APPENDIX

B. HYDROLOGY DESIGN AIDS

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Tables

Figures

Table B-1: Overland Flow Manning's n Values

	Value	Recommended Range of Values
Concrete	0.011	0.010 - 0.013
Asphalt	0.012	0.010 - 0.015
Bare sand [a]	0.010	0.010 - 0.016
Graveled surface [a]	0.012	0.012 - 0.030
Bare clay-loam (eroded) [a]	0.012	0.012 - 0.033
Fallow (no residue) [b]	0.05	0.006 - 0.16
Chisel plow (<1/4 tons/acre residue)	0.07	0.006 - 0.17
Chisel plow (1/4 - 1 tons/acre residue)	0.18	0.070 - 0.34
Chisel plow (1 - 3 tons/acre residue)	0.30	0.190 - 0.47
Chisel plow (>3 tons/acre residue)	0.40	0.340 - 0.46
Disk/Harrow (<1/4 tons/acre residue)	0.08	0.008 - 0.41
Disk/Harrow (1/4 - 1 tons/acre residue)	0.16	0.100 - 0.25
Disk/Harrow (1 - 3 tons/acre residue)	0.25	0.140 - 0.53
Disk/Harrow (>3 tons/acre residue)	0.30	-- --
No till (</4 tons/acre residue)	0.04	0.030 - 0.07
No till (1/4 - 1 tons/acre residue)	0.07	0.010 - 0.13
No till (1 - 3 tons/acre residue)	0.30	0.160 - 0.47
Plow (Fall)	0.06	0.020 - 0.10
Coulter	0.10	0.050 - 0.13
Range (natural)	0.13	0.010 - 0.32
Range (clipped)	0.08	0.020 - 0.24
Grass (bluegrass sod)	0.45	0.390 - 0.63
Short grass prairie [a]	0.15	0.100 - 0.20
Dense grass [c]	0.24	0.170 - 0.30
Bermuda grass [c]	0.41	0.300 - 0.48
Woods	0.45	-- --

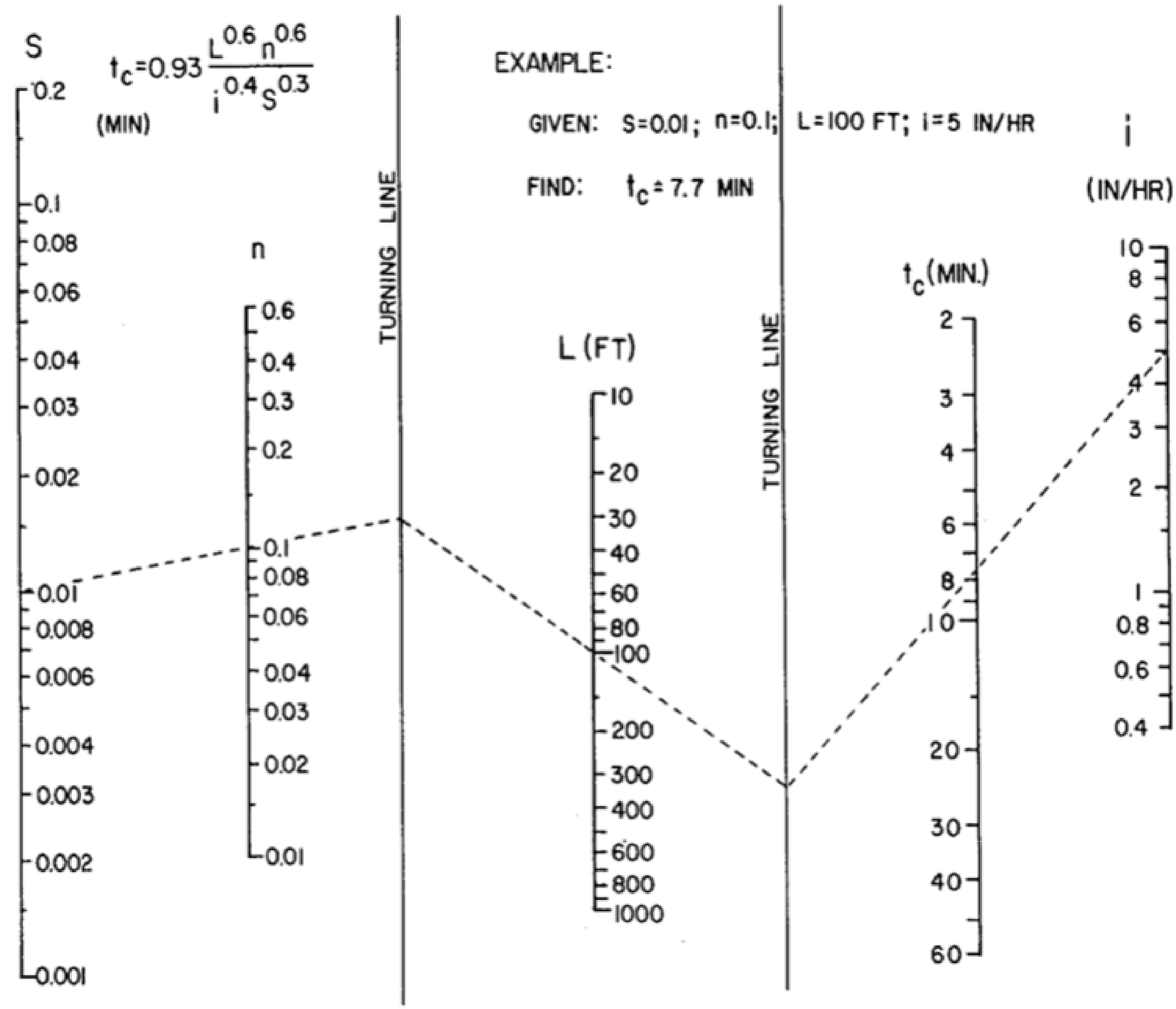
All values are from Engman (1983), unless noted otherwise.

[a]Woolhiser (1975).

[b]Fallow has been idle for one year and is fairly smooth.

[c]Palmer (1946). Weeping love grass, bluegrass, buffalo grass, blue gamma grass, native grass mix (OK), alfalfa, lespedeza.

Note: These values were determined specifically for overland flow conditions and are not appropriate for conventional open channel flow calculations. See Chapter 3, for open channel flow procedures.



Reference: USDOT, FHWA, HEC-12 (1984).

Figure B-1: Kinematic Wave Formula for Determining Overland Flow Travel Time

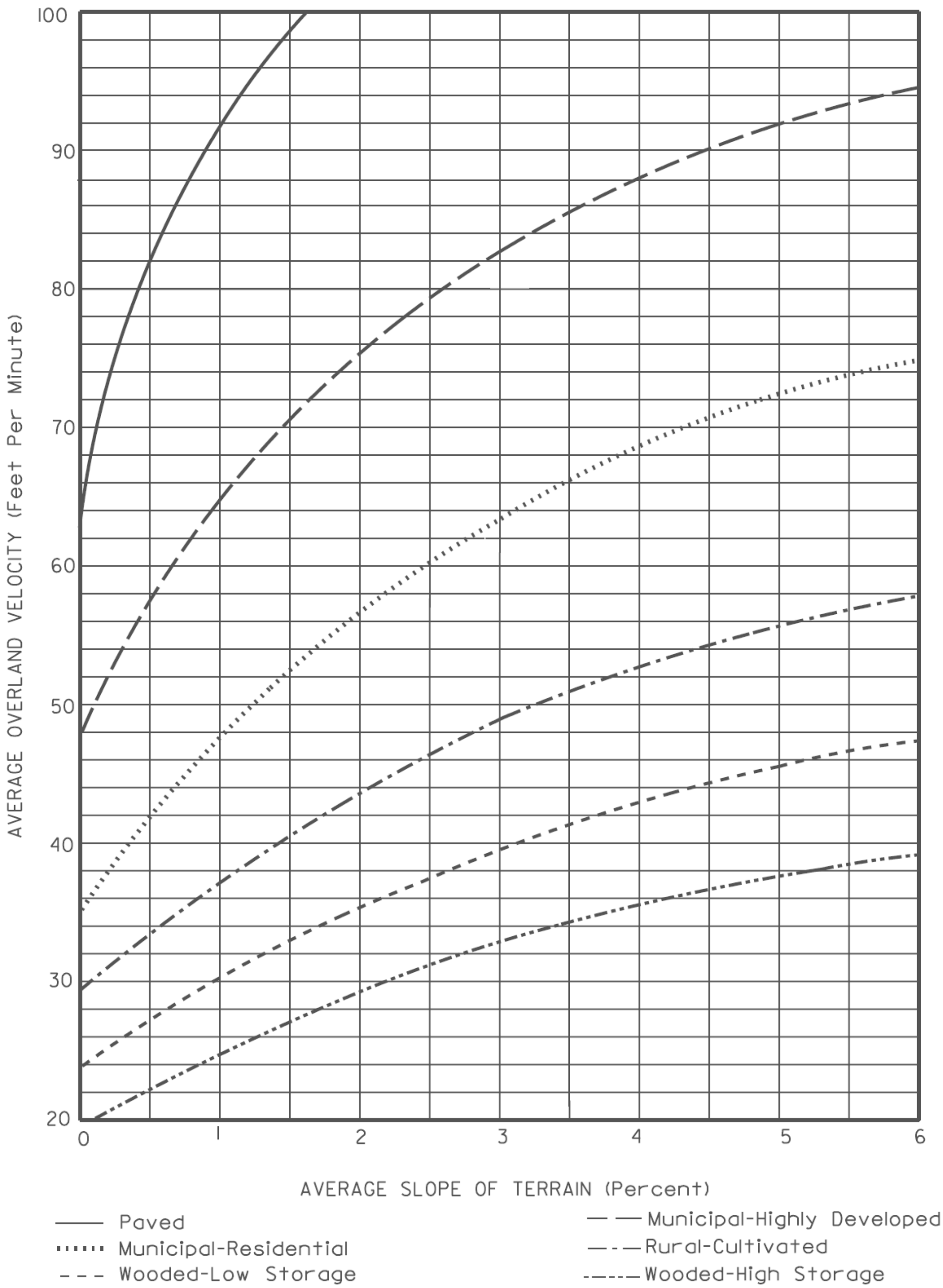
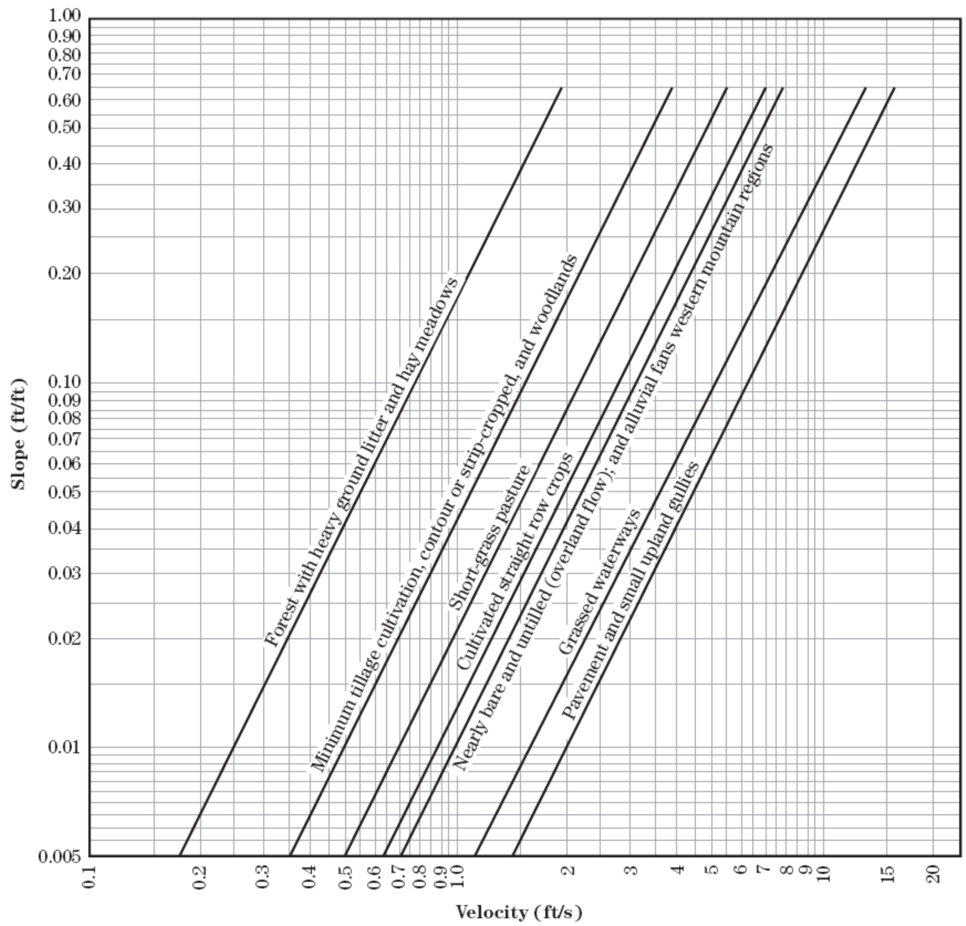


Figure B-2: Overland Flow Velocities for Various Land Use Types



Equations and assumptions from Figure B-3

Flow type	Depth (ft)	Manning's n	Velocity equation (ft/s)
Pavement and small upland gullies	0.2	0.025	$V = 20.328(s)^{0.5}$
Grassed waterways	0.4	0.050	$V=16.135(s)^{0.5}$
Nearly bare and untilled (overland flow); and alluvial fans in western mountain regions	0.2	0.051	$V=9.965(s)^{0.5}$
Cultivated straight row crops	0.2	0.058	$V=8.762(s)^{0.5}$
Short-grass pasture	0.2	0.073	$V=6.962(s)^{0.5}$
Minimum tillage cultivation, contour or strip-cropped, and woodlands	0.2	0.101	$V=5.032(s)^{0.5}$
Forest with heavy ground litter and hay meadows	0.2	0.202	$V=2.516(s)^{0.5}$

Ref: Chapter 15, Part 630, National Engineering Handbook, May 2010

Figure B-3: Velocity versus slope for Shallow Concentrated Flow

Table B-2: Manning's n Values for Street and Pavement Gutters

Type of Gutter or Pavement	Range of Manning's n
Concrete gutter, troweled finish	0.012
Asphalt pavement:	
Smooth texture	0.013
Rough texture [2]	0.016
Concrete gutter with asphalt pavement:	
Smooth	0.013
Rough	0.015
Concrete pavement:	
Float finish	0.014
Broom finish [3]	0.016
For gutters with small slopes, where sediment may accumulate increase above values of n by	0.002

Reference: FHWA HEC-22

Notes:
1) Estimates are by the Federal Highway Administration.

2) The Department's friction course is rough texture asphalt.

3) The Department's standard is brush (broom) finish for concrete curb. [Specification Section 520]

Table B-3: Recommended Manning's n Values for Artificial Channels

Channel Lining	Lining Description	Design Manning's n Value
Bare Earth or Vegetative Linings		
Bare earth, fairly uniform	Clean, recently completed	0.022
Bare earth, fairly uniform	Short grass and some weeds	0.028
Dragline excavated	No vegetation	0.030
Dragline excavated	Light brush	0.040
Channels not maintained	Dense weeds to flow depth	0.100
Channels not maintained	Clear bottom, brush sides	0.080
Maintained grass or sodded ditches	Good stand, well maintained 2" - 6"	0.060*
Maintained grass or sodded ditches	Fair stand, length 12" - 24"	0.200*
Rigid Linings		
Concrete paved	Broomed**	0.016
Concrete paved	"Roughened" - standard	0.020
Concrete paved	Gunite	0.020
Concrete paved	Over rubble	0.023
Asphalt concrete	Smooth	0.013
Asphalt concrete	Rough	0.016

* Decrease 30% for flows > 0.7' (maximum flow depth 1.5').

** Because this is not the standard finish, it must be specified.

Table B-4: Runoff Coefficients for Storm Return Period ≤ 10 Years [a]

Slope	Land Use	Sandy Soils Min.	Sandy Soils Max.	Clay Soils Min.	Clay Soils Max.
Flat (0-2%)	Woodlands	0.10	0.15	0.15	0.20
	Pasture, grass, and farmland [b]	0.15	0.20	0.20	0.25
	Bare Earth	0.30	0.50	0.50	0.60
	Rooftops and pavement	0.95	0.95	0.95	0.95
	Pervious pavements [c]	0.75	0.95	0.90	0.95
	SFR: 1/2-acre lots and larger	0.30	0.35	0.35	0.45
	Smaller lots	0.35	0.45	0.40	0.50
	Duplexes	0.35	0.45	0.40	0.50
	MFR: Apartments, townhouses, and condominiums	0.45	0.60	0.50	0.70
	Commercial and Industrial	0.50	0.95	0.50	0.95
Rolling (2-7%)	Woodlands	0.15	0.20	0.20	0.25
	Pasture, grass, and farmland [b]	0.20	0.25	0.25	0.30
	Bare Earth	0.40	0.60	0.60	0.70
	Rooftops and pavement	0.95	0.95	0.95	0.95
	Pervious pavements [c]	0.80	0.95	0.90	0.95
	SFR: 1/2-acre lots and larger	0.35	0.50	0.40	0.55
	Smaller lots	0.40	0.55	0.45	0.60
	Duplexes	0.40	0.55	0.45	0.60
	MFR: Apartments, townhouses, and condominiums	0.50	0.70	0.60	0.80
	Commercial and Industrial	0.50	0.95	0.50	0.95
Steep (7%+)	Woodlands	0.20	0.25	0.25	0.30
	Pasture, grass, and farmland [b]	0.25	0.35	0.30	0.40
	Bare Earth	0.50	0.70	0.70	0.80
	Rooftops and pavement	0.95	0.95	0.95	0.95
	Pervious pavements [c]	0.85	0.95	0.90	0.95
	SFR: 1/2-acre lots and larger	0.40	0.55	0.50	0.65
	Smaller lots	0.45	0.60	0.55	0.70
	Duplexes	0.45	0.60	0.55	0.70
	MFR: Apartments, townhouses, and condominiums	0.60	0.75	0.65	0.85
	Commercial and Industrial	0.60	0.95	0.65	0.95

[a] Weighted coefficient based on percentage of impervious surfaces and green areas must be selected for each site.

[b] Coefficients assume good ground cover and conservation treatment.

[c] Depends on depth and degree of permeability of underlying strata.

Note: SFR = Single Family Residential
MFR = Multi-Family Residential

Table B-5: Design Storm Frequency Factors for Pervious Area Runoff Coefficients*

Return Period (years)	Design Storm Frequency Factor, X_T
2 to 10	1.0
25	1.1
50	1.2
100	1.25

Reference: Wright-McLaughlin Engineers (1969).

* DUE TO THE INCREASE IN THE DURATION TIME THAT THE PEAK OR NEAR PEAK DISCHARGE RATE IS RELEASED FROM STORMWATER MANAGEMENT SYSTEMS, THE USE OF THESE SHORT DURATION PEAK RATE DISCHARGE ADJUSTMENT FACTORS IS NOT APPROPRIATE FOR FLOOD ROUTING COMPUTATIONS.

Table B-6: Definitions of Four SCS Hydrologic Soil Groups

Hydrologic Soil Group	Definition
A	Low Runoff Potential Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of deep, well-to-excessively-drained sands or gravels. These soils have a high rate of water transmission.
B	Moderately Low Runoff Potential Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep, to deep, moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
C	Moderately High Runoff Potential Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, soils with moderate fine to fine texture, or soils with moderate water tables. These soils have a slow rate of water transmission.
D	High Runoff Potential Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Reference: USDA, SCS, NEH-4 (1972).

Table B-7: SCS Runoff Curve Numbers – Agricultural, Suburban, and Urban Land

Land Use Description		Hydrologic Soil Group A	B	C	D
Cultivated Land[a]:					
Without conservation treatment		72	81	88	91
With conservation treatment		62	71	78	81
Pasture or range land:					
Poor condition		68	79	86	89
Good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or Forest Land:					
Thin stand, poor cover, no mulch		45	66	77	83
Good cover [b]		25	55	70	77
Open Spaces, Lawns, Parks, Golf Courses, Cemeteries:					
Good condition: grass cover on 75% or more of the area		39	61	74	80
Fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Poor condition: grass cover on 50% or less of the area		68	79	86	89
Commercial and Business Areas (85% impervious[d])		89	92	94	95
Industrial Districts (72% impervious[d])		81	88	91	93
Residential [c]					
Average lot size	Average % Impervious [d]				
1/8 acre or less	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
Paved Parking Lots, Roofs, Driveways [e]:		98	98	98	98
Streets and Roads:					
Paved with curbs and storm sewers [e]		98	98	98	98
Gravel		76	85	89	91
Dirt		72	82	87	89
Paved with open ditches		83	89	92	93
Newly graded area (no vegetation established)[f]		77	86	91	94

[a] For a more detailed description of agricultural land use curve numbers, refer to Table B-8. .
[b] Good cover is protected from grazing and litter and brush cover soil.
[c] Curve numbers are computed assuming the runoff from the house and driveway is directed toward the street with a minimum of roof water directed to lawns where additional infiltration could occur, which depends on the depth and degree of the permeability of the underlying strata.
[d] The percent impervious is presumed to be directly connected impervious area (DCIA). The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers. Reference TR-55 from USDA SCS Urban Hydrology Manual Figure 2-3 if the DCIA differs from the average percent used in this CN table, and Figure 2-4 if the impervious area is not directly connected to develop site specific CN for the project.
[e] In some warmer climates of the country, a curve number of 96 may be used.
[f] Use for temporary conditions during grading and construction.
Note: These values are for Antecedent Moisture Condition II, and $I_a = 0.2S$.
Reference: USDA, SCS, TR-55 (1984).

Table B-8: SCS Runoff Curve Numbers for Agricultural Use

Land Use	Treatment or Practice	Hydrologic Condition	Hydrologic Soil Group A	B	C	D
Fallow	Straight row	-----	77	86	91	94
Row Crops	Straight row	Poor	72	81	88	91
	Straight row	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	and terraced	Poor	66	74	80	82
	and terraced	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
	Straight row	Good	63	75	83	87
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	73	81	84
	Contoured	Good	55	69	78	83
	and terraced	Poor	61	72	79	82
	and terraced	Good	59	70	78	81
Close seeded legumes[a] or rotation meadow	Straight row	Poor	66	77	85	89
	Straight row	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	Contoured	Good	55	69	78	83
	and terraced	Poor	63	73	80	83
	and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		-----	59	74	82	86
Road (dirt)[b]		-----	72	82	87	89
(hard surface)[b]		-----	74	84	90	92

[a] Closed-drilled or broadcast.
[b] Including right-of-way.
Note: These values are for Antecedent Moisture Condition II, and $I_a = 0.2S$.
Reference: USDA, SCS, NEH-4 (1972)

Table B-9: SCS Classifications of Vegetative Covers by Hydrologic Properties

Vegetative Cover	Hydrologic Condition	
Crop rotation	Poor:	Contains a high proportion of row crops, small grain, and fallow.
	Good:	Contains a high proportion of alfalfa and grasses.
Native pasture or range	Poor:	Heavily grazed or having plant cover on less range than 50% of the area.
	Fair:	Moderately grazed; 50 - 75% plant cover.
	Good:	Lightly grazed; more than 75% plant cover.
	Permanent Meadow: 100% plant cover.	
Woodlands	Poor:	Heavily grazed or regularly burned so that litter, small trees, and brush are destroyed.
	Fair:	Grazed but not burned; there may be some litter.
	Good:	Protected from grazing so that litter and shrubs cover the soil.

Reference: USDA, SCS, NEH-4 (1972).

Figure B-4: Regions for USGS Regression Equations – Natural Flow Conditions

Table B-10: USGS Regression Equations – Natural Flow Conditions - Region 1

Peak Runoff Equation			Standard Error of Prediction (%)
Q_2	=	$127\ A^{0.656}\ (ST+1)^{-0.098}$	43
Q_5	=	$248\ A^{0.662}\ (ST+1)^{-0.189}$	40
Q_{10}	=	$357\ A^{0.666}\ (ST+1)^{-0.239}$	42
Q_{25}	=	$528\ A^{0.671}\ (ST+1)^{-0.293}$	47
Q_{50}	=	$684\ A^{0.675}\ (ST+1)^{-0.328}$	52
Q_{100}	=	$864\ A^{0.679}\ (ST+1)^{-0.362}$	57
Q_{200}	=	$1072\ A^{0.683}\ (ST+1)^{-0.392}$	62
Q_{500}	=	$1395\ A^{0.688}\ (ST+1)^{-0.430}$	70

Q_T = Peak runoff rate for return period of T-years, in cfs

A = Drainage area, in miles^2

ST = Basin storage, the percentage of the drainage basin occupied by lakes, reservoirs, swamps, and wetland. In-channel storage of a temporary nature, resulting from detention ponds or roadway embankments, is not included in the computation of ST

Basin Characteristic	Range of Applicability
Drainage Area (A)	0.14 miles^2 (89.6 acres) to 4,385 miles^2
Storage Area (ST)	0% to 44.29%

Reference: Verdi (2006)

See Figure B-4 for region delineation.

Table B-11: USGS Regression Equations – Natural Flow Conditions - Region 2

Peak Runoff Equation	Standard Error of Prediction (%)
$Q_2 = 101\ A^{0.617}\ (ST+1)^{-0.211}$	58
$Q_5 = 184\ A^{0.620}\ (ST+1)^{-0.212}$	53
$Q_{10} = 253\ A^{0.621}\ (ST+1)^{-0.215}$	52
$Q_{25} = 353\ A^{0.621}\ (ST+1)^{-0.221}$	53
$Q_{50} = 435\ A^{0.621}\ (ST+1)^{-0.226}$	54
$Q_{100} = 525\ A^{0.621}\ (ST+1)^{-0.231}$	56
$Q_{200} = 622\ A^{0.621}\ (ST+1)^{-0.236}$	59
$Q_{500} = 764\ A^{0.620}\ (ST+1)^{-0.244}$	63

Q_T = Peak runoff rate for return period of T-years, in cfs
A = Drainage area, in miles^2
ST = Basin storage, the percentage of the drainage basin occupied by lakes, reservoirs, swamps, and wetland. In-channel storage of a temporary nature, resulting from detention ponds or roadway embankments, is not included in the computation of ST

Basin Characteristic	Range of Applicability
Drainage Area (A)	0.06 miles^2 (38.4 acres) to 2,647 miles^2
Storage Area (ST)	0% to 74.33%

Reference: Verdi (2006)

See Figure B-4 for region delineation.

Table B-12: USGS Regression Equations – Natural Flow Conditions - Region 3

Peak Runoff Equation	Standard Error of Prediction (%)
$Q_2 = 72.7\ A^{0.741}\ (ST+1)^{-0.589}$	87
$Q_5 = 164\ A^{0.704}\ (ST+1)^{-0.587}$	62
$Q_{10} = 250\ A^{0.686}\ (ST+1)^{-0.592}$	56
$Q_{25} = 390\ A^{0.668}\ (ST+1)^{-0.601}$	53
$Q_{50} = 517\ A^{0.656}\ (ST+1)^{-0.608}$	53
$Q_{100} = 664\ A^{0.646}\ (ST+1)^{-0.616}$	54
$Q_{200} = 833\ A^{0.638}\ (ST+1)^{-0.625}$	56
$Q_{500} = 1094\ A^{0.629}\ (ST+1)^{-0.638}$	59

Q_T = Peak runoff rate for return period of T-years, in cfs
A = Drainage area, in miles^2
ST = Basin storage, the percentage of the drainage basin occupied by lakes, reservoirs, swamps, and wetland. In-channel storage of a temporary nature, resulting from detention ponds or roadway embankments, is not included in the computation of ST

Basin Characteristic	Range of Applicability
Drainage Area (A)	0.41 miles^2 (262.4 acres) to 3,244 miles^2
Storage Area (ST)	0.18% to 48.04%

Reference: Verdi (2006)

See Figure B-4 for region delineation.

Table B-13: USGS Regression Equations – Natural Flow Conditions - Region 4

Peak Runoff Equation	Standard Error of Prediction (%)
$Q_2 = 171\ A^{0.628}\ (ST+1)^{-0.401}$	36
$Q_5 = 321\ A^{0.618}\ (ST+1)^{-0.395}$	39
$Q_{10} = 447\ A^{0.614}\ (ST+1)^{-0.396}$	43
$Q_{25} = 636\ A^{0.610}\ (ST+1)^{-0.401}$	48
$Q_{50} = 797\ A^{0.609}\ (ST+1)^{-0.406}$	53
$Q_{100} = 975\ A^{0.608}\ (ST+1)^{-0.411}$	57
$Q_{200} = 1171\ A^{0.608}\ (ST+1)^{-0.416}$	62
$Q_{500} = 1461\ A^{0.609}\ (ST+1)^{-0.424}$	69

Q_T = Peak runoff rate for return period of T-years, in cfs
A = Drainage area, in miles^2
ST = Basin storage, the percentage of the drainage basin occupied by lakes, reservoirs, swamps, and wetland. In-channel storage of a temporary nature, resulting from detention ponds or roadway embankments, is not included in the computation of ST

Basin Characteristic	Range of Applicability
Drainage Area (A)	0.20 miles^2 (120 acres) to 2,833 miles^2
Storage Area (ST)	0% to 34.12%

Reference: Verdi (2006)

See Figure B-4 for region delineation.

Table B-14: USGS Nationwide Regression Equations for Urban Conditions

Peak Runoff Equation	R^2	Standard Error (%)
$UQ_2 = 2.35A^{0.41} SL^{0.17} (i_2 + 3)^{2.04} (ST + 8)^{-0.65} (13 - BDF)^{-0.32} IA^{0.15} RQ_2^{0.47}$	0.93	38
$UQ_5 = 2.70A^{0.35} SL^{0.16} (i_2 + 3)^{1.86} (ST + 8)^{-0.59} (13 - BDF)^{-0.31} IA^{0.11} RQ_5^{0.54}$	0.93	37
$UQ_{10} = 2.99A^{0.32} SL^{0.15} (i_2 + 3)^{1.75} (ST + 8)^{-0.57} (13 - BDF)^{-0.30} IA^{0.09} RQ_{10}^{0.58}$	0.93	38
$UQ_{25} = 2.78A^{0.31} SL^{0.15} (i_2 + 3)^{1.76} (ST + 8)^{-0.55} (13 - BDF)^{-0.29} IA^{0.07} RQ_{25}^{0.60}$	0.93	40
$UQ_{50} = 2.67A^{0.29} SL^{0.15} (i_2 + 3)^{1.74} (ST + 8)^{-0.53} (13 - BDF)^{-0.28} IA^{0.06} RQ_{50}^{0.62}$	0.92	42
$UQ_{100} = 2.50A^{0.29} SL^{0.15} (i_2 + 3)^{1.76} (ST + 8)^{-0.52} (13 - BDF)^{-0.28} IA^{0.06} RQ_{100}^{0.63}$	0.92	44
$UQ_{500} = 2.27A^{0.29} SL^{0.16} (i_2 + 3)^{1.86} (ST + 8)^{-0.54} (13 - BDF)^{-0.27} IA^{0.05} RQ_{500}^{0.63}$	0.90	49

UQ_T = Peak discharge, in cfs, for the urban watershed for recurrence interval T.

SL = Main channel slope, in ft/mile, measured between points which are 10 and 85 percent of the main channel length upstream from the study site. For sites where SL is greater than 70 ft/mile, 70 ft/mile is used in the equations.

A = Contributing drainage area, in $miles^2$.

i_2 = Rainfall intensity, in inches, for the 2-hour 2-year occurrence.

ST = Basin storage, the percentage of the drainage basin occupied by lakes, reservoirs, swamps, and wetland. In-channel storage of a temporary nature, resulting from detention ponds or roadway embankments, is not included in the computation of ST.

BDF = Basin development factor, an index of the prevalence of the drainage aspects of (a) storm sewers, (b) channel improvements, (c) impervious channel linings, and (d) curb and gutter streets. The range of BDF is 0-12. A value of zero for BDF indicates the above drainage aspects are not prevalent, but does not necessarily mean the basin is non-urban. A value of 12 indicates full development of the drainage aspects throughout aspects throughout the basin. See Chapter 2, Section 2.2.3 & Example 2.2-2 of this document for details of computing BDF.

IA = Percentage of the drainage basin occupied by impervious surfaces, such as houses, buildings, streets, and parking lots.

RQ_T = Peak discharge, in cfs, for an equivalent rural drainage basin in the same hydrologic area as the urban basin, and for recurrence interval T.

Reference: Sauer et al. (1983).

Table B-15: Urban Watershed Regression Equations for Tampa Bay Area

Peak Runoff Equation	R^2	Standard Error in %
$Q_2 = 3.72\,A^{1.07}\ BDF^{1.05}\ SL^{0.77}(DTENA + 0.01)^{-0.11}$	0.92	33
$Q_5 = 7.94\,A^{1.03}\ BDF^{0.87}\ SL^{0.81}\ (DTENA + 0.01)^{-0.10}$	0.90	32
$Q_{10} = 12.9\,A^{1.04}\ BDF^{0.75}\ SL^{0.83}\ (DTENA + 0.01)^{-0.10}$	0.88	35
$Q_{25} = 214\ A^{1.13}\ (13 - BDF)^{-0.59}\ SL^{0.73}$	0.85	37
$Q_{50} = 245\ A^{1.14}\ (13 - BDF)^{-055}\ SL^{0.74}$	0.83	39
$Q_{100} = 282\ A^{0.918}\ (13- BDF)^{-0.51}\ SL^{0.76}$	0.83	42

Q_T = Peak runoff rate for return period of T-years, in cfs

A = Drainage area, in $miles^2$

BDF = Basin development factor, dimensionless; see Example 2.2-2 and the discussion on Nationwide Regression Equations in Chapter 2, Section 2.2.3 of this document.

SL = Channel slope, in ft/mile, measured between points at 10 and 85 percent of the distance from the design point to the watershed boundary.

DTENA = Surface area of lakes, ponds, and detention and retention basins, expressed as a percentage of drainage area.

Watershed Characteristic	Range of Applicability
Drainage Area	0.34 $miles^2$ (220 acres) to 3.45 $miles^2$
Noncontributing internal drainage	0 to 0.3 percent of watershed area
Soil-infiltration index	2.05 to 3.89 inches
Total impervious area	19 to 61 percent of watershed area
Hydraulically connected impervious area	5.5 to 53 percent of watershed area
Effective impervious area	5.5 to 40 percent of watershed area
Channel slope	4.6 to 23.6 ft/mile
Lake and detention basin area	0 to 3.5 percent of watershed area
Basin development factor	3 to 12 (dimensionless)

Reference: Lopez and Woodham (1983).

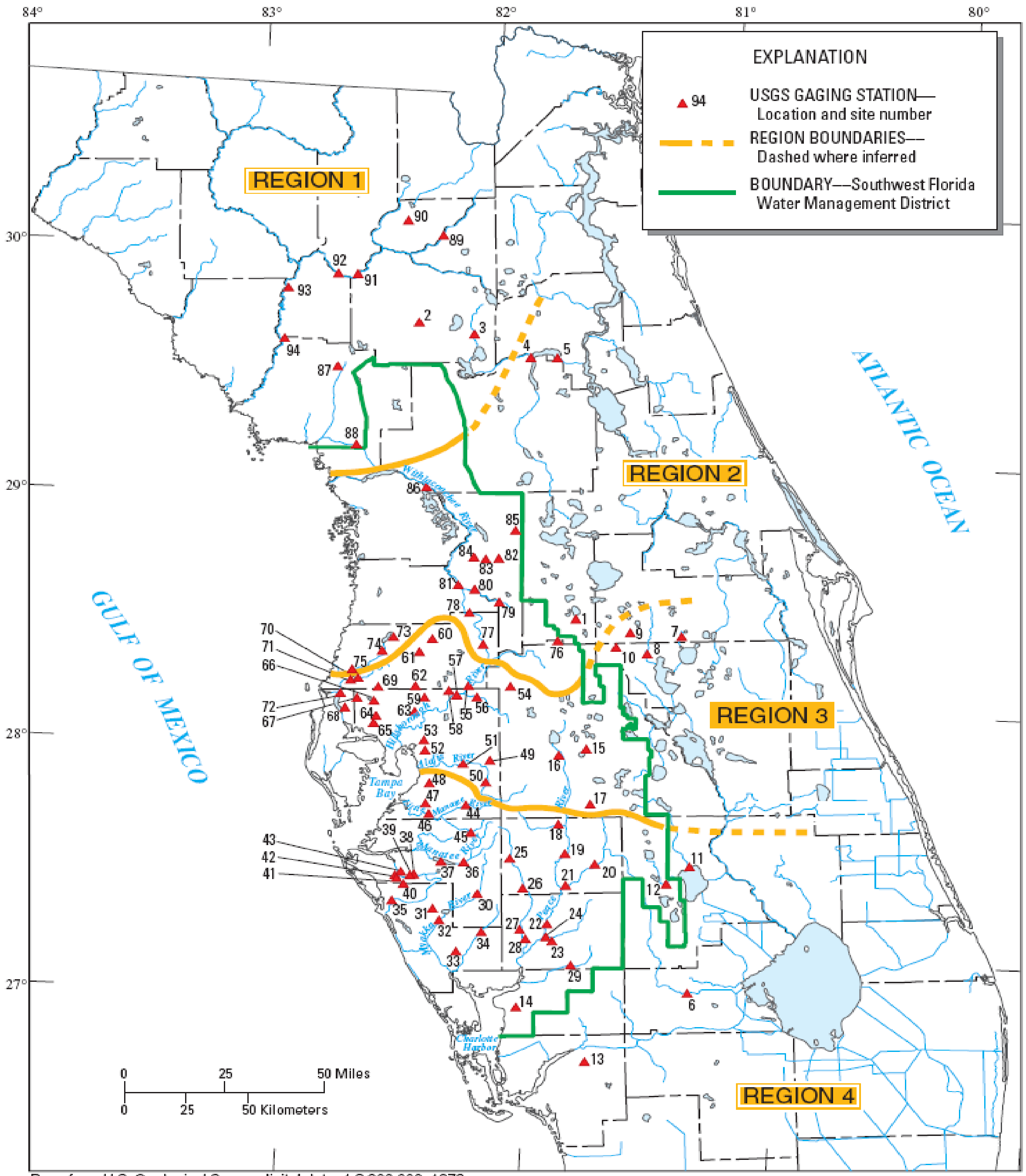
Table B-16: Urban Watershed Regression Equations for Leon County, Florida

Peak Runoff Equation: Outside Lake Lafayette Basin	Peak Runoff Equation: Inside Lake Lafayette Basin	R^2	Standard Error in %
$Q_2 = 10.7\ A^{0.766}\ IA^{1.07}$	$Q_2\ (LL) = 1.71\ A^{0.766}\ IA^{1.07}$	0.99	18
$Q_5 = 24.5\ A^{0.770}\ IA^{0.943}$	$Q_5\ (LL) = 4.51\ A^{0.770}\ IA^{0.943}$	0.98	18
$Q_{10} = 39.1\ A^{0.776}\ IA^{0.867}$	$Q_{10}\ (LL) = 7.98\ A^{0.776}\ IA^{0.867}$	0.98	20
$Q_{25} = 63.2\ A^{0.787}\ IA^{0.791}$	$Q_{25}\ (LL) = 14.6\ A^{0.787}\ IA^{0.791}$	0.98	22
$Q_{50} = 88.0\ A^{0.797}\ IA^{0.736}$	$Q_{50}\ (LL) = 22.1\ A^{0.797}\ IA^{0.736}$	0.97	24
$Q_{100} = 118\ A^{0.808}\ IA^{0.687}$	$Q_{100}\ (LL) = 32.4\ A^{0.808}\ IA^{0.687}$	0.97	25
$Q_{500} = 218\ A^{0.834}\ IA^{0.589}$	$Q_{500}\ (LL) = 71.7\ A^{0.834}\ IA^{0.589}$	0.97	30

Q_T = Peak runoff rate outside Lake Lafayette Basin for return period T, in cfs.
A = Drainage area, in $miles^2$
IA = Impervious area, in percentage of drainage area.
Q_T (LL) = Peak runoff rate inside Lake Lafayette Basin for return period T, in cfs.

Watershed Characteristic	Range of Applicability
Drainage Area	0.26 $miles^2$ (166 acres) to 15.9 $miles^2$
Impervious area	5.8 to 54 %
Channel slope	11.9 to 128 ft/mile
Basin development factor	0 to 8 (dimensionless)
Main Channel Length	0.58 to 6.50 miles
Storage (area of ponds, lakes, swamps)	0 to 4.26 percent

Reference: Franklin and Losey (1984).



Base from U.S. Geological Survey digital data, 1:2,000,000, 1972
Albers Equal-Area Conic projection
Standard Parallels 29°30′ and 45°30′, central meridian –83°00′

Reference: Hammett and DelCharco (2001).

Figure B-5: Regions for USGS Regression Equations for Natural Flow Conditions in West Central Florida

Table B-17: USGS Watershed Regression Equations for West Central Florida

Regression equations	Standard error of model, SE_m (percent)	SE_m (+percent)	SE_m (– percent)	Average standard error of prediction (ASEP) (percent)	Equivalent length of record (years)
Region 1					
$Q_2 = 132\ (DA)^{0.528}\ (LK+0.6)^{-0.542}$	57.9	71.2	-41.6	69	1.35
$Q_5 = 267\ (DA)^{0.510}\ (LK+0.6)^{-0.534}$	50.3	60.8	-37.8	60	2.29
$Q_{10} = 389\ (DA)^{0.500}\ (LK+0.6)^{-0.535}$	48.3	58.0	-36.7	58	3.27
$Q_{25} = 583\ (DA)^{0.489}\ (LK+0.6)^{-0.540}$	47.1	56.5	-36.1	57	4.64
$Q_{50} = 760\ (DA)^{0.481}\ (LK+0.6)^{-0.545}$	46.9	56.2	-36.0	58	5.64
$Q_{100} = 965\ (DA)^{0.474}\ (LK+0.6)^{-0.550}$	47.0	56.4	-36.1	58	6.58
$Q_{200} = 1{,}200\ (DA)^{0.467}\ (LK+0.6)^{-0.557}$	47.4	56.9	-36.3	59	7.43
$Q_{500} = 1{,}562\ (DA)^{0.460}\ (LK+0.6)^{-0.566}$	48.4	58.2	-36.8	61	8.41
Region 2					
$Q_2 = 2.03\ (DA)^{1.065}\ (LK+3.0)^{-0.259}\ (SL)^{-0.017}$	57.3	70.3	-41.3	68	1.98
$Q_5 = 5.82\ (DA)^{1.023}\ (LK+3.0)^{-0.339}\ (SL)^{0.149}$	54.9	67.1	-40.1	65	2.58
$Q_{10} = 9.84\ (DA)^{0.999}\ (LK+3.0)^{-0.371}\ (SL)^{0.226}$	54.7	66.7	-40.0	65	3.34
$Q_{25} = 17.0\ (DA)^{0.972}\ (LK+3.0)^{-0.398}\ (SL)^{0.298}$	54.3	66.3	-39.9	66	4.48
$Q_{50} = 24.1\ (DA)^{0.953}\ (LK+3.0)^{-0.412}\ (SL)^{0.339}$	54.0	65.8	-39.7	66	5.39
$Q_{100} = 32.7\ (DA)^{0.936}\ (LK+3.0)^{-0.423}\ (SL)^{0.372}$	53.5	65.2	-39.5	66	6.34
$Q_{200} = 42.8\ (DA)^{0.921}\ (LK+3.0)^{-0.432}\ (SL)^{0.400}$	52.9	64.4	-39.2	66	7.31
$Q_{500} = 58.7\ (DA)^{0.903}\ (LK+3.0)^{-0.440}\ (SL)^{0.428}$	52.3	63.5	-38.8	66	8.59
Region 3					
$Q_2 = 21.0\ (DA)^{0.890}\ (LK+3.0)^{-0.601}\ (SL)^{0.452}$	54.6	66.7	-40.0	60	1.99
$Q_5 = 54.0\ (DA)^{0.841}\ (LK+3.0)^{-0.593}(SL)^{0.374}$	49.1	59.1	-37.2	54	3.02
$Q_{10} = 87.2\ (DA)^{0.819}\ (LK+3.0)^{-0.594}\ (SL)^{0.338}$	49.9	60.2	-37.6	56	3.85
$Q_{25} = 140\ (DA)^{0.799}\ (LK+3.0)^{-0.593}\ (SL)^{0.308}$	52.6	63.9	-39.0	59	4.74
$Q_{50} = 186\ (DA)^{0.789}\ (LK+3.0)^{-0.591}\ (SL)^{0.294}$	55.2	67.4	-40.3	62	5.27
$Q_{100} = 236\ (DA)^{0.782}\ (LK+3.0)^{-0.588}(SL)^{0.284}$	57.9	71.3	-41.6	66	5.69
$Q_{200} = 289\ (DA)^{0.776}\ (LK+3.0)^{-0.584}\ (SL)^{0.278}$	60.9	75.4	-43.0	69	6.02
$Q_{500} = 364\ (DA)^{0.771}\ (LK+3.0)^{-0.578}\ (SL)^{0.274}$	64.9	80.9	-44.7	74	6.36
Region 4					
$Q_2 = 62.3\ (DA)^{0.661}\ (LK+3.0)^{-0.367}\ (SL)^{0.497}$	36.3	42.1	-29.6	40	3.86
$Q_5 = 127\ (DA)^{0.669}\ (LK+3.0)^{-0.435}\ (SL)^{0.493}$	35.9	41.7	-29.4	40	5.44
$Q_{10} = 182\ (DA)^{0.678}\ (LK+3.0)^{-0.474}\ (SL)^{0.495}$	37.0	43.1	-30.1	42	6.91
$Q_{25} = 262\ (DA)^{0.691}\ (LK+3.0)^{-0.514}\ (SL)^{0.502}$	38.9	45.6	-31.3	45	8.65
$Q_{50} = 326\ (DA)^{0.701}\ (LK+3.0)^{-0.538}\ (SL)^{0.508}$	40.7	47.9	-32.4	47	9.74
$Q_{100} = 394\ (DA)^{0.712}\ (LK+3.0)^{-0.559}\ (SL)^{0.513}$	42.6	50.5	-33.5	50	10.62
$Q_{200} = 465\ (DA)^{0.722}\ (LK+3.0)^{-0.576}\ (SL)^{0.519}$	44.7	53.2	-34.7	52	11.33
$Q_{500} = 562\ (DA)^{0.736}\ (LK+3.0)^{-0.595}\ (SL)^{0.527}$	47.6	57.1	-36.4	56	12.04

Reference: Hammett and DelCharco (2001).
See Figure B-5 for Region delineation.

Table B-18: USGS Watershed Regression Equations' Range of Applicability for West Central Florida

Basin characteristic	Region 1	Region 2	Region 3	Region 4
Drainage area (square miles)	18.5 – 9,640	28.6 – 2,100	4.43 – 390	0.94 – 330
Slope (feet per mile)	0.51 – 23.5	0.09 – 3.6	0.41 – 9.8	1.02 – 7.52
Lake area (percent)	0.03 – 8.67	0 – 26.35	0 – 27.5	0 – 19.3

Reference: Hammett and DelCharco (2001).