
2.4350	2.4359	2.4368	2.4377	2.4386	2.4395	2.4404
2.4413	2.4422	2.4431	2.4440	2.4449	2.4458	2.4466
2.4475	2.4484	2.4493	2.4501	2.4510	2.4519	2.4527
2.4536	2.4545	2.4553	2.4562	2.4571	2.4579	2.4588
2.4596	2.4605	2.4613	2.4621	2.4630	2.4638	2.4647
2.4655	2.4663	2.4672	2.4680	2.4688	2.4697	2.4705
2.4713	2.4721	2.4730	2.4738	2.4746	2.4754	2.4762
2.4770	2.4779	2.4787	2.4795	2.4803	2.4811	2.4819
2.4827	2.4835	2.4843	2.4851	2.4859	2.4866	2.4874
2.4882	2.4890	2.4898	2.4906	2.4914	2.4921	2.4929
2.4937	2.4945	2.4952	2.4960	2.4968	2.4976	2.4983
2.4991	2.4999	2.5006	2.5014	2.5021	2.5029	2.5037
2.5044	2.5052	2.5059	2.5067	2.5074	2.5082	2.5089
2.5097	2.5104	2.5111	2.5119	2.5126	2.5134	2.5141
2.5148	2.5156	2.5163	2.5170	2.5177	2.5185	2.5192
2.5199	2.5207	2.5214	2.5221	2.5228	2.5235	2.5242
2.5250	2.5257	2.5264	2.5271	2.5278	2.5285	2.5292
2.5299	2.5306	2.5313	2.5320	2.5327	2.5334	2.5341
2.5348	2.5355	2.5362	2.5369	2.5376	2.5383	2.5390
2.5397	2.5404	2.5411	2.5417	2.5424	2.5431	2.5438
2.5445	2.5451	2.5458	2.5465	2.5472	2.5478	2.5485
2.5492	2.5499	2.5505	2.5512	2.5519	2.5525	2.5532
2.5539	2.5545	2.5552	2.5558	2.5565	2.5571	2.5578
2.5585	2.5591	2.5598	2.5604	2.5611	2.5617	2.5624
2.5630	2.5637	2.5643	2.5650	2.5656	2.5662	2.5669
2.5675	2.5682	2.5688	2.5694	2.5701	2.5707	2.5713
2.5720	2.5726	2.5732	2.5739	2.5745	2.5751	2.5757
2.5764	2.5770	2.5776	2.5782	2.5789	2.5795	2.5801
2.5807	2.5813	2.5820	2.5826	2.5832	2.5838	2.5844
2.5850	2.5856	2.5862	2.5868	2.5875	2.5881	2.5887
2.5893	2.5899	2.5905	2.5911	2.5917	2.5923	2.5929
2.5935	2.5941	2.5947	2.5953	2.5959	2.5965	2.5970

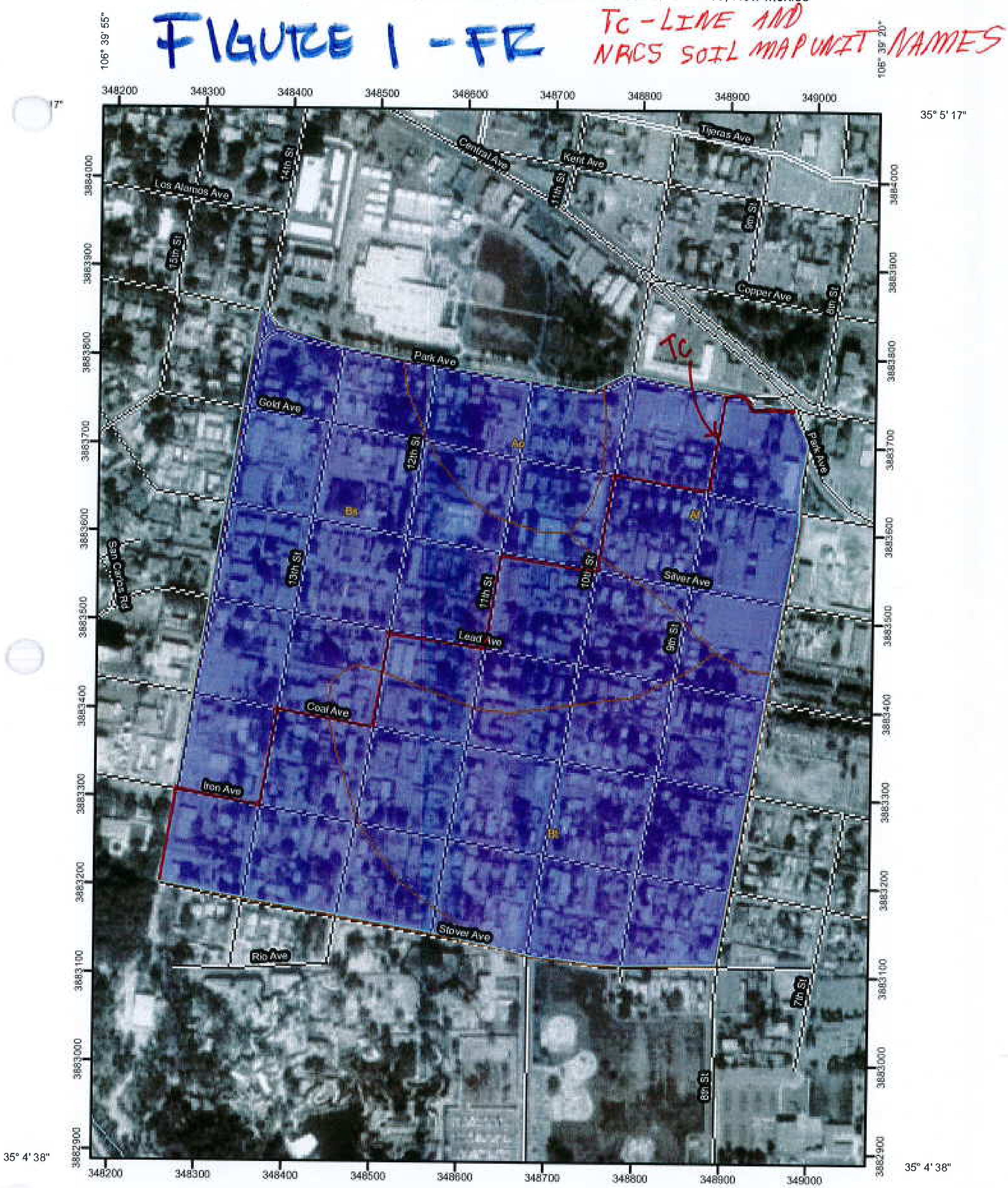
2.5976 2.5982 2.5988 2.5994 2.6000

NORMAL PROGRAM FINISH END TIME (HR:MIN:SEC) = 09:08:29

Q:\SEC---PROJECTS\2010 Projects\110112 COA MID VALLEY DMP\DMP Appendices Volume 3\Appendix 6 Sensitivity Analysis (AHYMO vs SWMM)\report & fig & tab\AHYMO_97 final 100-24 rainfall hyetograph.txt

FIGURE 1 - FR

Tc - LINE AND NRCS SOIL MAP UNIT NAMES



Map Scale: 1:5,690 if printed on A size (8.5" x 11") sheet.

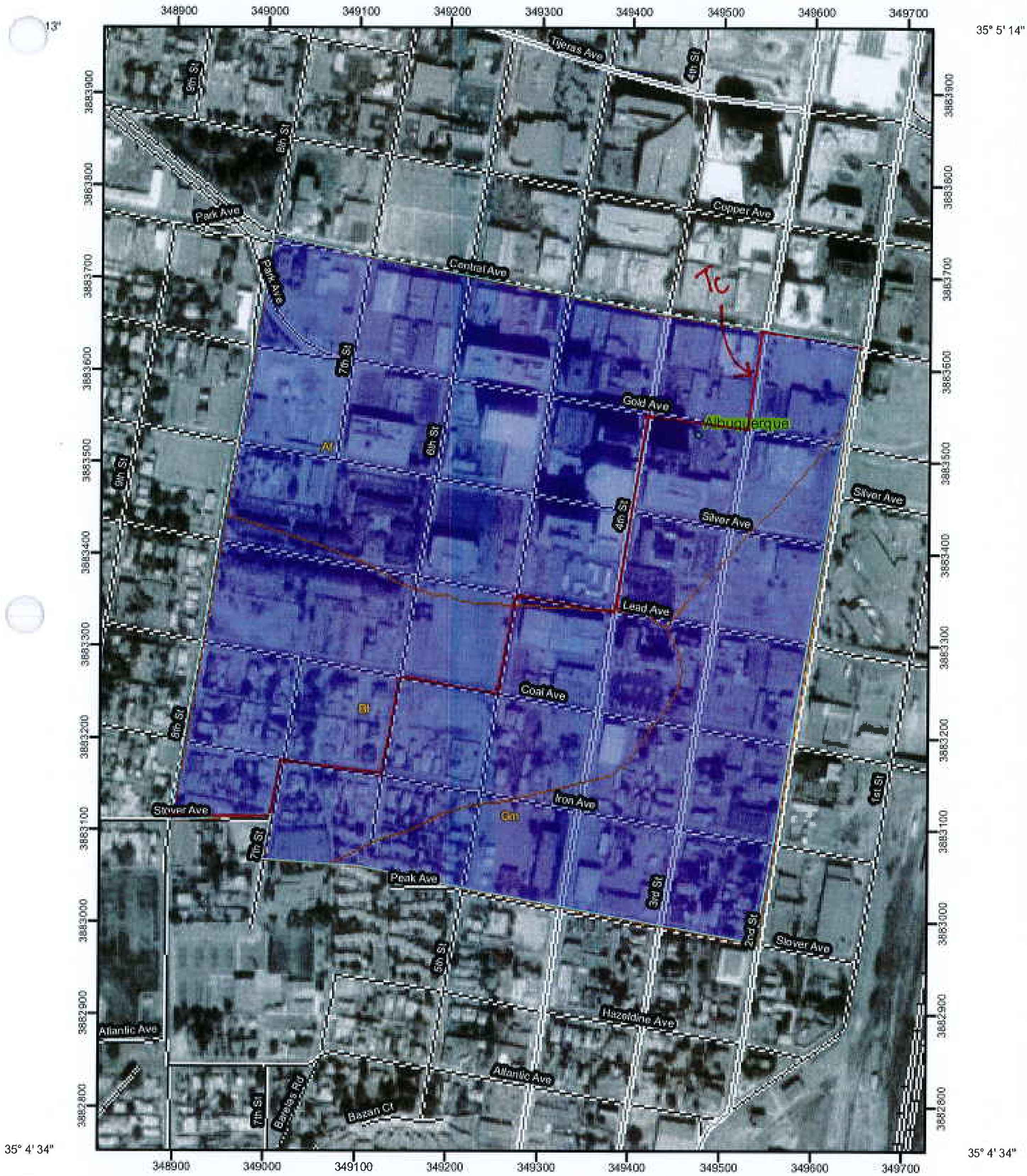
N

Meters: 0, 50, 100, 200, 300

Feet: 0, 200, 400, 800, 1,200

FIGURE 2 - FIC

Tc LINE AND NRCS SOIL MAPUNIT NAMES



Map Scale: 1:5,820 if printed on A size (8.5" x 11") sheet.

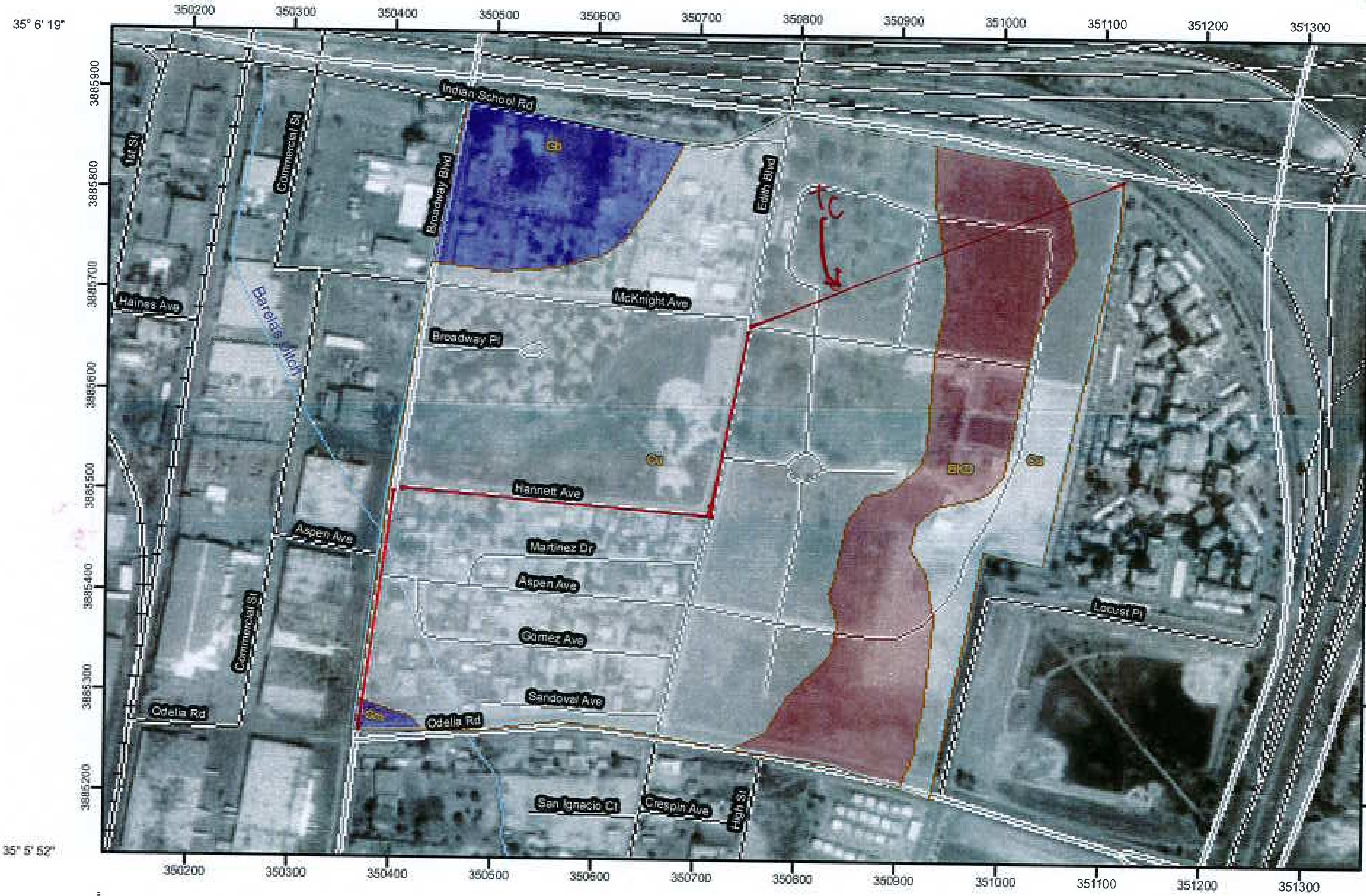
N

Meters: 0, 50, 100, 200, 300

Feet: 0, 200, 400, 800, 1,200

FIGURE 3 - 5F/31C

Tc LINE AND NRCS SOIL MAP UNIT NAMES



Map Scale: 1:5,890 if printed on A size (8.5" x 11") sheet.

106° 38' 39"

106° 37' 50"

Meters: 0, 50, 100, 200, 300

Feet: 0, 300, 600, 1,200, 1,800

USDA Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

[yellow] = FORMULA ALL OTHER CELLS DATA MUST BE ENTERED

TABLE 2

BASIN HYDROLOGIC DATA

Mid Valley Drainage Management Plan

General Basin Data: Basin No.	Basin Area (sq ft) (a)	Basin Area (acres) (a)	Basin Area (sq. mi.) (a)	Runoff Curve Number / % Impervious: CN / % Impervious (c)	Hydrologic Soil Groups in Basins	Number of Reaches	Time of Concentration (tc) Data: L Length of Longest Water-course (ft) (a)	L_{ca} Centroid Length (ft) (a)	Sc Composite Slope (ft/ft)	Kc Composite K	Upper Reach or Entire Reach: Top Elevation at beginning of water course (ft) (a)	Bottom Elevation (ft) (a)	Length (L_1) (ft) (a)	Slope (S_1) (ft/ft)	K_{N1} (d)	K_1 (b)	V_1 (ft/sec) (e)
BASINS WITH LONGEST FLOW PATH < 4,000 FEET																	
SR	4,168,692	95.700	0.1495	79.8 / 56 %	A, B	2	3,805		0.0158	2.3476	5025	5014	400	0.0275		0.7	1.16
SIC	4,168,692	95.700	0.1495	86.75 / 80%	A, B	2	3,805		0.0158	2.5520	5025	5014	400	0.0275		1	1.66
BASINS WITH LONGEST FLOW PATH BETWEEN 4,000 FEET AND 12,000 FEET											(estimate a weighted Kn by stream length - use same value for each reach)						
FR	4,473,612	102.700	0.1605	85 / 56%	B	2	4,177	2,089	0.0010	2.5626	4954	4953	400	0.0025	0.025	1.0	0.50
FIC	4,595,580	105.500	0.1648	90 / 80%	B	2	4,243	2,122	0.0012	2.5909	4960	4959	400	0.0025	0.025	1.0	0.50
			TOTAL 0.6244														

Basin No.	Middle or Lower Reach: Elevation at lower end of water course (ft) (a)	Length (L_2) (ft) (a)	Slope (S2) (ft/ft)	K_{N2} (d)	K_2 (b)	V_2 (ft/sec) (e)	Lower Reach: Elevation at lower end of water course (ft) (a)	Length (L_3) (ft) (a)	Slope (S3) (ft/ft)	K_{N3} (d)	K_3 (b)	V_3 (ft/sec) (e)	Tc and tp Results: Actual tc (hours) (f)	Final t_c (hours) (g)	t_p (unit hydrograph) (hours) (h)	Lag Time (SCS) (hours) (i)	Lag Time (SCS) minutes (i)	Basin No. (a)
SR	4965	3405	0.0144		3	3.60						0.00	0.36	0.36	0.24	0.27	16	SR
SIC	4965	3405	0.0144		3	3.60						0.00	0.33	0.33	0.22	0.25	15	SIC
																	0	
FR	4950	3,777	0.0008	0.021	3	0.85						0.00	1.39	1.39	0.93	1.04	63	FR
FIC	4955	3,843	0.0010	0.021	3	0.97						0.00	1.24	1.24	0.83	0.93	56	FIC

(a) All measurements were obtained from the Drainage Basin Maps (1-2 ft. contours) and 8.5" x 11" Figures in Appendix A

(b) Obtained from Table B-1 in the City of Albuquerque DPM, Chapter 22, pg. 22-22.

(c) See Table 3-4 for assumptions and computations - the soils maps as obtained from the NRCS to determine Hydrologic Soil Groups in Appendix A

(d) Obtained from Table B-2 in the City of Albuquerque DPM, Chapter 22, pg. 22-23.

(e) V= 10*K*s^0.5 formula b-2, DPM Chapter 22, pg. 22-22

(f) See DMP, Chapter 22, pages 22-22 through 22-24 for following formulas

If L < 4000 ft, then

Tc= (L1/V1 + L2/V2 + L3/V3)3600 sec/hour formula b-1, DPM, Chapter 22, pg. 22-22

If L is between 4,000 ft and 12,000 ft, then

Tc= ((12,000-L) / (72,000*K*s^0.5)) + ((L-4000)*Kn*(Lca/L)^0.33 / (552.2*s^0.165)) (ignore upper reach K - it is insignificant for long lengths and assume middle reach K for this equation)

If L > 12000 ft, then

Tc= (4/3)*26*Kn*((L*Lca/(5280^2*(s*5280)^0.5))^0.33) NOTE - Lag Time is same equation without the (4/3) Factor

(g) Tc= if Tc is computed to be less than 0.2 hours, then use 0.2 hours DPM Chapter 22, pg. 22-22

(h) Tp= (2/3)*Tc per DPM Chapter 22, pg. 22-24

(I) Lg = Tc* (3/4) for basins less than 12,000 ft longest flow path, for basins >12,000 ft longest flow path, see (f)

Table 3–1 — Runoff Curve Numbers for Arid and Semiarid Rangelands[1]
Source: USDA SCS, TR–55, 1986

Cover Description		Curve Numbers for Hydrologic Soil Group –			
Cover Type	Hydrologic Condition[2]	A[3]	B	C	D
Herbaceous—mixture of grass, weeds, and	Poor		80	87	93
low growing brush, with brush the	Fair		71	81	89
minor element.	Good		62	74	85
Oak–aspen—mountain brush mixture of oak	Poor				
brush,	Fair		66	74	79
aspen, mountain mahogany, bitter brush, maple,	Good		48	57	63
and other brush.			30	41	48
Piñon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush,	Poor	63	77	85	88
greasewood, creosotebush, blackbrush, bursage,	Fair	55	72	81	86
palo verde, mesquite, and cactus.	Good	49	68	79	84

[1] Average runoff condition.

[2] Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: >70% ground cover.

[3] Curve numbers for group A have been developed only for desert shrub.

Table 3-4 — Runoff Curve Numbers Urban Areas[1]

Source: USDA SCS, TR-55, 1986

Cover Description		Curve Numbers for Hydrologic Soil Group –			
Cover Type and Hydrologic Condition	Average Percent Impervious Area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Vacant lands (CN's are determined using cover types similar to those in **Table 3-3**).					

(a) MAX. PER DPM EQ 9-4 = 56%

(b) DPM VALUES TABLE A-5

FR → 85 FIC → 90

SR = 65(77) + 35(85) / 100 = 79.8

SIC = 65(85) + 35(90) / 100 = 86.75

[1] Average runoff condition.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using Figure 3.9.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using Figure 3.9 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using Figure 3.9, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

BASIN F/C

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Bernalillo County and Parts of Sandoval and Valencia Counties, New Mexico				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
Af	Agua loam	B	15.0	14.6%
Ao	Anapra silty clay loam	B	7.7	7.5%
Bs	Brazito silty clay loam	B	48.3	47.1%
Bt	Brazito complex	B	31.7	30.9%
Totals for Area of Interest			**102.7**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

BASIN FR

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Bernalillo County and Parts of Sandoval and Valencia Counties, New Mexico				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
Af	Agua loam	B	48.7	46.2%
Bt	Brazito complex	B	32.5	30.8%
Gm	Glendale clay loam	B	24.2	23.0%
Totals for Area of Interest			**105.5**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

BASIN SR-SIC

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Bernalillo County and Parts of Sandoval and Valencia Counties, New Mexico				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
BKD	Bluepoint-Kokan association, hilly	A	15.8	16.6%
Cu	Cut and fill land		72.2	75.5%
Gb	Gila loam	B	7.3	7.6%
Gm	Glendale clay loam	B	0.3	0.3%
Totals for Area of Interest			**95.7**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

AHYMO_97 SUMMARY TABLE for:
(100-yr. 24-hour storm)
for:

Runoff Curve Number Method

and

Land Treatment Method

(Rainfall loss method comparison)

(one generic flat 100% Residential basin

```
AHYMO PROGRAM SUMMARY TABLE (AHYMO_97) -
INPUT FILE = Q:\SEOCVM~P\2FKWN6~Q\13AYKU~8\DDRU20~D\ABIJZX~P\AIQZF9~Z\AP3KME~J.TXT      - VERSION:  1997.02c      RUN DATE (MON/DAY/YR) =12/15/2010
                                                                                                                  USER NO.= AHYMO-S-9702c01SEC01A-AH

                            FROM  TO                  PEAK        RUNOFF               TIME TO   CFS
             HYDROGRAPH      ID   ID      AREA      DISCHARGE     VOLUME     RUNOFF     PEAK     PER     PAGE =    1
COMMAND    IDENTIFICATION    NO.  NO.    (SQ MI)      (CFS)       (AC-FT)   (INCHES)   (HOURS)   ACRE    NOTATION

START                                                                                                 TIME=        .00
*S
*S PROJECT NAME - MID VALLEY DRAINAGE MANAGEMENT PLAN
*S
*S   MODEL PURPOSE - TO COMPARE AHYMO_97 BASIN HYDROGRAPH RESULTS
*S                   TO SWMM V.0.021     BASIN HYDROGRAPH RESULTS
*S
*S
*S  MODEL DEVELOPMENT CONDITIONS AND ASSUMPTIONS
*S
*S        MODEL DESCRIPTION -
*S
*S   1.   EXISTING BASIN DEVELOPMENT CONDITIONS -
*S
*S   2.   NO SEDIMENT BULKING APPLIED
*S
*S   3.   USE PROCEDURES FROM City of Albuquerque
*S        Development Process Manual DPM SECTION 22
*S
*S PREPARED BY :  Pat Stovall, PE, CFM,     Felix Carles, PE, CFM
*S
```

***S input file name : ahymo97test2.txt**

***S summary table file name : ahymo97test2sm.doc**

***S output file name : ahymo97test2ot.doc**

***S**

100-YR. 24-HR. STORM

" "

" "

```
*S Prepared for  :  City of Albuquerque
*S
*S
*S  NOAA ATLAS 14 Rainfall Data for various return period
*S                24-hour storms follows:
*S   return period   1-hr. depth(in.)   6-hr. depth(in.)   24-hr. depth(in.)
*S      100-yr.           1.79               2.29                2.60
*S      500-yr.           2.31               2.92                3.21
*S       50-yr.           1.57               2.04                2.34
*S       10-yr.           1.12               1.49                1.76
*S        2-yr.           0.70               0.98                1.22
*S
*S 100-yr. 24-hr. rainfall   (DT = 0.05 hours = 3 minutes as time interval)
*S
```

1 of 2

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NRCS LAST UPDATED JULY 2004 PART 630 NATIONAL ENGINEERING HANDBOOK

Chapter 10 Estimation of Direct Runoff from Storm Rainfall

630.1000 Introduction

The Natural Resources Conservation Service (NRCS) method of estimating direct runoff from storm rainfall is described in this chapter. The rainfall-runoff relationship is developed, parameters in the relationship are described, and applications of the method are illustrated by examples.

The NRCS method of estimating direct runoff from storm rainfall was the end product of a major field investigation and the work of numerous early investigators (Mockus 1949, Sherman 1942, Andrews 1954, and Ogrosky 1956). A major catalyst for getting this procedure to the field was the passage of the Watershed Protection and Flood Prevention Act (Public Law 83-566) in August 1954. As a result, studies associated with small watershed planning requiring solutions of hydrologic problems were expected to produce a quantum jump in hydrologic computations within NRCS (Rallison 1980, Rallison and Miller 1982). Most NRCS work is with small, ungaged, agricultural watersheds, so the method was developed for rainfall and watershed data that are available or easily obtainable.

The method is a direct descendent of the hydrologic heritage developed in the United States in the first half of the 20th century. In the early 1900's investigators commonly plotted total runoff versus total rainfall to describe river hydrology. Mead (1919) showed several of these plots, which were reasonably useful on an annual basis. However, for shorter periods, such as seasons or months, the scatter became excessive. More than just rainfall depth alone was involved in determining the amount of runoff. Sherman (1942) attempted to include additional information by plotting runoff versus rainfall with separate curves for each month and a tabular adjustment for antecedent rainfall. This was an attempt to deal with event situations; however, the scatter of the data was still significant. Kohler and Linsley (1951) expanded upon the approach of Sherman with the multiple correlation diagram. This incorporated such items as antecedent precipitation, week of the year, and storm duration along with the basic rainfall and runoff values. Coaxial correlation diagrams must be generated for each basin, so this approach cannot be used in an ungaged situation.

Mockus' goal was to develop a procedure for use on small, ungaged agricultural watersheds. No evidence indicates that he had the coaxial graphical correlation diagrams in mind when he started the work that led to curve numbers. It does seem appropriate, however, to consider the procedures to be related with curve number tables taking the place of some graphs used for coaxial correlation work. Rallison (1980) and Rallison and Miller (1982), in describing the origin and evolution of the runoff equation, point to this heritage.

The principal application of the method is in estimating quantities of runoff in flood hydrographs or in relation to flood peak rates (National Engineering Handbook 630 (NEH-630), chapter 16). An understanding of runoff types is necessary to apply the method properly in different climatic regions. Four types are distinguished: channel, surface, lateral subsurface flow, and baseflow.

Channel runoff occurs when rain falls on a flowing stream. It appears in the hydrograph at the start of the storm and continues throughout the storm, varying with the rainfall intensity. This type of runoff is generally a negligible quantity in flood hydrographs and is ignored except in special studies.

Surface runoff or overland flow occurs when the rainfall rate is greater than the infiltration rate. The runoff equation was developed for this condition. The runoff flows on the surface of the watershed and through channels to the point of reference. This type of runoff appears in the hydrograph after the initial demands of interception, infiltration, and surface storage have been satisfied. It varies during the storm and ends during or soon after the storm. The volume of surface runoff flowing down dry channels of watersheds in arid, semiarid, or subhumid climates may be reduced by transmission losses (NEH, part 630, chapter 19), which could be large enough to eliminate the runoff.

Subsurface flow occurs when infiltrated rainfall meets a subsurface horizon of lower hydraulic conductivity, travels laterally above the interface, and reappears as a seep or spring. This type runoff is often called quick return flow because it contributes to the hydrograph during or soon after the storm.

Baseflow occurs when there is a fairly steady flow from natural storage. The flow comes from an aquifer that is replenished by infiltrated rainfall or surface runoff. Changes in this type of runoff seldom appear soon enough after a storm to have an influence on the hydrograph for that storm, but an increase in baseflow from a previous storm increases the streamflow rate. Baseflow must be considered in the design of the principal spillway of a floodwater-retarding structure (NEH, part 630, chapter 21). The runoff equation does not include baseflow.

All types of runoff do not regularly appear on all watersheds. Climate is one indicator of the probability of the types of runoff that will occur in a given watershed. In arid regions the flow on smaller watersheds is nearly always surface runoff. Subsurface flow is more likely in humid regions. A long succession of storms, however, may produce subsurface flow or changes in baseflow even in arid climates, although the probability of this occurring is less in arid than in humid climates.

In flood hydrology baseflow is generally dealt with separately, and all other types are combined into *direct runoff*, which consists of channel runoff, surface runoff, and subsurface flow in unknown proportions. The curve number method estimates this combined direct runoff.

630.1001 Rainfall-runoff relationship

The NRCS runoff equation was developed to estimate total storm runoff from total storm rainfall. That is, the relationship excludes time as a variable. Rainfall intensity is ignored. An early version of the relationship was described by Mockus (1949). The material that follows evolved from that 1949 report.

(a) Development

The curve number runoff equation is:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad P > I_a$$
$$Q = 0 \qquad P \le I_a \qquad [10\text{–}1]$$

where:
Q = depth of runoff, in inches
P = depth of rainfall, in inches
I_a = initial abstraction, in inches
S = maximum potential retention, in inches

The derivation that follows is from Mockus. It should be viewed as an effort to get a curve of the proper shape. This derivation is not physically based, but it does satisfy conservation of mass.

A curve drawn through a plot of total storm runoff versus total storm rainfall for many storms on a watershed is concave upward and shows that no runoff occurs for small storms. The trend as storm size increases is for the curve to become asymptotic to a line parallel to a line of equality. The goal of Mockus was to determine an equation for a curve that describes that pattern. First he considered the condition in which no initial abstraction occurs; i.e., $I_a = 0$. Mockus found that an appropriate curve resulted from using the relationship among rainfall, runoff, and retention (the rain not converted into runoff) given by

$$\frac{F}{S} = \frac{Q}{P} \qquad [10\text{–}2]$$

where:
F = actual retention after runoff begins, in inches
S = potential maximum retention after runoff begins ($S \geq F$), in inches
Q = actual runoff, in inches
P = actual rainfall ($P \geq Q$), in inches

To satisfy the conservation of mass:

$$F = P - Q \quad [10\text{–}3]$$

Substituting the equation 10–3 definition of F into equation 10–2 yields

$$\frac{P-Q}{S} = \frac{Q}{P} \quad [10\text{–}4]$$

and solving for Q produces

$$Q = \frac{P^2}{P+S} \quad [10\text{–}5]$$

This is the rainfall-runoff relationship in which the initial abstraction I_a is zero.

When the initial abstraction is not zero, the amount of rainfall available for runoff is $(P - I_a)$ instead of P. Substituting $(P - I_a)$ for P in equation 10–2 results in

$$\frac{F}{S} = \frac{Q}{P - I_a} \quad [10\text{–}6]$$

where:
$F \leq S$
$Q \leq (P - I_a)$

The total retention for a storm consists of both I_a and F, so the conservation of mass equation can be expressed

$$F = \left(P - I_a\right) - Q \quad [10\text{–}7]$$

Substituting equation 10–7 for F in equation 10–6 results in

$$\frac{\left(P - I_a\right) - Q}{S} = \frac{Q}{\left(P - I_a\right)} \quad [10\text{–}8]$$

Solving for the total storm runoff, Q, results in the runoff equation

$$Q = \frac{\left(P - I_a\right)^2}{\left(P - I_a\right) + S} \quad [10\text{–}9]$$

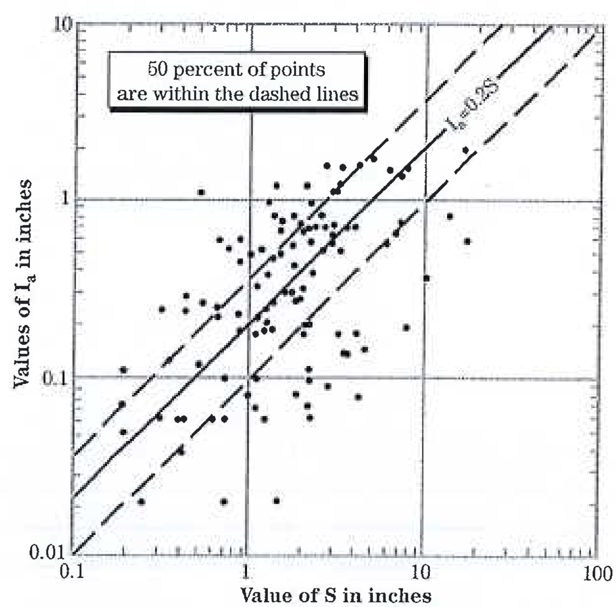
This is the rainfall-runoff relationship with the initial abstraction explicitly taken into account.

The initial abstraction consists mainly of interception, infiltration during early parts of the storm, and surface depression storage. It can be determined from observed rainfall-runoff events for small watersheds, where lag is minimal, as the rainfall that occurs before runoff begins. Interception and surface depression storage may be estimated from cover and surface conditions, but infiltration during the early part of the storm is highly variable and dependent on such factors as rainfall intensity, soil crusting, and soil moisture. Establishing a relationship for estimating I_a is not easy. Thus, I_a was assumed to be a function of the maximum potential retention, S. An empirical relationship between I_a and S was expressed as

$$I_a = 0.2S \quad [10\text{–}10]$$

Figure 10–1 illustrates the variability for this relationship. The points plotted in the figure are derived from experimental watershed data.

Figure 10–1 Relationship between I_a and S



The rainfall-runoff relationship is obtained by substituting equation 10–10 for initial abstraction into equation 10–9

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad P > I_a \qquad [10–11]$$

Equation 10–11, using $I_a = 0.2S$, was used to determine the curve numbers in NEH, part 630, chapter 9. Thus, if a relationship different from $I_a = 0.2S$ is used, a new set of curve numbers must be developed.

(b) Use of S and CN

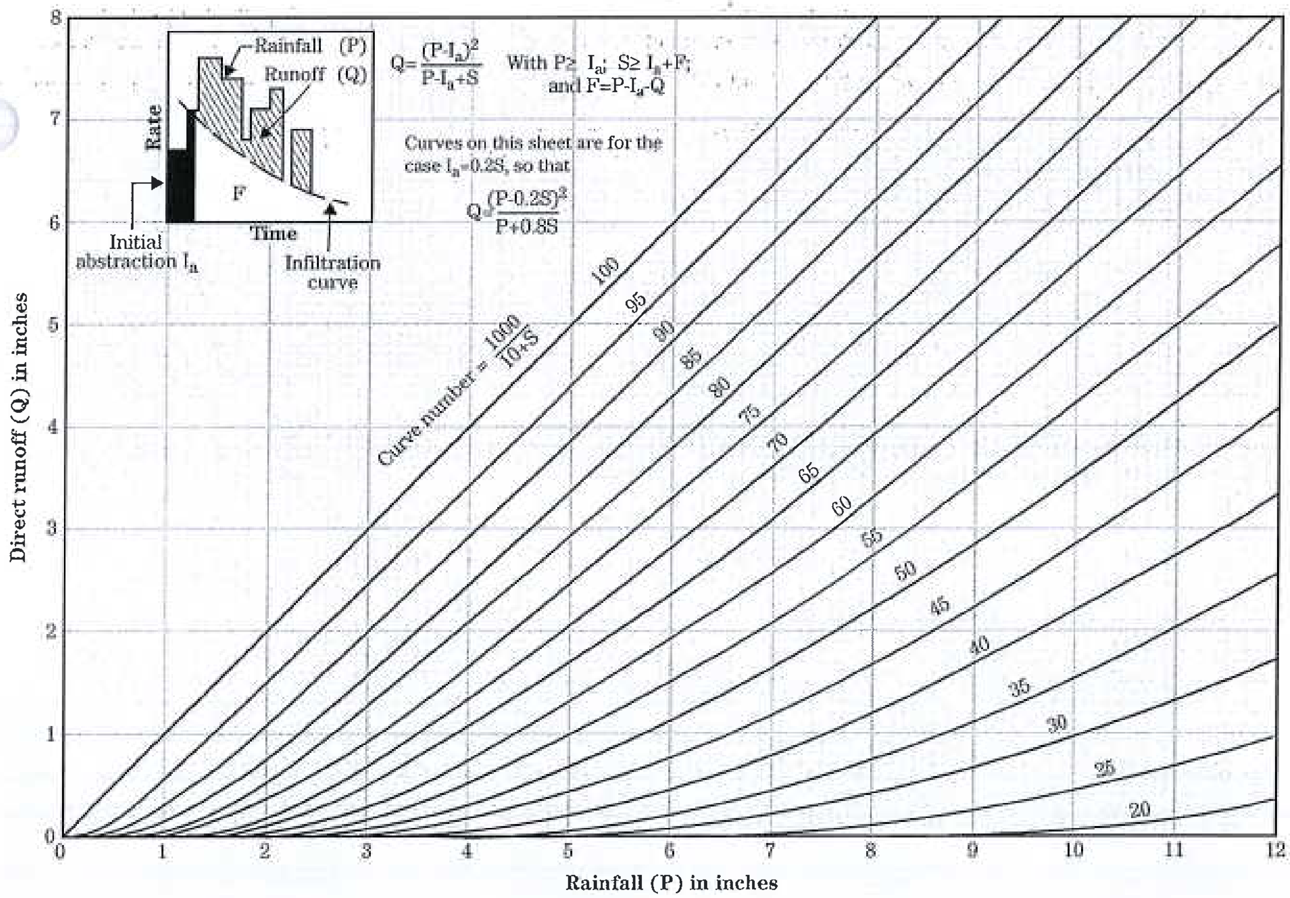
Figure 10–2 shows the solution of the runoff equation (eq. 10–11). The parameter CN (curve number) is a transformation of S.

$$CN = \frac{1000}{10 + S} \qquad [10–12]$$

for potential maximum retention (S) in inches. If S is in millimeters:

$$CN = \frac{1000}{10 + \frac{S}{25.4}} \qquad [10–13]$$

Figure 10–2 ES–1001 graphical solution of the equation $Q = \frac{(P - 0.2S)^2}{P + 0.8S}$



Note: Appendix A gives the tabular solution to this equation for P and Q up to 40 inches. In most cases use of this appendix gives a more exact solution than reading from the figure.

Figure 10–2 and appendix 10A are convenient ways to estimate runoff from rainfall directly without having to calculate S. S is generally needed for other applications, such as the analysis of runoff data or the development of supplementary runoff relationships.

(c) Retention parameters

Several retention parameters were used in the derivation of the runoff relationship, equation 10–11. The initial abstraction, I_a, can be considered the boundary between the storm size that produces runoff and the storm size that produces no runoff. The potential maximum retention, S, is dependent upon the soil-cover complex and, in principle, should not vary from storm to storm. It is in excess of the initial abstraction so that the maximum possible loss is given by $I_a + S$. This can be demonstrated noting that the loss is given by the difference between the rainfall and runoff (P – Q). Substituting equation 10–9 for Q results in

$$\text{Loss} = P - Q = P - \frac{(P - I_a)^2}{(P - I_a) + S} \qquad [10\text{–}14]$$

After multiplying both terms on the right hand side by:

$$1 = \frac{(P - I_a) + S}{(P - I_a) + S}$$

with some manipulation this becomes:

$$\text{Loss} = \frac{(S + I_a) - \frac{I_a^2}{P}}{1 - \frac{I_a}{P} + \frac{S}{P}} \qquad [10\text{–}15]$$

As P becomes large, where large is defined as P being much greater than the maximum potential retention (S), the terms with P in the denominator approach zero, with the result

$$\text{Loss} = S + I_a \qquad [10\text{–}16]$$

The parameter F is the actual retention for a storm and is more than the initial abstraction. That is, the total actual retention is given by the sum of the initial abstraction and the actual retention (I_a + F).

The preceding material, which shows that the S does not include I_a, has little significance in the normal application of the runoff equation. It is significant if an attempt is made to demonstrate a physical basis for the potential maximum retention. It is tempting to assume that S stands for storage, so that one can determine pore space and initial soil moisture to determine S in the same sense that Holtan and Lopez (1971) determined S in their infiltration relation. One of the difficulties in using this approach for an ungaged watershed is establishing an appropriate hydrologically active depth, a problem shared with the application of Holtan's equation. Chen (1976) and Hjelmfelt (1980a) showed that the Holtan and Lopez (1971) equation and the curve number runoff equation are identical for the special case of constant rainfall intensity and for zero asymptotic infiltration rate.

(d) Curve number variability

Rainfall-runoff data do not fit the curve number runoff concept precisely. This is exhibited in the data used in NEH, part 630, chapter 5, examples 5–4 and 5–5, and is expressed by the bounding curves in figure 5–6. The curve numbers for the enveloping curves were empirically related to the curve numbers of NEH, part 630, chapter 9, table 9–1. The results of the empirical relation are shown in columns 1, 2, and 3 of table 10–1, which also gives values of S, given I_a = 0.2 S for the curve number in column 1.

The variability in the CN results from rainfall intensity and duration, total rainfall, soil moisture conditions, cover density, stage of growth, and temperature. These causes of variability are collectively called the *Antecedent Runoff Condition* (ARC). ARC is divided into three classses: II for average conditions, I for dry conditions, and III for wetter conditions. Past attempts to explain the scatter quantitatively have focused on the antecedent soil moisture, usually as indicated by 5-day antecedent precipitation. This was used in early editions of National Engineering Handbook Section 4 (now Part 630, Hydrology).

A graph of the maximum potential retention versus the 5-day antecedent precipitation for Watershed 2 at Treynor, Iowa, is shown in figure 10–3. Data plotted are from the same events used in NEH, part 630,

Table 10–1 Curve numbers (CN) and constants for the case $I_a = 0.2S$

1	2	3	4	5	1	2	3	4	5
CN for ARC II	-- CN for ARC -- I	III	S values* (in)	Curve* starts where P = (in)	CN for ARC II	-- CN for ARC -- I	III	S values* (in)	Curve* starts where P = (in)
100	100	100	0	0	60	40	78	6.67	1.33
99	97	100	.101	.02	59	39	77	6.95	1.39
98	94	99	.204	.04	58	38	76	7.24	1.45
97	91	99	.309	.06	57	37	75	7.54	1.51
96	89	99	.417	.08	56	36	75	7.86	1.57
95	87	98	.526	.11	55	35	74	8.18	1.64
94	85	98	.638	.13	54	34	73	8.52	1.70
93	83	98	.753	.15	53	33	72	8.87	1.77
92	81	97	.870	.17	52	32	71	9.23	1.85
91	80	97	.989	.20	51	31	70	9.61	1.92
90	78	96	1.11	.22	50	31	70	10.0	2.00
89	76	96	1.24	.25	49	30	69	10.4	2.08
88	75	95	1.36	.27	48	29	68	10.8	2.16
87	73	95	1.49	.30	47	28	67	11.3	2.26
86	72	94	1.63	.33	46	27	66	11.7	2.34
85	70	94	1.76	.35	45	26	65	12.2	2.44
84	68	93	1.90	.38	44	25	64	12.7	2.54
83	67	93	2.05	.41	43	25	63	13.2	2.64
82	66	92	2.20	.44	42	24	62	13.8	2.76
81	64	92	2.34	.47	41	23	61	14.4	2.88
80	63	91	2.50	.50	40	22	60	15.0	3.00
79	62	91	2.66	.53	39	21	59	15.6	3.12
78	60	90	2.82	.56	38	21	58	16.3	3.26
77	59	89	2.99	.60	37	20	57	17.0	3.40
76	58	89	3.16	.63	36	19	56	17.8	3.56
75	57	88	3.33	.67	35	18	55	18.6	3.72
74	55	88	3.51	.70	34	18	54	19.4	3.88
73	54	87	3.70	.74	33	17	53	20.3	4.06
72	53	86	3.89	.78	32	16	52	21.2	4.24
71	52	86	4.08	.82	31	16	51	22.2	4.44
70	51	85	4.28	.86	30	15	50	23.3	4.66
69	50	84	4.49	.90	25	12	43	30.0	6.00
68	48	84	4.70	.94	20	9	37	40.0	8.00
67	47	83	4.92	.98	15	6	30	56.7	11.34
66	46	82	5.15	1.03	10	4	22	90.0	18.00
65	45	82	5.38	1.08	5	2	13	190.0	38.00
64	44	81	5.62	1.12	0	0	0	infinity	infinity
63	43	80	5.87	1.17					
62	42	79	6.13	1.23					
61	41	78	6.39	1.28					

* For CN in column 1.