APPENDIX B

Hydrologic Tables and Graphs

Table B-1: Sheet flow "n" Values and "k" Values Used in Time Calculations for Hydrographs

"n_s" Sheet Flow Equation Manning's Values (for the initial 300 feet of travel)	n_s*
Smooth surfaces (concrete, asphalt, gravel, or bare hand packed soil)	0.011
Fallow fields or loose soil surface (no residue)	0.05
Cultivated soil with residue cover (s≤ 0.20 ft/ft)	0.06
Cultivated soils with residue cover (s> 0.20 ft/ft)	0.17
Short prairie grass and lawns	0.15
Dense grasses	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods or forest with light underbrush	0.40
Woods or forest with dense underbrush	0.80

*Manning values for sheet flow only, from Overton and Meadows 1976 (See TR-55, 1986)

"k" Values Used in Travel Time/Time of Concentration Calculations

Shallow Concentrated Flow (After the initial 300 feet of sheet flow, R = 0.1)	k_s
1. Forest with heavy ground litter and meadows (n = 0.10)	3
2. Brushy ground with some trees (n = 0.060)	5
3. Fallow or minimum tillage cultivation (n = 0.040)	8
4. High grass (n = 0.035)	9
5. Short grass, pasture and lawns (n = 0.030)	11
6. Nearly bare ground (n = 0.25)	13
7. Paved and gravel areas (n = 0.012)	27

Channel Flow (intermittent) (At the beginning of visible channels R = 0.2)	k_c
1. Forested swale with heavy ground litter (n = 0.10)	5
2. Forested drainage course/ravine with defined channel bed (n = 0.050)	10
3. Rock-lined waterway (n = 0.035)	15
4. Grassed waterway (n = 0.030)	17
5. Earth-lined waterway (n = 0.025)	20
6. CMP pipe (n = 0.024)	21
7. Concrete pipe (0.012)	42
8. Other waterways and pipe	0.508/n

Channel Flow (Continuous stream, R = 0.4)	k_c
9. Meandering stream with some pools (n = 0.040)	20
10. Rock-lined stream (n = 0.035)	23
11. Grass-lined stream (n = 0.030)	27
12. Other Stream, man-made channels and pipe	0.807/n

Reference: DOE Stormwater Management Manual for the Puget Sound Basin, February 1992.

Table B-2: Values of the Open Channel Roughness Coefficient, "n"

Type of Channel and Description	Manning's "n"
A. Constructed Channels	
a. Earth, straight and uniform	
1. Clean, recently completed	0.018
2. Gravel, uniform section, clean	0.025
3. With short grass, few weeds	0.027
b. Earth, winding and sluggish	
1. No vegetation	0.025
2. Grass, some weeds	0.030
3. Dense weeds or aquatic plants in deep channels	0.035
4. Earth bottom and rubble sides	0.030
5. Stony bottom and weedy banks	0.035
6. Cobble bottom and clean sides	0.040
c. Rock lined	
1. Smooth and uniform	0.035
2. Jagged and irregular	0.040
d. Channels not maintained, weeds and brush uncut	
1. Dense weeds, high as flow depth	0.080
2. Clean bottom, brush on sides	0.050
3. Same as above, highest stage of flow	0.070
4. Dense brush, high stage	0.100
B. Natural Streams	
B-1 Minor streams (top width at flood stage < 100 ft.)	
a. Streams on plain	
1. Clean, straight, full stage no rifts or deep pools	0.030
2. Same as above, but more stones and weeds	0.035
3. Clean, winding, some pools and shoals	0.040
4. Same as above, but some weeds	0.040
5. Same as 4, but more stones	0.050
6. Sluggish reaches, weedy deep pools	0.070
7. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.100

Type of Channel and Description	Manning's "n"
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages	
1. Bottom: gravel, cobbles, and few boulders	0.040
2. Bottom: cobbles with large boulders	0.050
B-2 Flood plains	
a. Pasture, no brush	
1. short grass	0.030
2. High grass	0.035
b. Cultivated areas	
1. No crop	0.030
2. Mature row crops	0.035
3. Mature field crops	0.040
c. Brush	
1. Scattered brush, heavy weeds	0.050
2. Light brush and trees	0.060
3. Medium to dense brush	0.070
4. Heavy, dense brush	0.100
d. Trees	
1. Dense willows, straight	0.150
2. Cleared land with tree stumps, no sprouts	0.040
3. Same as above, but with heavy growth of sprouts	0.060
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.100
5. Same as above, but with flood stage reaching branches	0.120

Reference: DOE Stormwater Management Manual for Puget Sound Basin, February 1992

Table B-3: 24-hour Design Storm Hyetograph Values

Time (hours)	Time (minutes)	Percent Rainfall	Cumulative Percent Rainfall
0.0	0	0.0	0.0
	10	0.4	0.4
	20	0.4	0.8
	30	0.4	1.2
	40	0.4	1.6
	50	0.4	2.0
1.0	60	0.4	2.4
	70	0.4	2.8
	80	0.4	3.2
	90	0.4	3.6
	100	0.4	4.0
	110	0.5	4.5
2.0	120	0.5	5.0
	130	0.5	5.5
	140	0.5	6.0
	150	0.5	6.5
	160	0.5	7.0
	170	0.6	7.6
3.0	180	0.6	8.2
	190	0.6	8.8
	200	0.6	9.4
	210	0.6	10.0
	220	0.6	10.6
	230	0.7	11.3
4.0	240	0.7	12.0
	250	0.7	12.7
	260	0.7	13.4
	270	0.7	14.1
	280	0.7	14.8
	290	0.8	15.6
5.0	300	0.8	16.4
	310	0.8	17.3
	320	0.8	18.1
	330	0.8	18.9
	340	0.8	19.7
	350	1.0	20.7
6.0	360	1.0	21.6
	370	1.0	22.6
	380	1.0	23.5
	390	1.0	24.5
	400	1.0	25.4
	410	1.3	26.8

Time (hours)	Time (minutes)	Percent Rainfall	Cumulative Percent Rainfall
7.0	420	1.3	28.1
	430	1.3	29.4
	440	1.8	31.2
	450	1.8	33.0
	460	3.4	36.4
	470	5.4	41.8
8.0	480	2.7	44.5
	490	1.8	46.3
	500	1.3	47.7
	510	1.3	49.0
	520	1.3	50.4
	530	0.9	51.2
9.0	540	0.9	52.1
	550	0.9	53.0
	560	0.9	53.9
	570	0.9	54.8
	580	0.9	55.6
	590	0.9	56.5
10.0	600	0.9	57.4
	610	0.9	58.3
	620	0.9	59.2
	630	0.9	60.0
	640	0.9	60.9
	650	0.7	61.6
11.0	660	0.7	62.4
	670	0.7	63.1
	680	0.7	63.8
	690	0.7	64.5
	700	0.7	65.2
	710	0.7	66.0
12.0	720	0.7	66.7
	730	0.7	67.4
	740	0.7	68.1
	750	0.7	68.8
	760	0.7	69.6
	770	0.6	70.1
13.0	780	0.6	70.7
	790	0.6	71.3
	800	0.6	71.8
	810	0.6	72.4
	820	0.6	73.0
	830	0.6	73.6

Table B-3: 24-hour Design Storm Hyetograph Values (continued)

Time (hours)	Time (minutes)	Percent Rainfall	Cumulative Percent Rainfall
14.0	840	0.6	74.1
	850	0.6	74.7
	860	0.6	75.3
	870	0.6	75.8
	880	0.6	76.4
	890	0.5	76.9
15.0	900	0.5	77.4
	910	0.5	77.9
	920	0.5	78.4
	930	0.5	78.9
	940	0.5	79.4
	950	0.5	79.9
16.0	960	0.5	80.4
	970	0.5	80.9
	980	0.5	81.4
	990	0.5	81.9
	1000	0.5	82.4
	1010	0.4	82.8
17.0	1020	0.4	83.2
	1030	0.4	83.6
	1040	0.4	84.0
	1050	0.4	84.4
	1060	0.4	84.8
	1070	0.4	85.2
18.0	1080	0.4	85.6
	1090	0.4	86.0
	1100	0.4	86.4
	1110	0.4	86.8
	1120	0.4	87.2
	1130	0.4	87.6
19.0	1140	0.4	88.0
	1150	0.4	88.4
	1160	0.4	88.8
	1170	0.4	89.2
	1180	0.4	89.6
	1190	0.4	90.0
20.0	1200	0.4	90.4
	1210	0.4	90.8
	1220	0.4	91.2
	1230	0.4	91.6
	1240	0.4	92.0
	1250	0.4	92.4

Time (hours)	Time (minutes)	Percent Rainfall	Cumulative Percent Rainfall
21.0	1260.0	0.4	92.8
	1270.0	0.4	93.2
	1280.0	0.4	93.6
	1290.0	0.4	94.0
	1300.0	0.4	94.4
	1310.0	0.4	94.8
22.0	1320.0	0.4	95.2
	1330.0	0.4	95.6
	1340.0	0.4	96.0
	1350.0	0.4	96.4
	1360.0	0.4	96.8
	1370.0	0.4	97.2
23.0	1380.0	0.4	97.6
	1390.0	0.4	98.0
	1400.0	0.4	98.4
	1410.0	0.4	98.8
	1420.0	0.4	99.2
	1430.0	0.4	99.6
24.0	1440.0	0.4	100.0

Figure B-1: 24 Hour Hyetograph
SCS Type 1A Distribution
Resolved to 10 Minute Time Steps

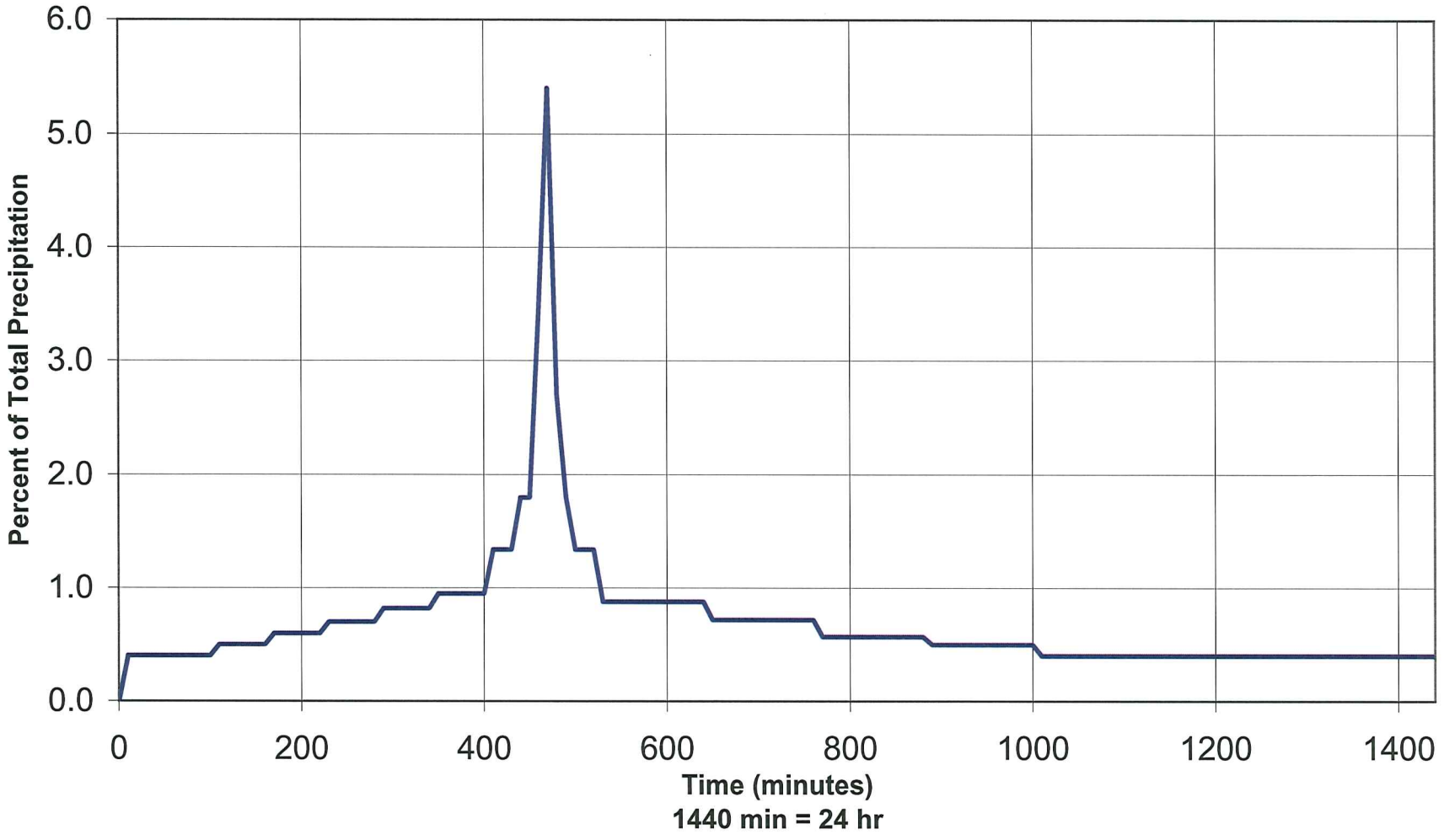

Figure B-2

Isopluvial Maps for Design Storms in Clark County

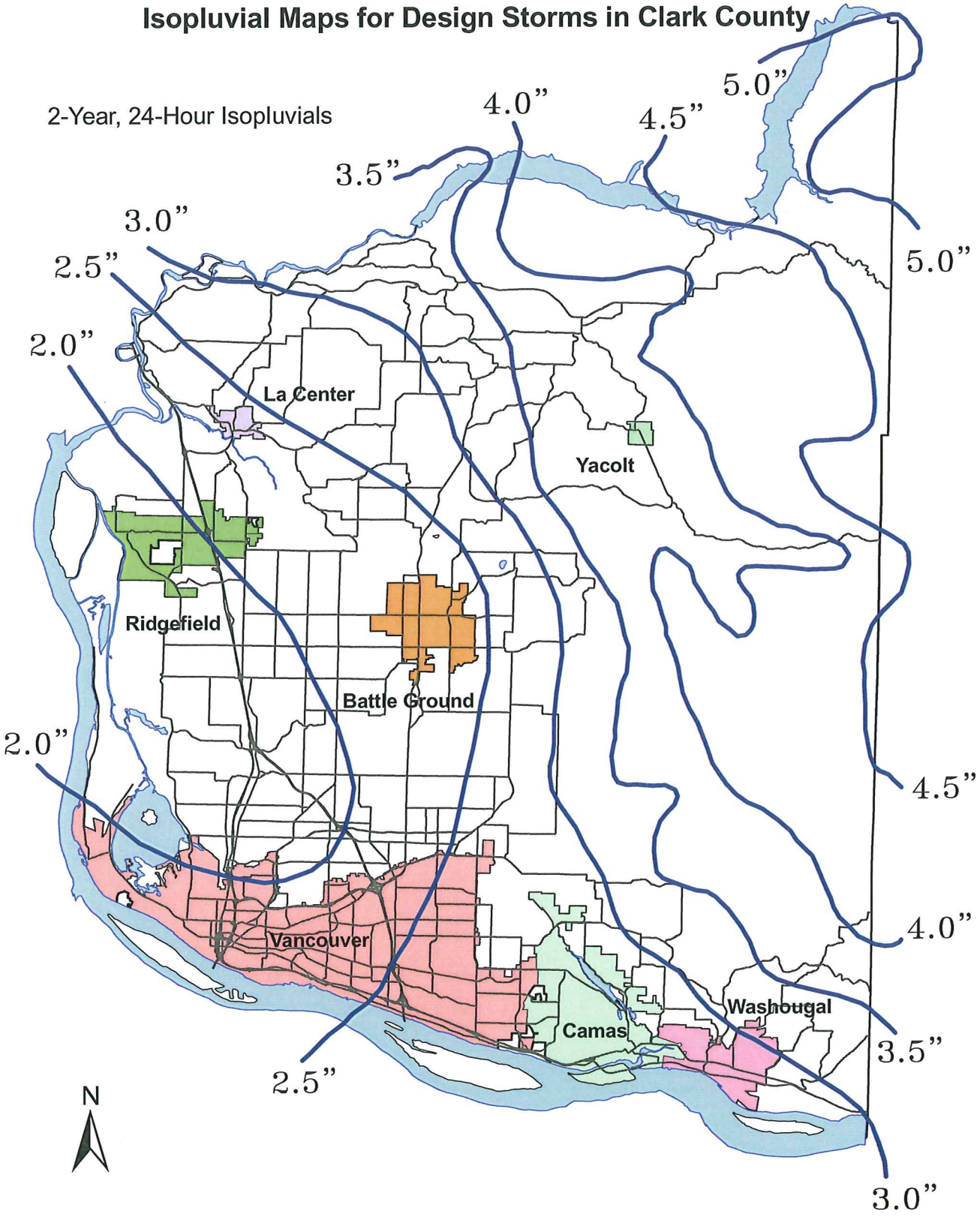

Figure B-3

Isopluvial Maps for Design Storms in Clark County

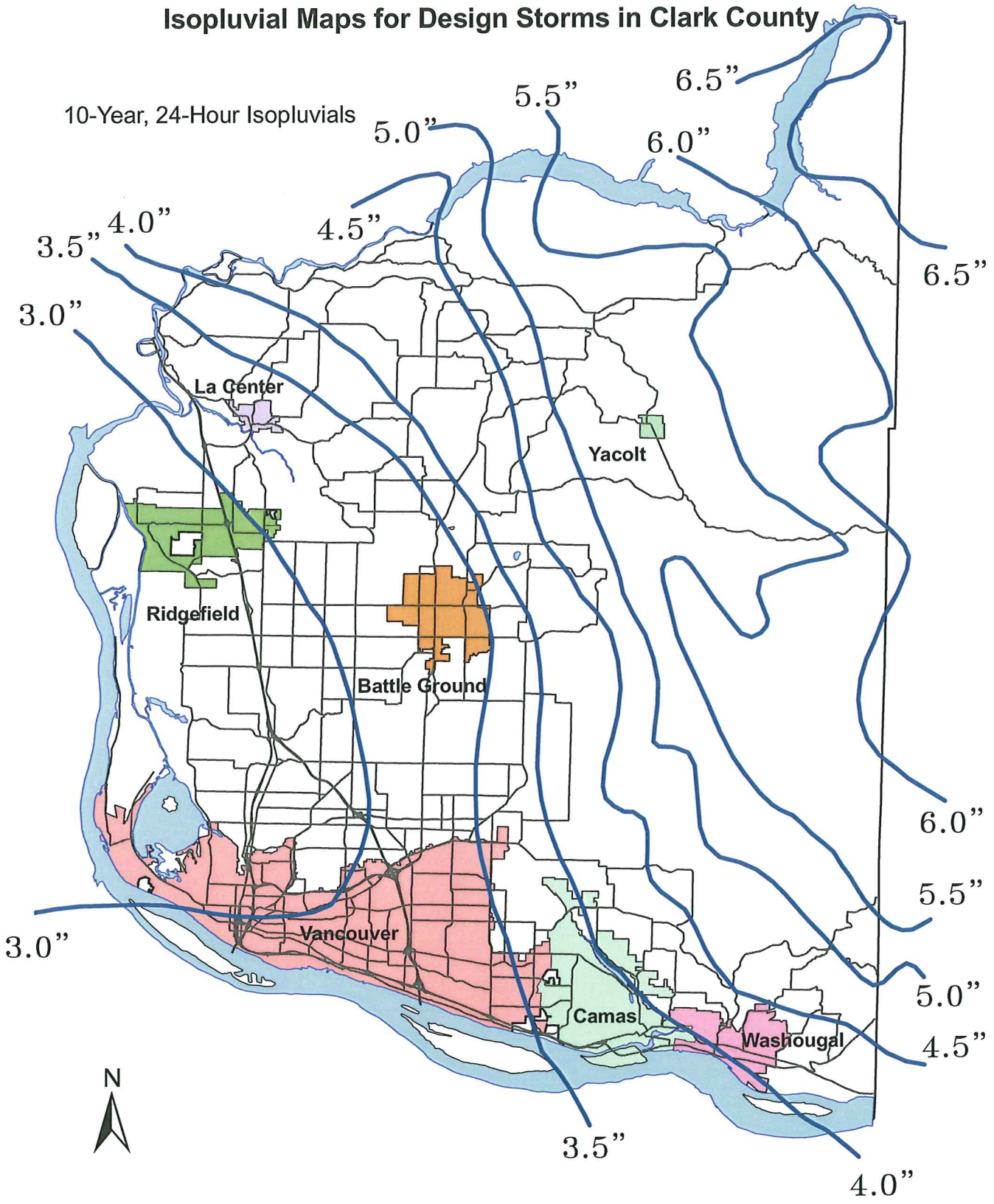

Figure B-4

Isopluvial Maps for Design Storms in Clark County

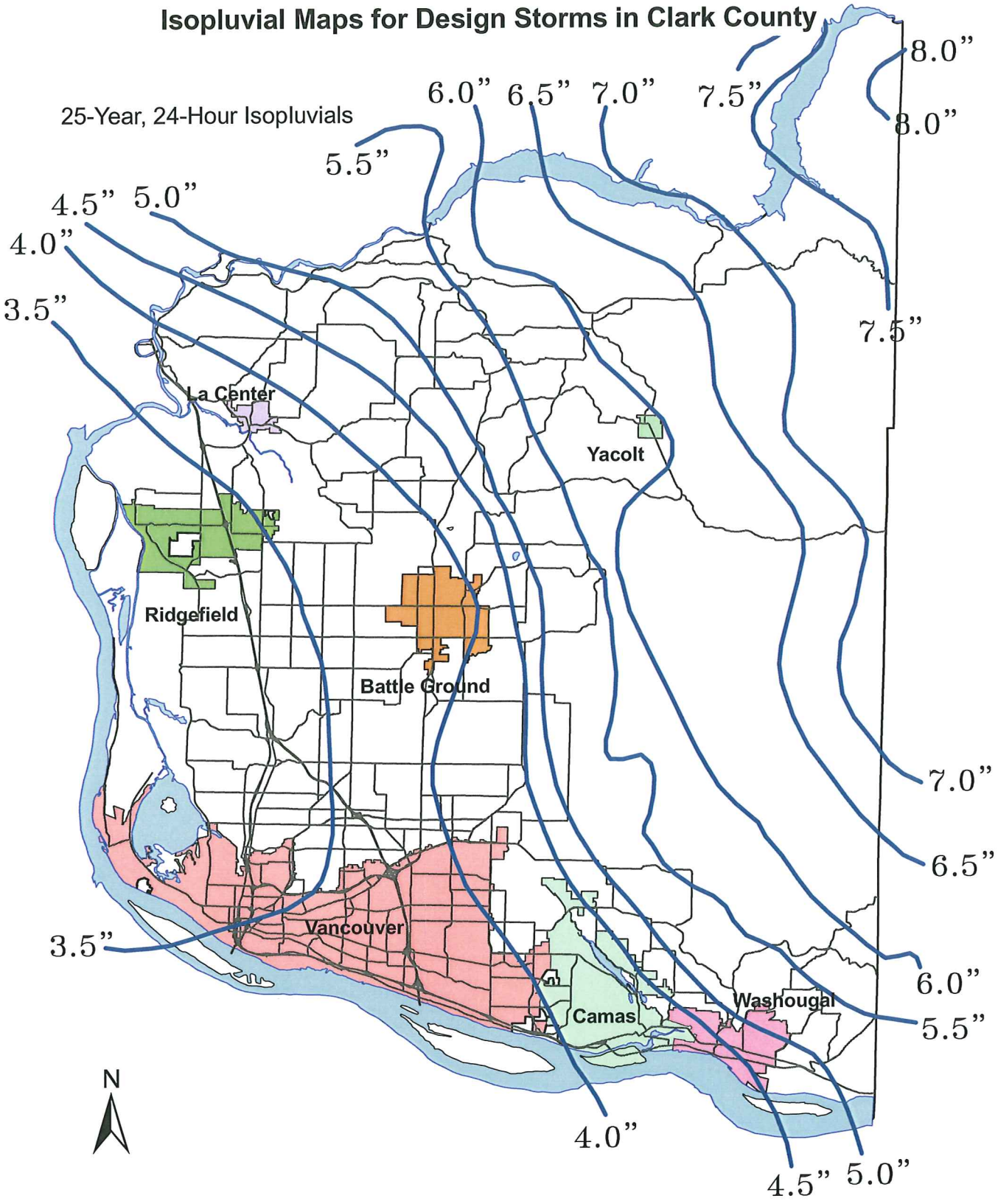

Figure B-5

Isopluvial Maps for Design Storms in Clark County

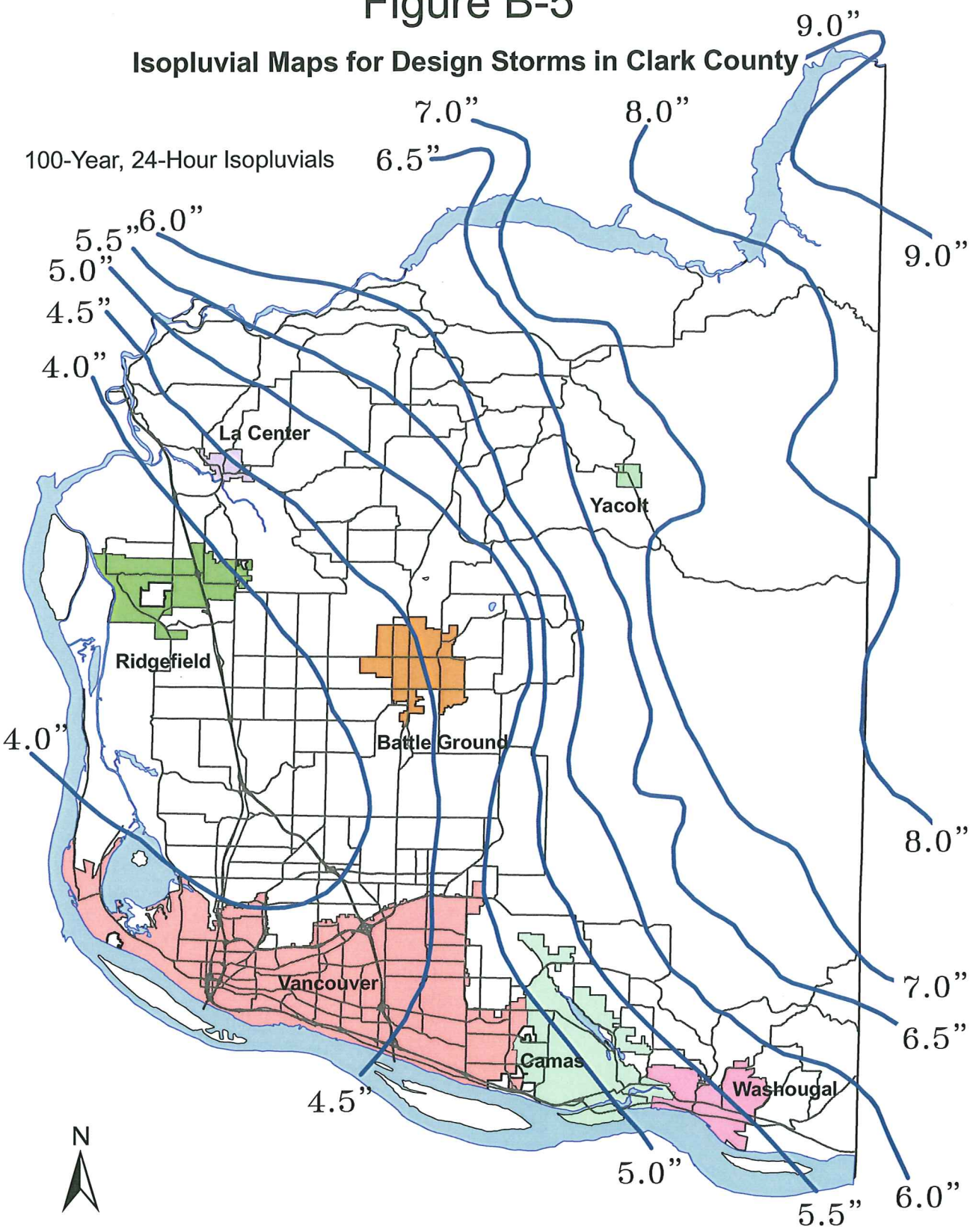

Table B-4: Hydrologic Soil Groups for Soils in Clark County

U.S. Department of Agriculture
Soil Conservation Service

WATER FEATURES

Survey Area - CLARK COUNTY, WASHINGTON

Map Symbol	Soil Name	Hydrologic Group
BpB	BEAR PRARIE	B
BpC	BEAR PRARIE	B
CnB	CINEBAR	B
CnD	CINEBAR	B
CnE	CINEBAR	B
CnG	CINEBAR	B
CrE	CINEBAR	B
CrG	CINEBAR	B
CsF	CISPUS	B
CtA	CLOQUATO	B
CvA	COVE	D
CwA	COVE	D
DoB	DOLLAR	C
Fn	FILL LAND	In-situ
GeB	GEE	C
GeD	GEE	C
GeE	GEE	C
GeF	GEE	C
GuB	GUMBOOT	D
HcB	HESSON	C
HcD	HELLSON	C
HcE	HESSON	C
HcF	HESSON	C
HgB	HESSON	C
HgD	HESSON	C
HhE	HESSON	C
HIA	HILLSBORO	B
HIB	HILLSBORO	B
HIC	HILLSBORO	B
HID	HILLSBORO	B
HIE	HILLSBORO	B
HIF	HILLSBORO	B
HoA	HILLSBORO	B
HoB	HILLSBORO	B

Table B-4 (continued)

Map Symbol	Soil Name	Hydrologic Group
HoC	HILLSBORO	B
HoD	HILLSBORO	B
HoE	HILLSBORO	B
HoG	HILLSBORO	B
HsB	HILLSBORO	B
HtA	HOCKINSON	D
HuB	HOCKINSON	D
HvA	HOCKINSON	D
KeC	KINNEY	B
KeE	KINNEY	B
KeF	KINNEY	B
KnF	KINNEY	B
LaE	LARCHMOUNT	B
LaG	LARCHMOUNT	B
LcG	LARCHMOUNT	B
LeB	LAUREN	B
LgB	LAUREN	B
LgD	LAUREN	B
LgF	LAUREN	B
LIB	LAUREN	B
LrC	LAUREN	C
LrF	LAUREN	C
McB	McBEE	C
MeA	McBEE	C
MIA	McBEE	C
MnA	MINNIECE	D
MnD	MINNIECE	D
MoA	MINNIECE VARIANT	D
MsB	MOSSYROCK	B
NbA	NEWBERG	B
NbB	NEWBERG	B
OdB	ODNE	D
OeD	OLEQUA	B
OeE	OLEQUA	B
OeF	OLEQUA	B
OhD	OLEQUA VARIANT	C
OhF	OLEQUA VARIANT	C
OIB	OLYMPIC	B
OID	OLYMPIC	B
OIE	OLYMPIC	B

Table B-4 (continued)

Map Symbol	Soil Name	Hydrologic Group
OIF	OLYMPIC	B
OmE	OLYMPIC	B
OmF	OLYMPIC	B
OpC	OLYMPIC VARIANT	C
OpE	OLYMPIC VARIANT	C
OpG	OLYMPIC VARIANT	C
OrC	OLYMPIC VARIANT	C
PhB	PILCHUCK	C
PoB	POWELL	C
PoD	POWELL	C
PoE	POWELL	C
PuA	PUYALLUP	B
Ra	RIVERWASH	D
Rc	RIVERWASH	D
Rk	ROCK LAND	D
Ro	ROUGH BROKEN LAND	A
SaC	SALKUM	B
SIB	SARA	D
SID	SARA	D
SIF	SARA	D
SmA	SAUVIE	B
SmB	SAUVIE	B
SnA	SAUVIE	D
SpB	SAUVIE	B
Sr	SEMIAHMOO	C
Su	SEMIAHMOO VARIANT	D
SvA	SIFTON	B
ThA	TISCH	D
VaB	VADER	B
VaC	VADER	B
WaA	WASHOUGAL	B
WgB	WASHOUGAL	B
WgE	WASHOUGAL	B
WhF	WASHOUGAL	B
WnB	WIND RIVER VARIANT	B
WnD	WIND RIVER VARIANT	B
WnG	WIND RIVER VARIANT	B
WrB	WIND RIVER VARIANT	B
WrF	WIND RIVER VARIANT	B
YaA	YACOLT	B

Table B-4 (continued)

Map Symbol	Soil Name	Hydrologic Group
YaC	YACOLT	B
YcB	YACOLT	B

Table B-5: Runoff Coefficients for the Rational Method			
Type of Cover	Flat	Rolling 2% - 10%	Hilly Over 10%
Pavement and Roofs	0.90	0.90	0.90
Earth Shoulders	0.50	0.50	0.50
Drives and Walks	0.75	0.80	0.85
Gravel Pavement	0.50	0.55	0.60
City Business Areas	0.80	0.85	0.85
Suburban Residential	0.25	0.35	0.40
Single Family Residential	0.30	0.40	0.50
Multi Units, Detached	0.40	0.50	0.60
Multi Units, Attached	0.60	0.65	0.70
Lawns, Very Sandy Soil	0.05	0.07	0.10
Lawns, Sandy Soil	0.10	0.15	0.20
Lawns, Heavy Soil	0.17	0.22	0.35
Grass Shoulders	0.25	0.25	0.25
Side Slopes, Earth	0.60	0.60	0.60
Side Slopes, Turf	0.30	0.30	0.30
Median Areas, Turf	0.25	0.30	0.30
Cultivated Land, Clay and Loam	0.50	0.55	0.60
Cultivated Land, Sand and Gravel	0.25	0.30	0.35
Industrial Areas, Light	0.50	0.70	0.80
Industrial Areas, Heavy	0.60	0.80	0.90
Parks and Cemeteries	0.10	0.15	0.25
Playgrounds	0.20	0.25	0.30
Woodland and Forests	0.10	0.15	0.20
Meadows and Pasture Land	0.25	0.30	0.35
Pasture with Frozen Ground	0.40	0.45	0.50
Unimproved Areas	0.10	0.20	0.30

Figure B-6: Vancouver - La Center - Battle Ground - Camas
Intensity-Duration-Frequency Curves

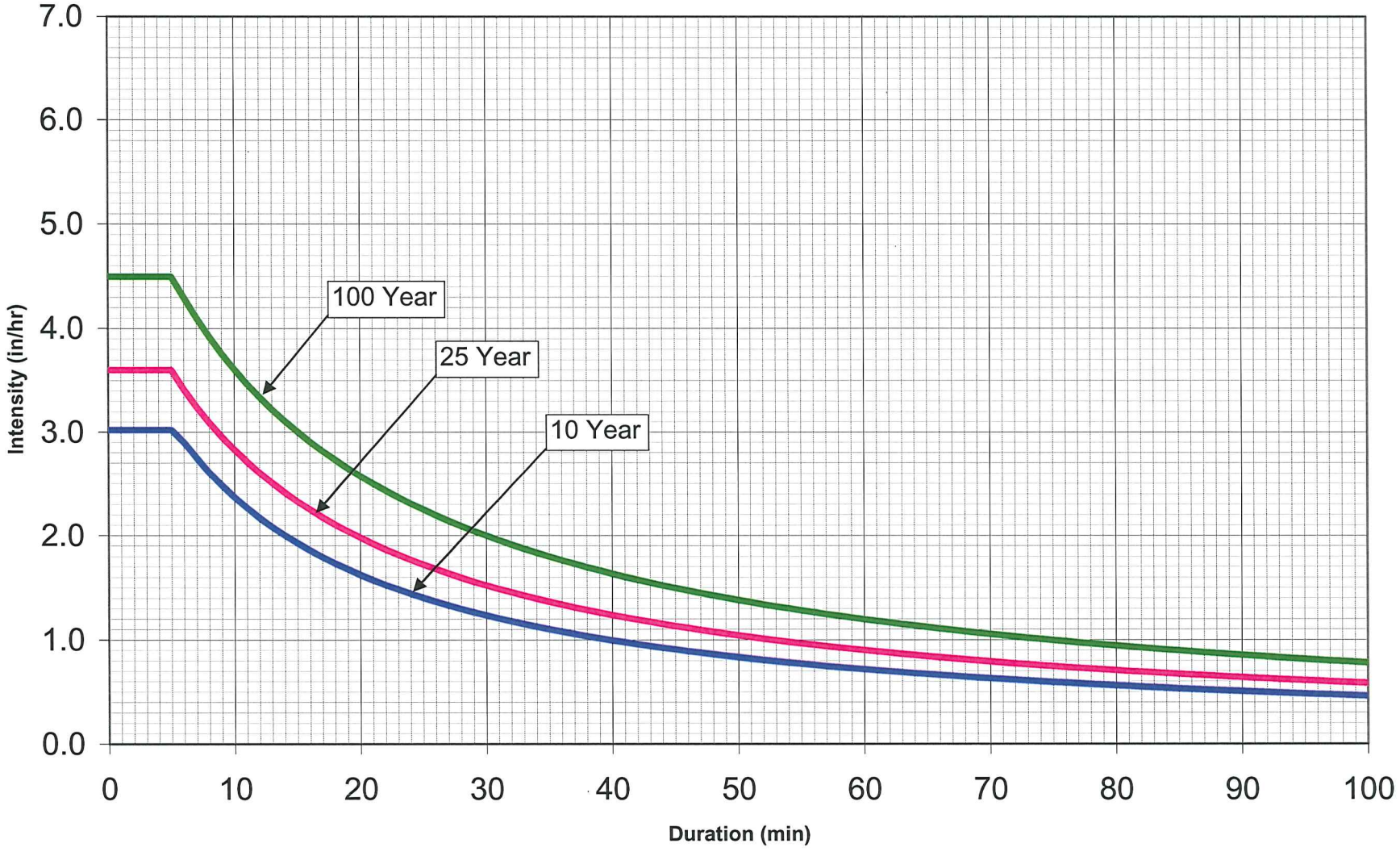

Figure B-7: Yacolt - Amboy - Chelatchie
Intensity-Duration-Frequency Curves

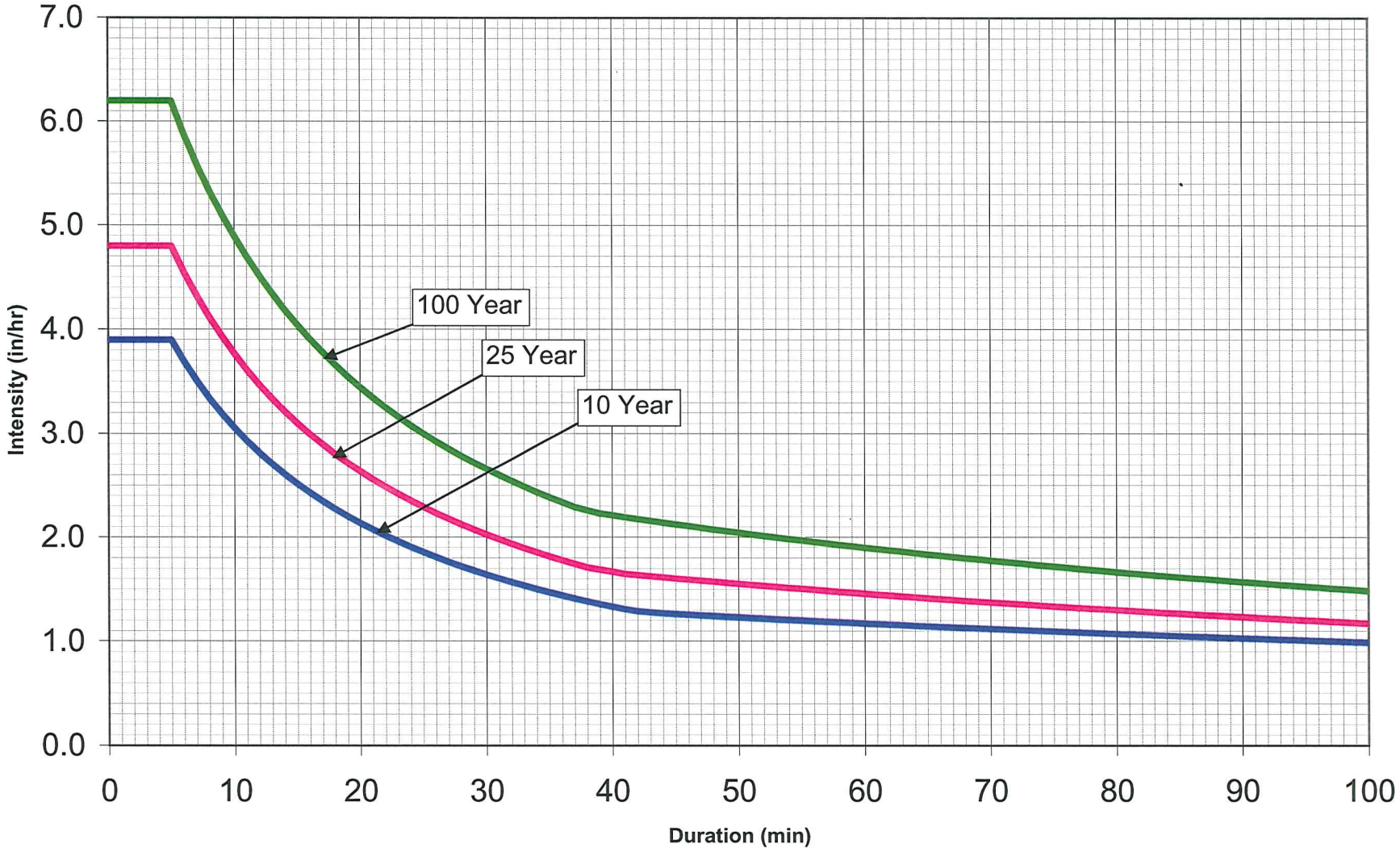

Figure B-8: Ridgefield
Intensity-Duration-Frequency Curves