APPENDIX A

NOAA ATLAS 14 INFORMATION

APPENDIX A

Below is the depth-duration-frequency and intensity-duration-frequency data for Alpine City.

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 40.474 N 111.756 W 5209 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: Thu Jul 23 2009

Precipitation Frequency Estimates (inches)

AEP* (1-in-Y)	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
2	0.16	0.24	0.30	0.41	0.50	0.63	0.74	1.01	1.33	1.58	1.99	2.45	3.02
5	0.24	0.36	0.44	0.60	0.74	0.88	1.00	1.32	1.73	2.05	2.59	3.22	3.95
10	0.30	0.45	0.56	0.76	0.94	1.09	1.21	1.55	2.02	2.37	3.00	3.75	4.59
25	0.39	0.60	0.74	1.00	1.23	1.41	1.53	1.88	2.42	2.78	3.52	4.45	5.43
50	0.48	0.73	0.91	1.22	1.51	1.71	1.80	2.14	2.74	3.09	3.93	4.99	6.08
100	0.58	0.88	1.09	1.47	1.82	2.05	2.14	2.44	3.08	3.40	4.34	5.55	6.74
200	0.70	1.06	1.32	1.77	2.20	2.45	2.53	2.78	3.45	3.72	4.75	6.13	7.42
500	0.89	1.35	1.68	2.26	2.80	3.11	3.18	3.41	4.01	4.15	5.32	6.92	8.35
1000	1.07	1.62	2.01	2.71	3.35	3.71	3.78	3.98	4.48	4.48	5.75	7.55	9.08

* These precipitation frequency estimates are based on an annual maxima series. AEP is the Annual Exceedance Probability.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

Precipitation Intensity Estimates (in/hr)

AEP* (1-in-Y)	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
2	1.91	1.46	1.20	0.81	0.50	0.31	0.25	0.17	0.11	0.07	0.04	0.03	0.02
5	2.82	2.15	1.78	1.20	0.74	0.44	0.33	0.22	0.14	0.09	0.05	0.03	0.02
10	3.57	2.72	2.25	1.51	0.94	0.55	0.40	0.26	0.17	0.10	0.06	0.04	0.03
25	4.71	3.58	2.96	1.99	1.23	0.71	0.51	0.31	0.20	0.12	0.07	0.05	0.03
50	5.76	4.38	3.62	2.44	1.51	0.85	0.60	0.36	0.23	0.13	0.08	0.05	0.04
100	6.97	5.30	4.38	2.95	1.82	1.02	0.71	0.41	0.26	0.14	0.09	0.06	0.04
200	8.38	6.38	5.27	3.55	2.20	1.23	0.84	0.46	0.29	0.16	0.10	0.06	0.04
500	10.69	8.13	6.72	4.52	2.80	1.55	1.06	0.57	0.33	0.17	0.11	0.07	0.05
1000	12.80	9.74	8.05	5.42	3.35	1.86	1.26	0.66	0.37	0.19	0.12	0.08	0.05

* These precipitation frequency estimates are based on an annual maxima series. AEP is the Annual Exceedance Probability.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

APPENDIX B

STORM DISTRIBUTIONS

APPENDIX B
STORM DISTRIBUTIONS

Below are the 10-year storm distributions for the 3-, 6-, and 24-hour storm durations. The total precipitation was obtained from the data shown in Appendix A. In order to apply these storm durations for other storm frequencies, multiply the incremental precipitation values by the ratio of the new storm frequency total depth to the 10-year total depth. The Farmer-Fletcher 3-hour modified storm distribution is the one exception to this rule. Below is an explanation of how that storm distribution was developed.

Salt Lake County developed the modified version of the Farmer-Fletcher distribution by nesting the one-hour (quartile 1) Farmer-Fletcher storm distribution, within the three hour period. The difference between the three-hour and the one-hour rainfall depths is divided equally and is distributed over the first 30 minutes of the storm and from hour 1.5 to 3.0 (see Table B-1).

Table B-1
Farmer-Fletcher Modified 3-Hour
Storm Distribution

Time (min)	Precipitation (Inches)
0	0.000
5	0.011
10	0.011
15	0.011
20	0.011
25	0.011
30	0.011
35	0.268*
40	0.212*
45	0.148*
50	0.094*
55	0.056*
60	0.043*
65	0.032*
70	0.024*
75	0.019*
80	0.017*
85	0.015*
90	0.012*

Time (min)	Precipitation (Inches)
95	0.011
100	0.011
105	0.011
110	0.011
115	0.011
120	0.011
125	0.011
130	0.011
135	0.011
140	0.011
145	0.011
150	0.011
155	0.011
160	0.011
165	0.011
170	0.011
175	0.011
180	0.011
Total:	1.21

* Nested 1-hour storm distribution

Table B-2
NOAA Atlas 14
General Precipitation Area
6-Hour Storm Distribution

Time (min)	Precipitation (Inches)
0	0.000
15	0.065
30	0.057
45	0.053
60	0.051
75	0.073
90	0.101
105	0.085
120	0.071
135	0.085
150	0.078
165	0.078
180	0.074
195	0.073
210	0.067
225	0.060
240	0.056
255	0.064
270	0.064
285	0.065
300	0.059
315	0.047
330	0.043
345	0.042
360	0.040
Total:	1.55

Table B-3
SCS Type II 24-Hour
Storm Distribution

Time (hours)	Precipitation (Inches)
0.0	0.000
0.5	0.013
1.0	0.013
1.5	0.013
2.0	0.014
2.5	0.014
3.0	0.015
3.5	0.016
4.0	0.016
4.5	0.017
5.0	0.018
5.5	0.019
6.0	0.020
6.5	0.021
7.0	0.023
7.5	0.025
8.0	0.027
8.5	0.030
9.0	0.033
9.5	0.037
10.0	0.043
10.5	0.055
11.0	0.073
11.5	0.114
12.0	0.900

Time (hours)	Precipitation (Inches)
12.5	0.170
13.0	0.088
13.5	0.063
14.0	0.049
14.5	0.043
15.0	0.037
15.5	0.033
16.0	0.030
16.5	0.027
17.0	0.025
17.5	0.023
18.0	0.022
18.5	0.020
19.0	0.019
19.5	0.018
20.0	0.017
20.5	0.016
21.0	0.015
21.5	0.015
22.0	0.014
22.5	0.014
23.0	0.013
23.5	0.013
24.0	0.013
Total:	2.37

APPENDIX C

TR-55 INFORMATION

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: 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
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.
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 2-3 or 2-4.
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 figures 2-3 or 2-4 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 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

1 Average runoff condition, and I_a=0.2S
2 Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.
3 Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c Runoff curve numbers for other agricultural lands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2/]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3/]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4/]	48	65	73
Woods—grass combination (orchard or tree farm). [5/]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6/]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4/]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.

2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

4 Actual curve number is less than 30; use CN = 30 for runoff computations.

5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d Runoff curve numbers for arid and semiarid rangelands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition [2/]	A [3/]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, 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, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

1 Average runoff condition, and I_a, = 0.2S. For range in humid regions, use table 2-2c.
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.

Antecedent runoff condition

The index of runoff potential before a storm event is the antecedent runoff condition (ARC). ARC is an attempt to account for the variation in CN at a site from storm to storm. CN for the average ARC at a site is the median value as taken from sample rainfall and runoff data. The CN's in table 2-2 are for the average ARC, which is used primarily for design applications. See NEH-4 (SCS 1985) and Rallison and Miller (1981) for more detailed discussion of storm-to-storm variation and a demonstration of upper and lower enveloping curves.

Urban impervious area modifications

Several factors, such as the percentage of impervious area and the means of conveying runoff from impervious areas to the drainage system, should be considered in computing CN for urban areas (Rawls et al., 1981). For example, do the impervious areas connect directly to the drainage system, or do they outlet onto lawns or other pervious areas where infiltration can occur?

Connected impervious areas — An impervious area is considered connected if runoff from it flows directly into the drainage system. It is also considered connected if runoff from it occurs as concentrated shallow flow that runs over a pervious area and then into the drainage system.

Urban CN's (table 2-2a) were developed for typical land use relationships based on specific assumed percentages of impervious area. These CN vales were developed on the assumptions that (a) pervious urban areas are equivalent to pasture in good hydrologic condition and (b) impervious areas have a CN of 98 and are directly connected to the drainage system. Some assumed percentages of impervious area are shown in table 2-2a

If all of the impervious area is directly connected to the drainage system, but the impervious area percentages or the pervious land use assumptions in table 2-2a are not applicable, use figure 2-3 to compute a composite CN. For example, table 2-2a gives a CN of 70 for a 1/2-acre lot in HSG B, with assumed impervious area of 25 percent. However, if the lot has 20 percent impervious area and a pervious area CN of 61, the composite CN obtained from figure 2-3 is 68. The CN difference between 70 and 68 reflects the difference in percent impervious area.

Unconnected impervious areas — Runoff from these areas is spread over a pervious area as sheet flow. To determine CN when all or part of the impervious area is not directly connected to the drainage system, (1) use figure 2-4 if total impervious area is less than 30 percent or (2) use figure 2-3 if the total impervious area is equal to or greater than 30 percent, because the absorptive capacity of the remaining pervious areas will not significantly affect runoff.

When impervious area is less than 30 percent, obtain the composite CN by entering the right half of figure 2-4 with the percentage of total impervious area and the ratio of total unconnected impervious area to total impervious area. Then move left to the appropriate pervious CN and read down to find the composite CN. For example, for a 1/2-acre lot with 20 percent total impervious area (75 percent of which is unconnected) and pervious CN of 61, the composite CN from figure 2-4 is 66. If all of the impervious area is connected, the resulting CN (from figure 2-3) would be 68.

TR 55 Worksheet 3: Time of Concentration (T_c) or Travel Time (T_t)

Project: ______________________ Designed By: ______________ Date: ________

Location: ______________________ Checked By: ______________ Date: ________

Check one: ☐ Present ☐ Developed

Check one: ☐ T_c ☐ T_t ☐ through subarea ______________________

NOTES: Space for as many as two segments per flow type can be used for each worksheet. Include a map, schematic, or description of flow segments.

Sheet Flow (Applicable to T_c only)				
Segment ID				
1. Surface description (Table 3-1)				
2. Manning's roughness coeff., n (Table 3-1)				
3. Flow length, L (total L $\leq$ 100 ft) ... ft				
4. Two-year 24-hour rainfall, P_2 ... in				
5. Land slope, s ... ft/ft				
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t ... hr		+		=

Shallow Concetrated Flow				
Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L ... ft				
9. Watercourse slope, s ... ft/ft				
10. Average velocity, V (Figure 3-1) ... ft/s				
11. $T_t = \frac{L}{3600\ V}$ Compute T_t ... hr		+		=

Channel Flow				
Segment ID				
12. Cross sectional flow area, a ... ft^2				
13. Wetted perimeter, P_w ... ft				
14. Hydraulic radius, $r = \frac{a}{P_w}$ Compute r ... ft				
15. Channel Slope, s ... ft/ft				
16. Manning's Roughness Coeff., n				
17. $V = \frac{1.49\ r^{2/3} s^{1/2}}{n}$ Compute V ... ft/s				
18. Flow length, L ... ft				
19. $T_t = \frac{L}{3600\ V}$ Compute T_t ... hr		+		=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19 ... hr ☐

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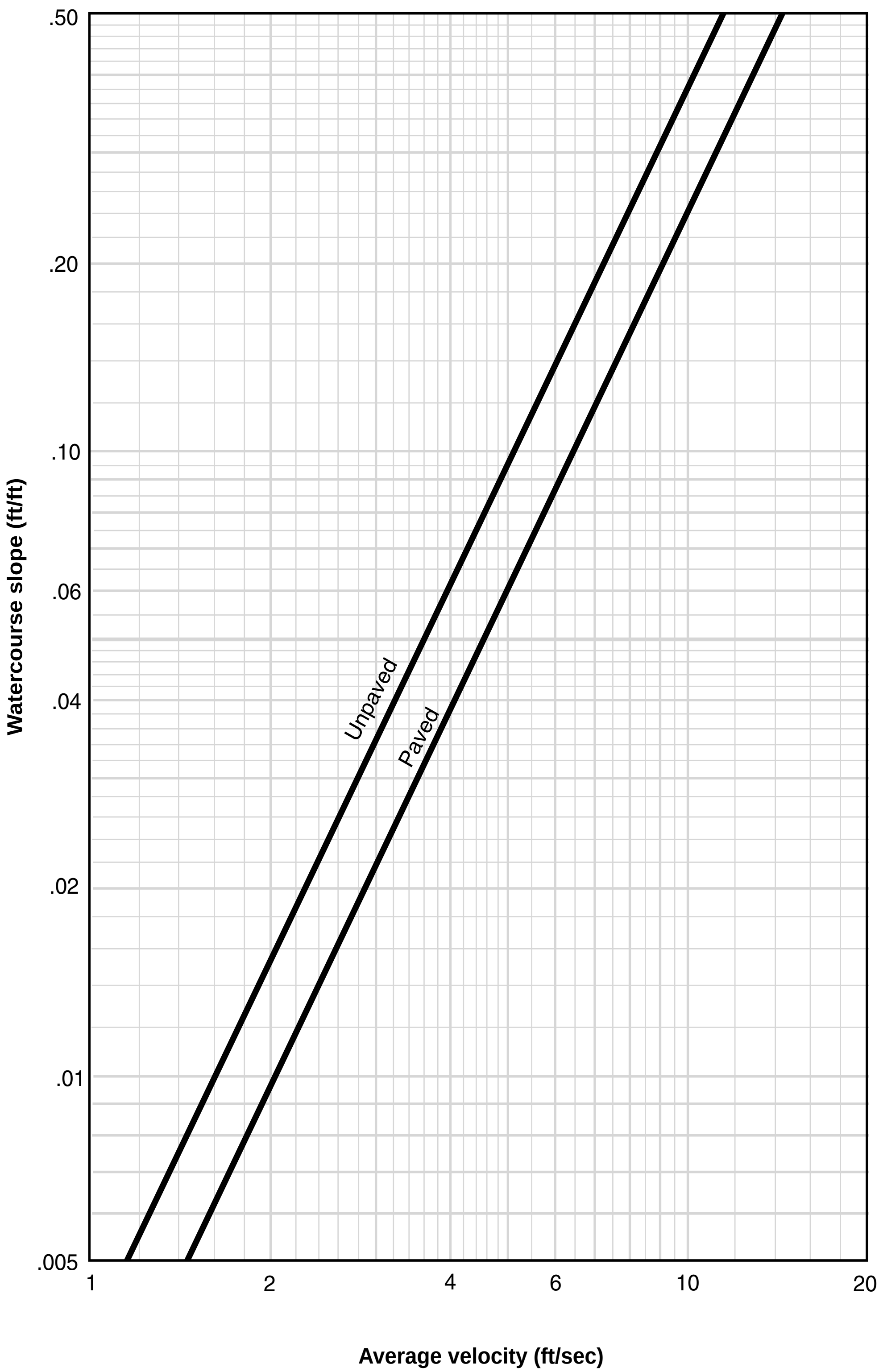
Figure 3-1 Average velocities for estimating travel time for shallow concentrated flow



Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n [1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

1 The n values are a composite of information compiled by Engman (1986).
2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
3 When selecting n , consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \quad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

Tr 55 Worksheet 4: Graphical Peak Discharge Method

Project: ______________________ Designed By: ______________ Date: __________

Location: ______________________ Checked By: ______________ Date: __________

Check one: ____ Present ____ Developed

1. Data:

Drainage area .... A_m = __________ mi^2 (acres/640)

Runoff curve number .... CN = __________ (From Worksheet 2)

Time of concentration ..... T_c = __________ hr (From Worksheet 3)

Rainfall distribution type ...... = __________ (II, III, DMVIII)

Pond and swamp areas spread throughout watershed .... = __________ percent of A_m (__________ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency..	yr			
3. Rainfall, P (24-hour)..................................	in			
4. Initial abstraction, I_a.................................. (Use CN with Table 4-1.)	in			
5. Compute I_a/P..				
6. Unit peak discharge, q_u.......................... (Use T_c and I_a/P with exhibit 4- 10)	csm/in			
7. Runoff, Q .... (From Worksheet 2)	in			
8. Pond and swamp adjustment factor, F_p........ (Use percent pond and swamp area with Table 4-2. Factor is 1.0 for zero percent pond and swamp area.)	in			
9. Peak discharge, q_p.................................... (Where $q_p = q_u A_m Q F_p$)	cfs			

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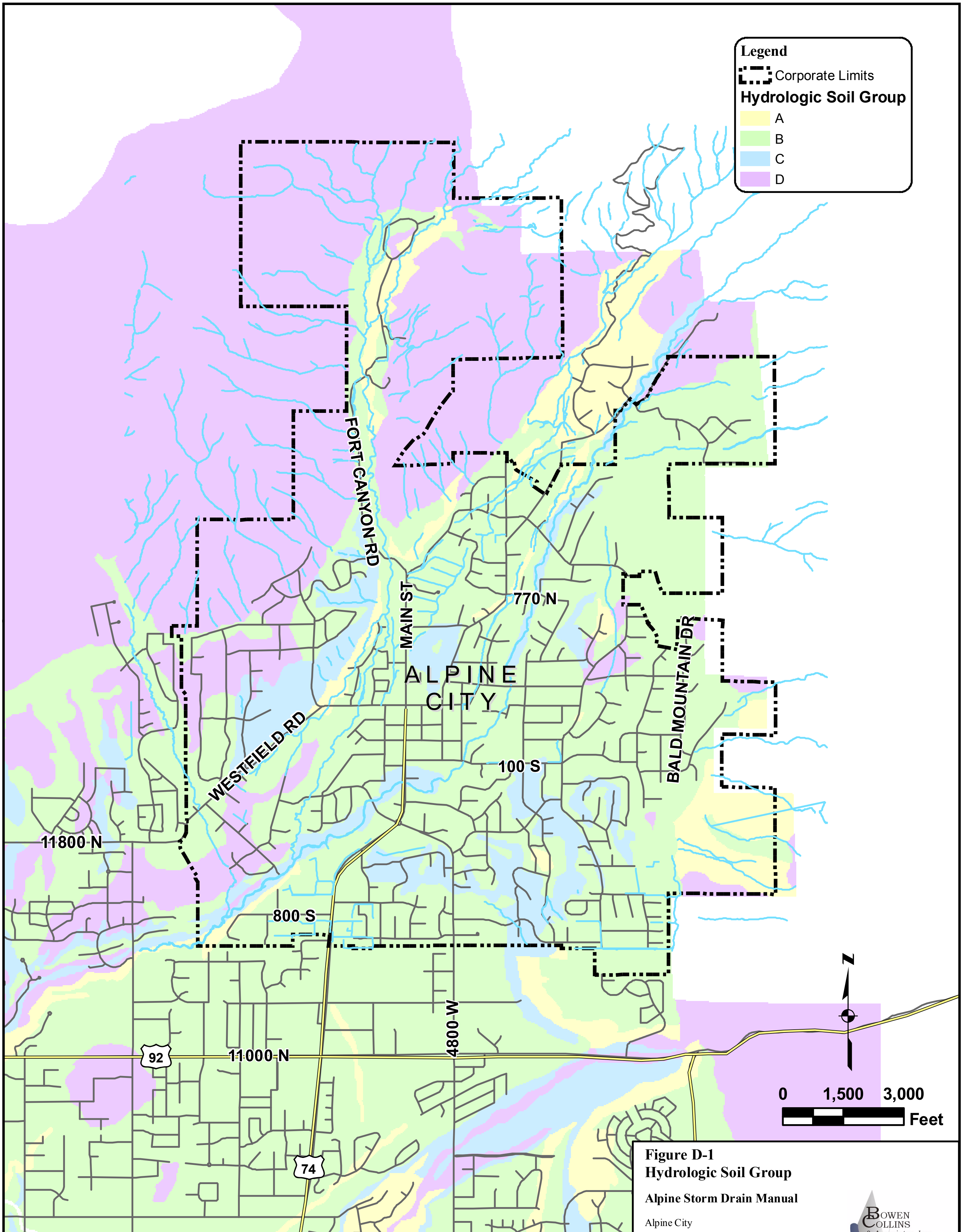
APPENDIX D

SOIL MAP



Printing Date: August 3, 2009
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