VA650.290 Purpose of Virginia Supplement

The purpose of this supplement is to assist Area and Field staff in utilizing the most current rainfall data available, National Oceanic and Atmospheric Administration Atlas 14 (NOAA 14), for the design of conservation practices. This supplement updates the rainfall depths, rainfall distribution types, and soils to be used in estimating runoff and peak discharges as described in NEH Part 650, Engineering Field Handbook Chapter 2 (EFH-2). This supplement updates rainfall and soils databases that are used by the computer program, EFH-2. This supplement releases the statewide GIS shapefile for design rainfall data (depths and types).

This supplement describes the implementation process, the technical background, and gives an example application of the rainfall data in the computer program, EFH-2.

VA650.291 Implementation of Virginia Supplement

Effective upon receipt, NRCS Area and Field staff are to use the updated rainfall depths, rainfall distribution types, and soils when estimating runoff and peak discharges described in NEH 650, Chapter 2. The implementation is in three parts, (1) updating NEH 650, Chapter 2 for Virginia; (2) updating the databases for the EFH-2 computer program; and (3) providing a statewide GIS shapefile for design rainfall data on the Geodatabase server (F drive).

(1) The methods and data described in this supplement supersede any applicable methods and data from NEH 650, Chapter 2 for Virginia. The design rainfall table in Appendix VA650.29-1 and rainfall maps in Appendix VA650.29-5 supersedes all rainfall data in NEH 650, Chapter 2 for Virginia. The design rainfall data in Appendix VA650.29- 1 will replace rainfall depths from Weather Bureau Technical Paper 40 (TP-40) and the 2008 Virginia Supplement to NEH 650, Chapter 2. The new rainfall distribution types (NOAA A, NOAA B, NOAA C, NOAA D, and DMV C) in Appendix VA650.29- 1 will replace the standard NRCS rainfall types Type II and Type III.

(2) This supplement will be implemented by replacing the rainfall database (**COUNTY.VA**), rainfall distribution types (**type.rf**), and hydrologic soil group database (**SOILS. HG**) used with the EFH-2 computer program. An example application of the EFH-2 Computer Program in Virginia specific example is included in Appendix VA650.29- 2. The procedure for loading the updated rainfall and soils databases is presented in Appendix VA650.29- 2.

(3) This supplement releases the statewide GIS shapefiles for design rainfall data (depths and types). The statewide GIS shapefiles are located on the Geodatabase server (F drive).

VA650.292 Technical Background

NOAA completed Volume 2 of Atlas 14 (NOAA 14) precipitation-frequency analysis in 2004. This is the first comprehensive precipitation-frequency analysis for the Ohio Valley and neighboring states since TP-

40 was completed in 1961. NOAA used periods of record for rainfall stations up through December 2000 to compute precipitation-duration-frequency values. The period of record for TP-40 ended in 1958. This additional 42 years of data gives different frequency-duration rainfall values than TP-40. These values were updated in 2008 and again in 2012 for Virginia.

(a) Rainfall Depth

Representative county values for the 24-hour rainfall depths are presented in Appendix VA650.29- 1 of this Supplement. The rainfall depths are incorporated into the rainfall database for use with the EFH-2 computer program (**COUNTY.VA**).

The representative county values were determined from the NOAA 14 GIS grid. The location of the representative county value is near the mean of the 100-year 24-hour rainfall for the county or rainfall zone (explained below). If a more precise rainfall estimate is desired, site specific data may be downloaded from the NOAA 14 website. Data are available for specific locations from an interactive web site (http://hdsc.nws.noaa.gov/hdsc/pfds/ .

(b) Rainfall Zones

Rainfall in NOAA Atlas 14 can be highly variable even on a county basis, particularly in the Appalachian Mountains and Blue Ridge regions where orographic effects are present. For example, the Rockingham County 100-year 24-hour storm ranges from 6.07 inches to 10.48 inches. When the 100-year 24 hour rainfalls ranged more than 1.5 inches within a county, the county was split into rainfall zones. Fifteen counties are split into zones where two or more rainfall values are designated. Federal land, such as National Forests and National Parks, were excluded from the analysis. Appendix VA650.29- 5 of this Supplement contains county maps that designate the boundaries of the zones.

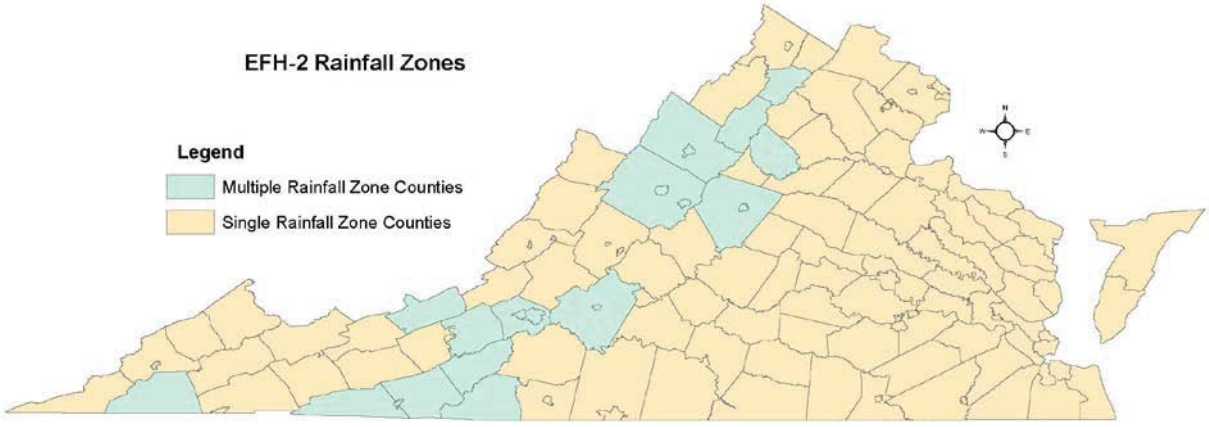


Figure VA2-1: EFH-2 Rainfall Zones for Virginia

(c) Rainfall Distribution Types

Four new rainfall distribution types (NOAA A, NOAA B, NOAA C, and NOAA D) were developed from the NOAA 14 data for the standard SCS unit hydrograph (dimensionless unit hydrograph peak factor of 484). Also the new rainfall type (DMV C) was developed for the Eastern Shore, part of the Delmarva Peninsula. Rainfall-runoff events on the Eastern Shore are better described by the DelMarVa unit hydrograph (dimensionless unit hydrograph peak factor of 284).

These new rainfall types replace the NRCS Type II and III in EFH-2 for Virginia. The Type II and III should no longer be used unless an old model needs to be recreated. Figure 2 displays appropriate rainfall distribution types to use per county and rainfall zone. The rainfall distribution type for each county and rainfall zone is presented in the table in Appendix VA650.29- 1 and the maps in Appendix VA650.29- 5 of this Supplement. The rainfall distribution type is developed for use with the EFH-2 computer program (**type.rf**).

The EFH-2 computer program is unable to use site specific rainfall types. Instead, EFH-2 uses equations to produce the unit peak discharge (cubic feet per second per inch of runoff per square mile of drainage area) from the time of concentration and excess runoff volume. The coefficients for these equations were developed for the five new rainfall types (NOAA A, NOAA B, NOAA C, NOAA D, and DMV C) from the NOAA 14 data. The equations, coefficients and plots for the five NOAA 14 rainfall distribution types are included in the **type.RF** file and described in this Supplement, Appendix VA650.29- 4.

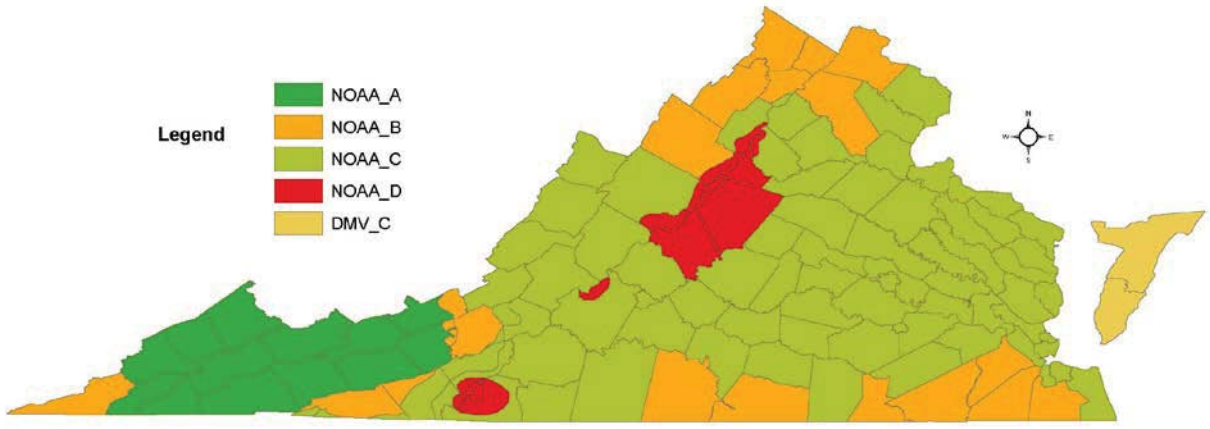


Figure VA2-2: EFH-2 Rainfall Distribution Types for Virginia

Appendix VA650.29-1. Rainfall Values and Distribution Types for each County and Rainfall Zone

Notes: Rainfall distribution type for each county and rainfall zone is shown with the county name (NOAA A, NOAA B, NOAA C, NOAA D, and DMV C). The 24-hour rainfall duration values are in units of inches.

County / Rainfall Zone	Rainfall Type	1-year	2-year	5-year	10-year	25-year	50-year	100-year
Accomack	DMV C	2.7	3.3	4.2	5.1	6.4	7.5	8.8
Albemarle ZONE-1	NOAA D	3.4	4.1	5.2	6.2	7.6	8.7	10.1
Albemarle ZONE-2	NOAA D	3	3.6	4.6	5.5	6.7	7.8	9
Alleghany	NOAA C	2.4	2.8	3.6	4.2	5	5.8	6.5
Amelia	NOAA C	2.7	3.3	4.2	5	6.1	7.1	8.2
Amherst	NOAA C	2.8	3.4	4.4	5.1	6.3	7.2	8.3
Appomattox	NOAA C	2.8	3.4	4.4	5.2	6.4	7.4	8.5
Augusta ZONE-1	NOAA C	2.4	3	3.7	4.4	5.3	6.1	6.9
Augusta ZONE-2	NOAA D	2.8	3.4	4.3	5.1	6.2	7.1	8.1
Bath NOAA-C	NOAA C	2.5	3	3.7	4.4	5.3	6	6.8
Bedford ZONE-1	NOAA D	3.1	3.8	4.8	5.7	7	8.1	9.3
Bedford ZONE-2	NOAA C	2.8	3.3	4.3	5	6.2	7.1	8.2
Bland	NOAA A	2.2	2.6	3.2	3.6	4.2	4.7	5.2
Botetourt	NOAA C	2.6	3.2	4.1	4.8	5.8	6.7	7.6
Brunswick	NOAA C	2.8	3.4	4.4	5.2	6.3	7.3	8.3
Buchanan	NOAA A	2.2	2.6	3.2	3.7	4.3	4.9	5.5
Buckingham	NOAA C	2.8	3.4	4.3	5.1	6.3	7.3	8.4
Campbell	NOAA C	2.7	3.3	4.3	5	6.2	7.2	8.3
Caroline	NOAA C	2.7	3.3	4.2	5	6.3	7.3	8.6
Carroll ZONE-1	NOAA B	2.3	2.7	3.4	4	4.8	5.5	6.1
Carroll ZONE-2	NOAA C	2.6	3.2	4	4.7	5.6	6.4	7.2
Carroll ZONE-3	NOAA C	3	3.6	4.6	5.3	6.5	7.5	8.5
Carroll ZONE-4	NOAA D	3.4	4.1	5.2	6.1	7.5	8.6	9.9
Charles City	NOAA C	2.8	3.4	4.4	5.2	6.5	7.6	8.8
Charlotte	NOAA C	2.7	3.3	4.2	5	6.1	7.1	8.1
Chesapeake City	NOAA B	3	3.7	4.8	5.7	7	8.2	9.4
Chesterfield	NOAA C	2.8	3.4	4.3	5.1	6.3	7.3	8.4
Clarke	NOAA B	2.4	2.9	3.6	4.3	5.2	5.9	6.8
Craig	NOAA C	2.4	2.9	3.6	4.2	5.1	5.9	6.6
Culpeper	NOAA C	2.7	3.3	4.2	5	6.2	7.2	8.4
Cumberland	NOAA C	2.7	3.3	4.2	5	6.1	7.1	8.1
Dickenson	NOAA A	2.2	2.6	3.2	3.7	4.4	5	5.7
Dinwiddie	NOAA C	2.8	3.4	4.4	5.2	6.3	7.3	8.4
Essex	NOAA C	2.7	3.2	4.2	5	6.3	7.4	8.6
Fairfax	NOAA C	2.6	3.1	4	4.8	6	7	8.2
Fauquier	NOAA B	2.6	3.2	4	4.8	5.9	6.9	8
Floyd ZONE-1	NOAA C	2.5	3.1	3.9	4.6	5.6	6.4	7.3
Floyd ZONE-2	NOAA C	2.9	3.5	4.4	5.2	6.4	7.4	8.4
Floyd ZONE-3	NOAA D	3.4	4.1	5.3	6.2	7.6	8.8	10.2
Floyd ZONE-4	NOAA D	3.8	4.6	5.9	7	8.6	10	11.5
Fluvanna	NOAA C	2.7	3.3	4.2	4.9	6	7	8.1
Franklin	NOAA C	2.8	3.4	4.4	5.2	6.3	7.3	8.4
Frederick	NOAA B	2.4	2.8	3.5	4.1	5	5.7	6.5
Giles ZONE- 1	NOAA A	2.1	2.5	3.1	3.6	4.3	4.9	5.5
Giles ZONE- 2	NOAA B	2.3	2.8	3.5	4.1	4.9	5.6	6.4
Gloucester	NOAA C	2.9	3.5	4.5	5.4	6.7	7.9	9.2
Goochland	NOAA C	2.7	3.3	4.2	5	6.1	7.1	8.2
Grayson ZONE-1	NOAA C	3.3	3.9	4.9	5.7	6.8	7.7	8.7

County / Rainfall Zone	Rainfall Type	1-year	2-year	5-year	10-year	25-year	50-year	100-year
Grayson ZONE-2	NOAA B	2.4	2.9	3.6	4.1	4.9	5.6	6.2
Grayson ZONE-3	NOAA C	2.7	3.2	4.1	4.7	5.7	6.5	7.3
Greene	NOAA D	3	3.7	4.7	5.5	6.7	7.8	8.9
Greensville	NOAA B	2.7	3.3	4.2	5	6.2	7.2	8.3
Halifax	NOAA B	2.7	3.3	4.1	4.9	6	6.9	7.9
Hampton City	NOAA C	2.9	3.6	4.6	5.5	6.9	8.1	9.3
Hanover	NOAA C	2.7	3.3	4.2	5	6.2	7.3	8.4
Henrico	NOAA C	2.7	3.3	4.3	5.1	6.3	7.3	8.4
Henry	NOAA C	2.9	3.5	4.5	5.3	6.5	7.5	8.7
Highland	NOAA C	2.4	2.9	3.6	4.2	5	5.7	6.4
Isle of Wight	NOAA B	3	3.6	4.7	5.5	6.8	8	9.2
James City	NOAA C	2.9	3.5	4.6	5.5	6.8	7.9	9.2
King and Queen	NOAA C	2.7	3.3	4.3	5.1	6.4	7.5	8.7
King George	NOAA C	2.6	3.2	4.1	5	6.2	7.3	8.5
King William	NOAA C	2.7	3.3	4.2	5.1	6.3	7.4	8.6
Lancaster	NOAA C	2.7	3.3	4.3	5.2	6.5	7.6	8.9
Lee	NOAA B	2.5	3	3.7	4.2	5	5.7	6.3
Loudon	NOAA B	2.6	3.1	4	4.7	5.7	6.7	7.7
Louisa	NOAA C	2.7	3.3	4.2	5	6.2	7.2	8.3
Lunenburg	NOAA C	2.7	3.3	4.2	5	6.1	7.1	8.2
Lynchburg City	NOAA C	2.8	3.3	4.3	5	6.2	7.2	8.2
Madison ZONE-1	NOAA D	3.4	4.1	5.2	6.1	7.5	8.7	9.9
Madison ZONE-2	NOAA C	2.9	3.5	4.4	5.3	6.5	7.5	8.6
Mathews	NOAA C	2.8	3.4	4.5	5.4	6.7	7.9	9.2
Mecklenburg	NOAA B	2.7	3.2	4.1	4.9	5.9	6.8	7.8
Middlesex	NOAA C	2.8	3.4	4.4	5.3	6.6	7.7	9
Montgomery ZONE-1	NOAA B	2	2.4	3.1	3.6	4.3	5	5.6
Montgomery ZONE-2	NOAA B	2.3	2.7	3.5	4.1	5	5.7	6.5
Montgomery ZONE-3	NOAA C	2.6	3.2	4	4.7	5.8	6.6	7.6
Nelson	NOAA D	3	3.6	4.6	5.5	6.7	7.7	8.8
New Kent	NOAA C	2.8	3.4	4.4	5.2	6.4	7.5	8.7
Newport News City	NOAA C	2.9	3.6	4.6	5.5	6.9	8	9.3
Norfolk City	NOAA C	2.9	3.6	4.6	5.5	6.8	8	9.2
Northampton	DMV C	2.7	3.3	4.3	5.2	6.5	7.6	8.9
Northumberland	NOAA C	2.7	3.3	4.3	5.1	6.4	7.5	8.8
Nottoway	NOAA C	2.7	3.3	4.2	5	6.2	7.1	8.2
Orange	NOAA C	2.8	3.3	4.3	5.1	6.3	7.3	8.5
Page ZONE-1	NOAA C	2.4	2.9	3.7	4.4	5.3	6.1	6.9
Page ZONE-2	NOAA D	3	3.6	4.6	5.4	6.6	7.6	8.7
Patrick ZONE-1	NOAA D	3.8	4.6	5.9	7	8.6	9.9	11.5
Patrick ZONE-2	NOAA D	3.3	4	5.2	6.1	7.5	8.7	10
Patrick ZONE-3	NOAA C	3	3.7	4.7	5.6	6.8	7.9	9.1
Petersburg City	NOAA C	2.8	3.4	4.4	5.2	6.3	7.4	8.5
Pittsylvania	NOAA C	2.8	3.4	4.3	5.1	6.2	7.2	8.2
Poquoson City	NOAA C	2.9	3.6	4.6	5.5	6.9	8	9.4
Portsmouth City	NOAA C	3	3.6	4.7	5.6	6.9	8	9.3
Powhatan	NOAA C	2.7	3.3	4.2	5	6.1	7.1	8.2
Prince Edward	NOAA C	2.7	3.3	4.3	5	6.2	7.2	8.3

County / Rainfall Zone	Rainfall Type	1-year	2-year	5-year	10-year	25-year	50-year	100-year
Prince George	NOAA C	2.8	3.4	4.4	5.2	6.4	7.5	8.6
Prince William	NOAA C	2.5	3	3.9	4.7	5.8	6.9	8
Pulaski	NOAA A	2	2.4	3.1	3.6	4.3	5	5.6
Rappahannock	NOAA C	2.8	3.4	4.3	5	6.2	7.1	8.2
Richmond City	NOAA C	2.8	3.4	4.3	5.1	6.3	7.3	8.4
Richmond	NOAA C	2.7	3.3	4.3	5.1	6.4	7.5	8.8
Roanoke ZONE-1	NOAA C	2.4	2.9	3.6	4.2	5.2	5.9	6.7
Roanoke ZONE-2	NOAA C	2.6	3.2	4	4.7	5.7	6.6	7.5
Rockbridge	NOAA C	2.5	3	3.9	4.5	5.5	6.3	7.2
Rockingham ZONE-1	NOAA B	2.3	2.8	3.5	4.1	4.9	5.6	6.4
Rockingham ZONE-2	NOAA D	2.9	3.4	4.4	5.1	6.2	7.1	8.1
Russell	NOAA A	2.2	2.6	3.2	3.6	4.3	4.8	5.4
Scott ZONE-1	NOAA A	2.4	2.8	3.4	3.9	4.6	5.2	5.8
Scott ZONE-2	NOAA A	2.3	2.7	3.2	3.6	4.2	4.6	5
Shenandoah	NOAA B	2.3	2.8	3.5	4.1	5	5.7	6.5
Smyth	NOAA A	2.3	2.7	3.2	3.7	4.2	4.7	5.1
Southampton	NOAA B	2.9	3.5	4.5	5.4	6.6	7.7	8.8
Spotsylvania	NOAA C	2.7	3.2	4.2	4.9	6.1	7.2	8.4
Stafford	NOAA C	2.6	3.1	4	4.8	6	7	8.2
Suffolk City	NOAA B	3	3.6	4.7	5.6	6.9	8	9.3
Surry	NOAA C	2.9	3.5	4.6	5.4	6.7	7.8	9
Sussex	NOAA C	2.9	3.5	4.5	5.3	6.5	7.5	8.6
Tazewell	NOAA A	2.1	2.5	3	3.5	4.1	4.6	5.1
Virginia Beach City	NOAA C	3	3.7	4.7	5.7	7	8.2	9.4
Warren ZONE-1	NOAA B	2.5	3	3.8	4.4	5.4	6.2	7.1
Warren ZONE-2	NOAA C	2.8	3.4	4.3	5.1	6.2	7.2	8.3
Washington	NOAA A	2.2	2.6	3.1	3.5	4	4.4	4.8
Westmoreland	NOAA C	2.7	3.2	4.2	5	6.3	7.4	8.7
Wise	NOAA A	2.3	2.7	3.3	3.8	4.6	5.2	5.9
Wythe	NOAA A	2.1	2.5	3.1	3.6	4.2	4.7	5.3
York	NOAA C	2.9	3.6	4.6	5.5	6.8	8	9.3

Appendix VA650.29-2. Instructions for Incorporating Updated Rainfall and Soils Databases into EFH-2 Computer Program in Virginia

EFH-2 Runoff and Peak Discharge software requires a rainfall database (**COUNTY.VA**), rainfall distribution types (**type.rf**), and hydrologic soil group database (**SOILS. HG**). These databases are available on the Virginia NRCS Sharepoint Engineering site and will replace the TP40 based databases. The following describes the steps to use the current databases with the EFH-2 computer program.

1. Navigate to the EFH-2 Software Updates section of the Virginia NRCS Sharepoint Engineering site. https://nrcs.sc.egov.usda.gov/east/va/default.aspx . (Virginia > Engineering > Design Aids > Hydrology > EFH2 Software Updates)

2. Individually, save "**COUNTY.VA"**, " **type.rf"**, and "**SOILS. HG** " into C:\Program Files\USDA\EFH2 on your computer. This will replace the existing TP40 based data file. The EFH-2 software now has the NOAA 14 rainfall depths, rainfall distribution types, and Hydrologic Soil Group database for Virginia.

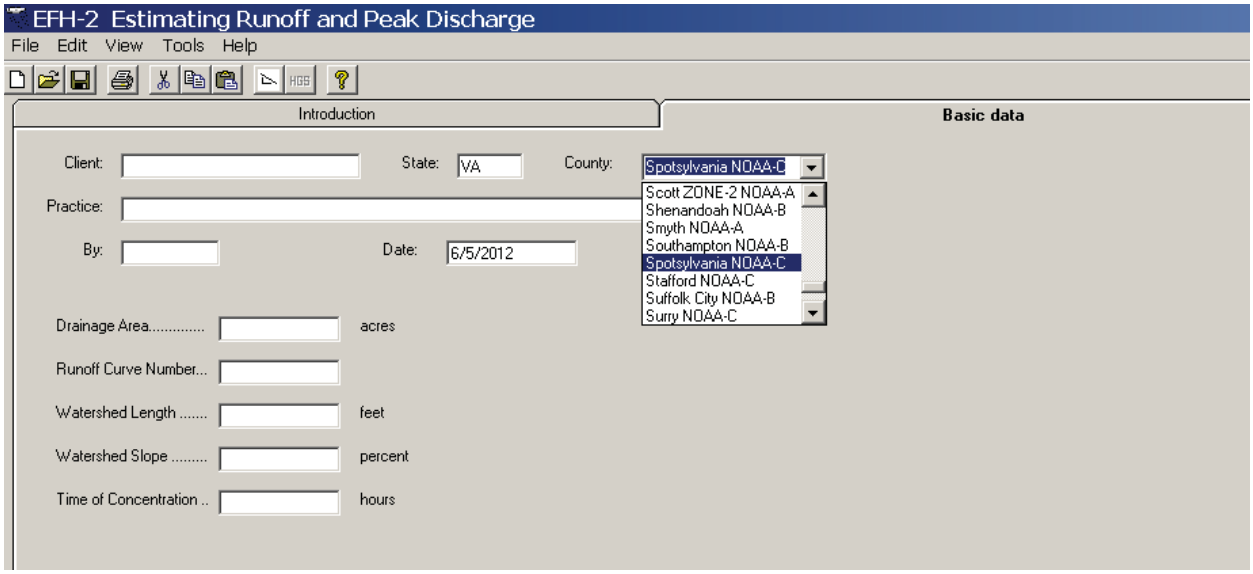
3. Within the EFH-2 computer program, type "VA" for the state under the Basic Data tab to see every county, city and rainfall zone in Virginia. Appendix VA650.29- 3 provides an example application of the Virginia rainfall data in EFH-2 software.

4. Within the EFH-2 computer program, click on the HSG button while within the RCN tab of the software, and a window will pop up with "Soil Name" "Surface Texture" and "Hydrologic Group". This database can be used in lieu of Table 2.1 Hydrologic soil groups for U.S. soil in the Engineering Field Handbook, Chapter 2.

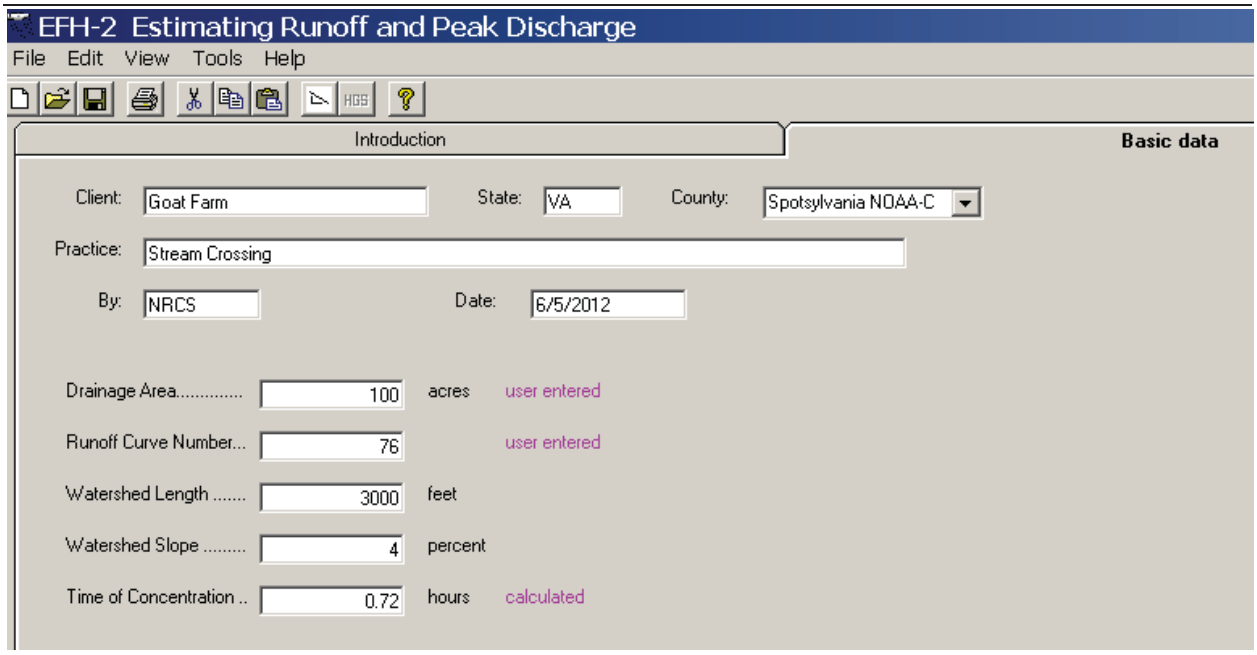
Appendix VA650.29 -3. Example Application of the EFH-2 Computer Program in Virginia

For this example, a small watershed in Spotsylvania County is selected. The drainage area is 100 acres, the curve number is 76, watershed length is 3000 feet, and average watershed slope is 4 percent. From the rainfall distribution map above, the rainfall distribution region is "C".

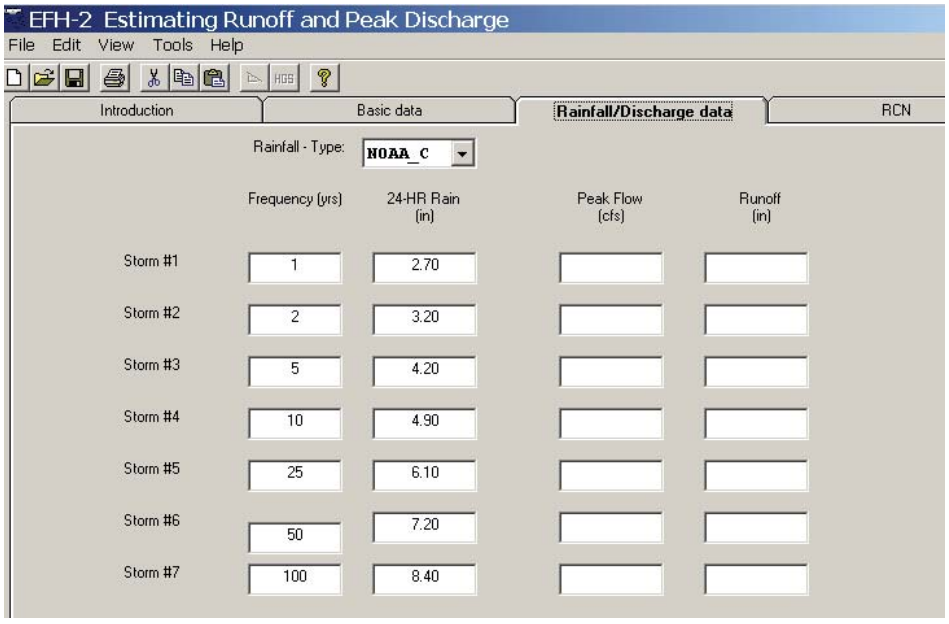
1. Open the EFH-2 computer program and open the Basic Data tab. Enter State: VA and use the pull-down menu to select Spotsylvania County. The name "NOAA C" next to the county name designates this county is in NOAA Rainfall Distribution Type C region.



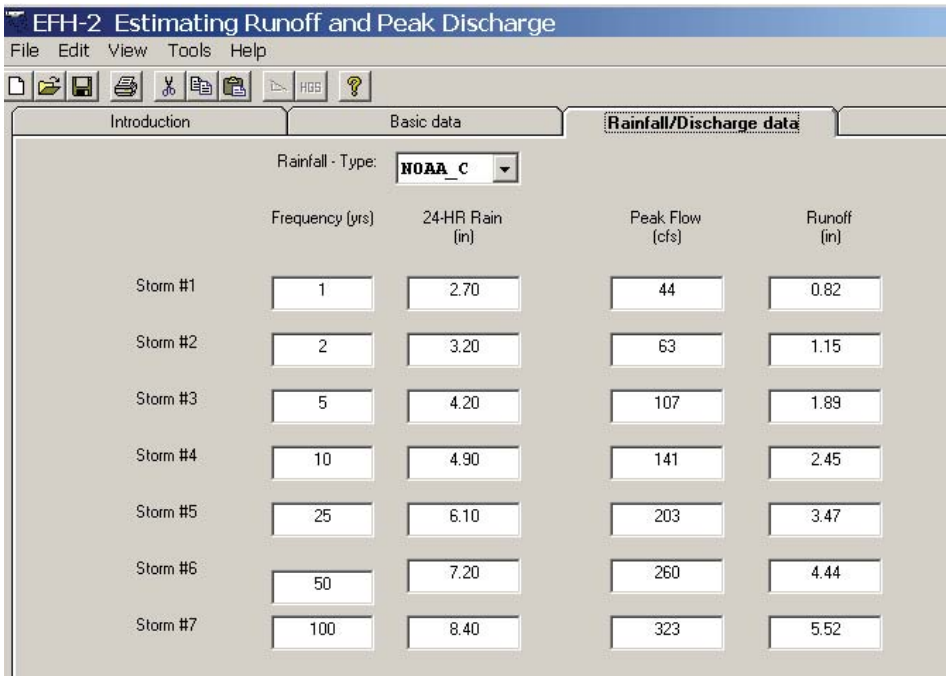
2. Enter the remaining data on this window (curve number, watershed length and watershed slope). The Drainage Area and Runoff Curve Number could alternatively be entered by opening the RCN tab (far right side of Basic data window).



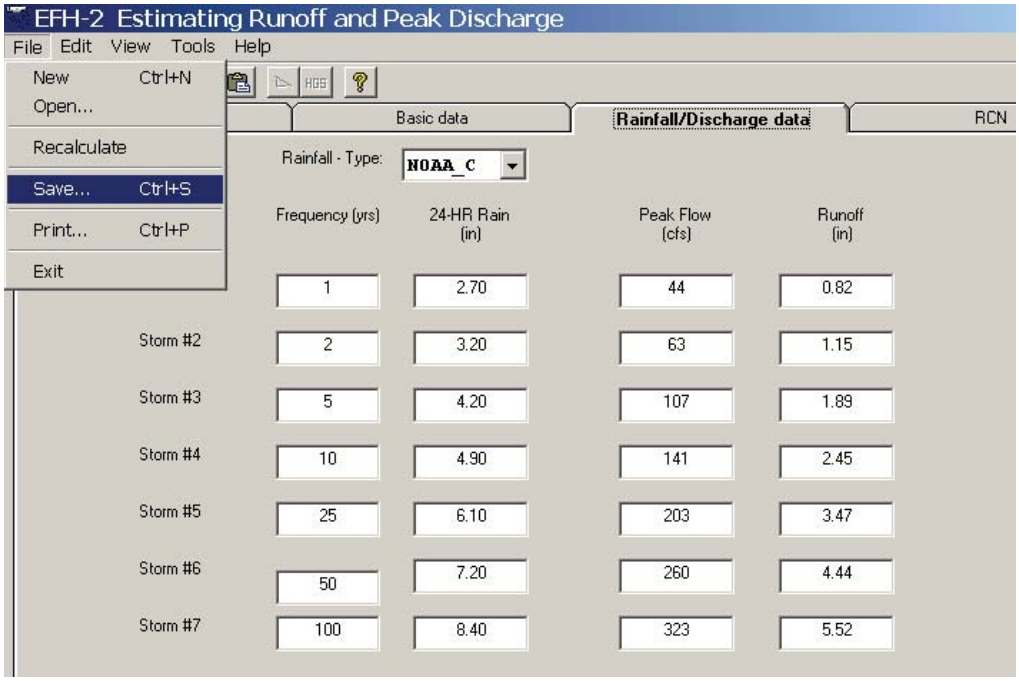
3. Open the Rainfall/Discharge data tab. The 24-hour rainfall data for Spotsylvania County has automatically been entered. At this point you may replace these county values with site specific data from http://hdsc.nws.noaa.gov/hdsc/pfds/ if desired. Use the Rainfall Type pull-down menu to select NOAA_C.



4. Upon choosing the rainfall type, the peak discharges and runoff depths are calculated.



5. To complete the project, click File and Save. Print output if desired. Close EFH-2.



Appendix VA650.29-4. Rainfall Distribution Type Equations, Peak Discharge Curves and Peak Discharge Equation Coefficients

Since the EFH-2 computer program cannot use actual rainfall distribution types, alternative methods of estimating peak discharges are needed as described below. Also, since NRCS Type II does not match the NOAA 14 data, new distribution types and peak flow coefficients were also created.

Extents of Rainfall Distribution Types

Five rainfall distribution types (NOAA A, NOAA B, NOAA C, NOAA D, and DMV C) were developed from the NOAA 14 data to replace the NRCS Type-II rainfall distribution and EFH-2 coefficients. The four rainfall distribution types were developed for the NOAA Atlas 14 Volume 2 region which includes 13 states from New Jersey west to Illinois and southeast to South Carolina. The extent of each region was based on the 60-minute/24-hour ratio of the 25-year NOAA 14 data. The thresholds for the 5 regions are as follows.

A > 0.48
B 0.43 to 0.48
C 0.38 to 0.43
D < 0.38

Peak Equation Coefficients

Rainfall distributions were created for each region and used in WinTR20 models to develop peak flow equation coefficients for use in EFH-2 computer program. To simplify the estimation of peak discharge, WinTR-20 was run for times of concentration of 0.1 to 10.0 hours and I_a/P ratios of 0.1, 0.25, 0.3, 0.4 and 0.5. I_a is initial abstraction in units of inches. Initial abstraction includes all losses before runoff begins (interception, depression storage, early storm infiltration, etc). P is the storm rainfall with units of inches and CN = NRCS runoff curve number.

$$I_a = 0.2 * ((1000 / CN) – 10) \quad \text{Eq. VA2-1}$$

Equations to relate time of concentration to unit peak discharge were then developed. The equation used to compute the unit peak discharge (q) for the EFH-2 computer program is:

$$q = 10 ^ (Coeff\_1 + Coeff\_2 * LOG(T_c) + Coeff\_3 * (LOG(T_c))^2) \quad \text{Eq. VA2-2}$$

The coefficients to be used with each rainfall distribution are tabulated below. For example, the equation applicable to the Region C rainfall distribution region of Virginia and I_a/P ratio of 0.1 is:

$$q = 10 ^ (\underline{2.4928} \underline{– 0.585} * LOG(T_c) \underline{– 0.137} * (LOG(T_c))^2) \quad \text{Eq. VA2-3}$$

For a time of concentration of 0.5 hours and I_a/P ratio of 0.1, the unit peak discharge is q = 453.41 cfs / inch / sq mile. If the drainage area is 200 acres (0.31 square miles) and there is 1.5 inches of runoff, the peak discharge, Q, is:

Q = 453.41 * 0.31 * 1.5 = 210 cfs Eq. VA2-4

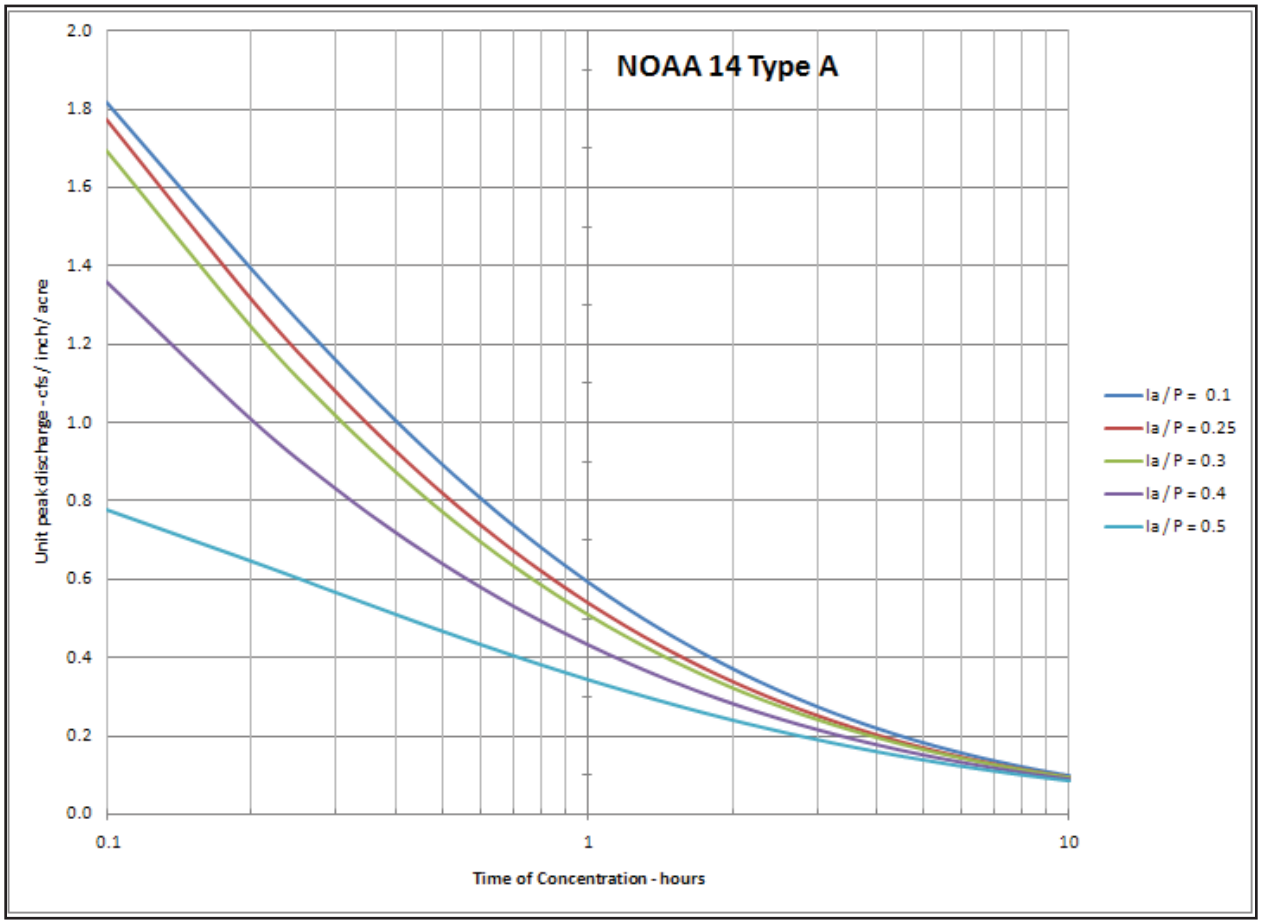


Figure A4-1, EFH-2 Peak Discharge Curves for NOAA-A

Table A4-1, EFH-2 Peak Discharge Equation Coefficients for NOAA-A

I_a/P	Coeff_1	Coeff_2	Coeff_3
0.1	2.5796	-0.6312	-0.1451
0.25	2.539	-0.6368	-0.1203
0.3	2.5126	-0.6315	-0.1087
0.4	2.4423	-0.5887	-0.0921
0.5	2.3435	-0.4789	-0.1246

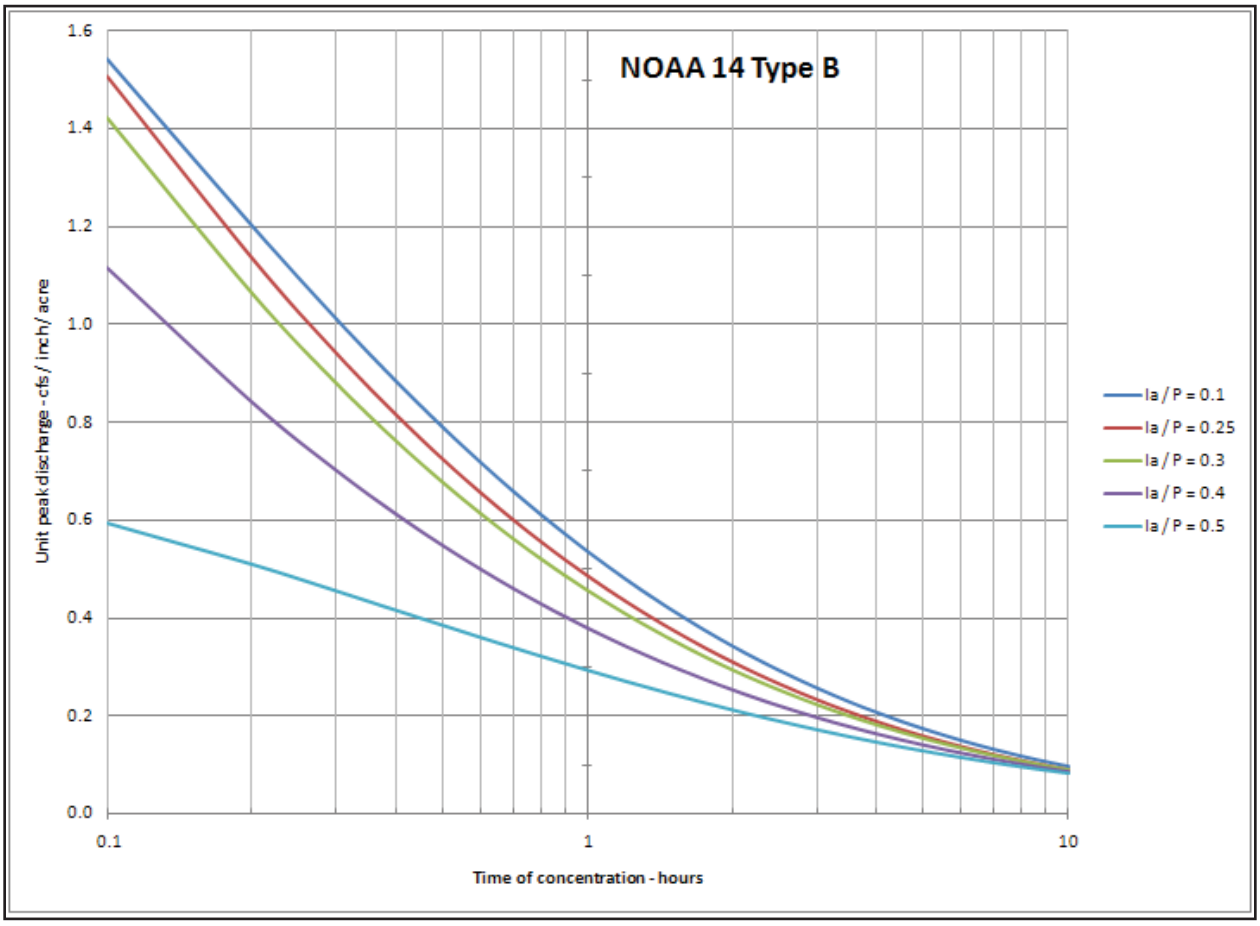


Figure A4-2, EFH-2 Peak Discharge Curves for NOAA-B

Table A4-2, EFH-2 Peak Discharge Equation Coefficients for NOAA-B

I_a/P	Coeff_1	Coeff_2	Coeff_3
0.1	2.5352	-0.603	-0.1433
0.25	2.4928	-0.6109	-0.1197
0.3	2.4646	-0.6035	-0.1085
0.4	2.3852	-0.5578	-0.0886
0.5	2.2713	-0.4318	-0.124

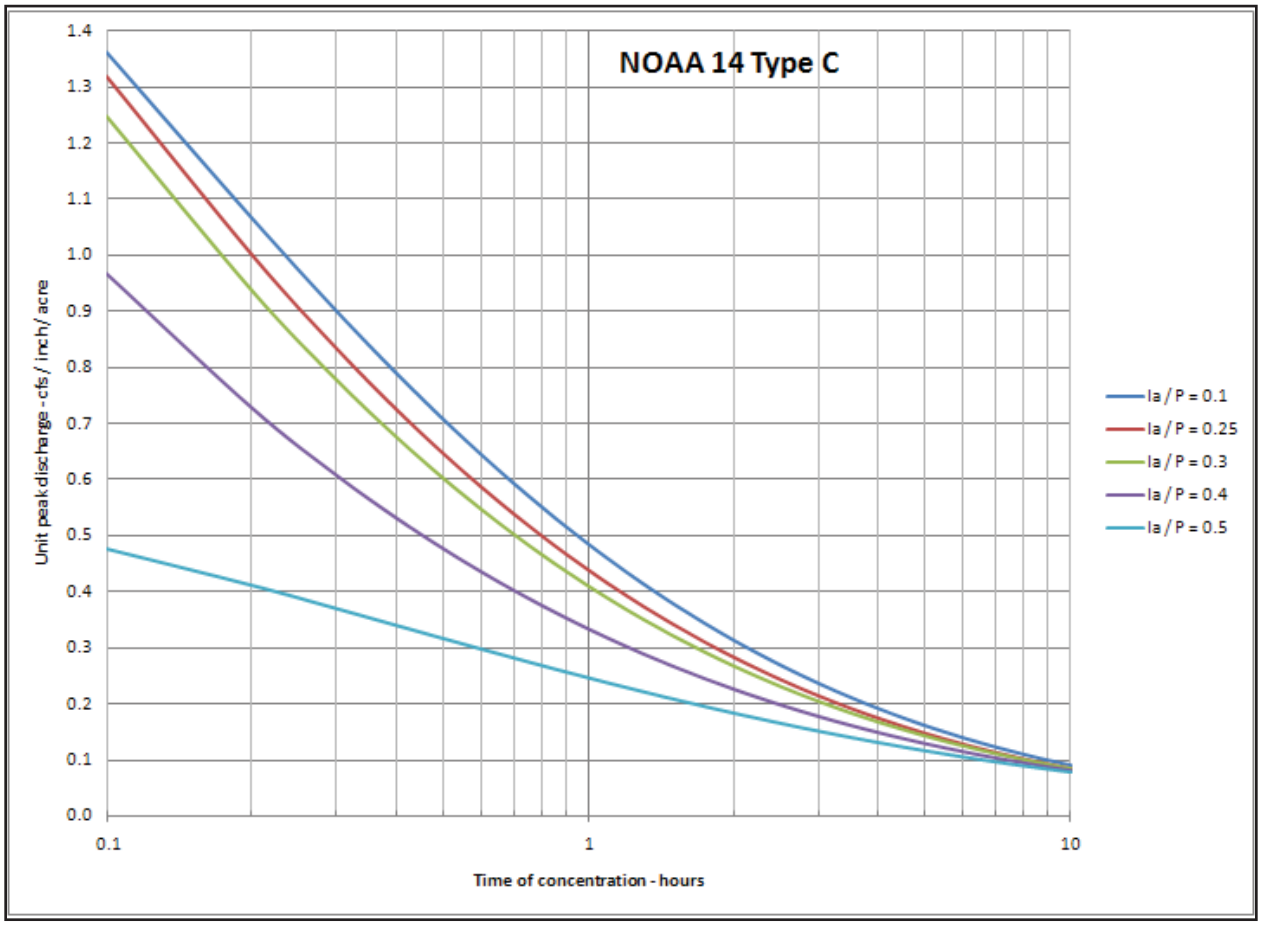


Figure A4-3, EFH-2 Peak Discharge Curves for NOAA-C

Table A4-3, EFH-2 Peak Discharge Equation Coefficients for NOAA-C

I_a/P	Coeff_1	Coeff_2	Coeff_3
0.1	2.4928	-0.585	-0.137
0.25	2.4494	-0.5928	-0.1154
0.3	2.4182	-0.5857	-0.1018
0.4	2.3289	-0.5381	-0.0754
0.5	2.1955	-0.3952	-0.1077

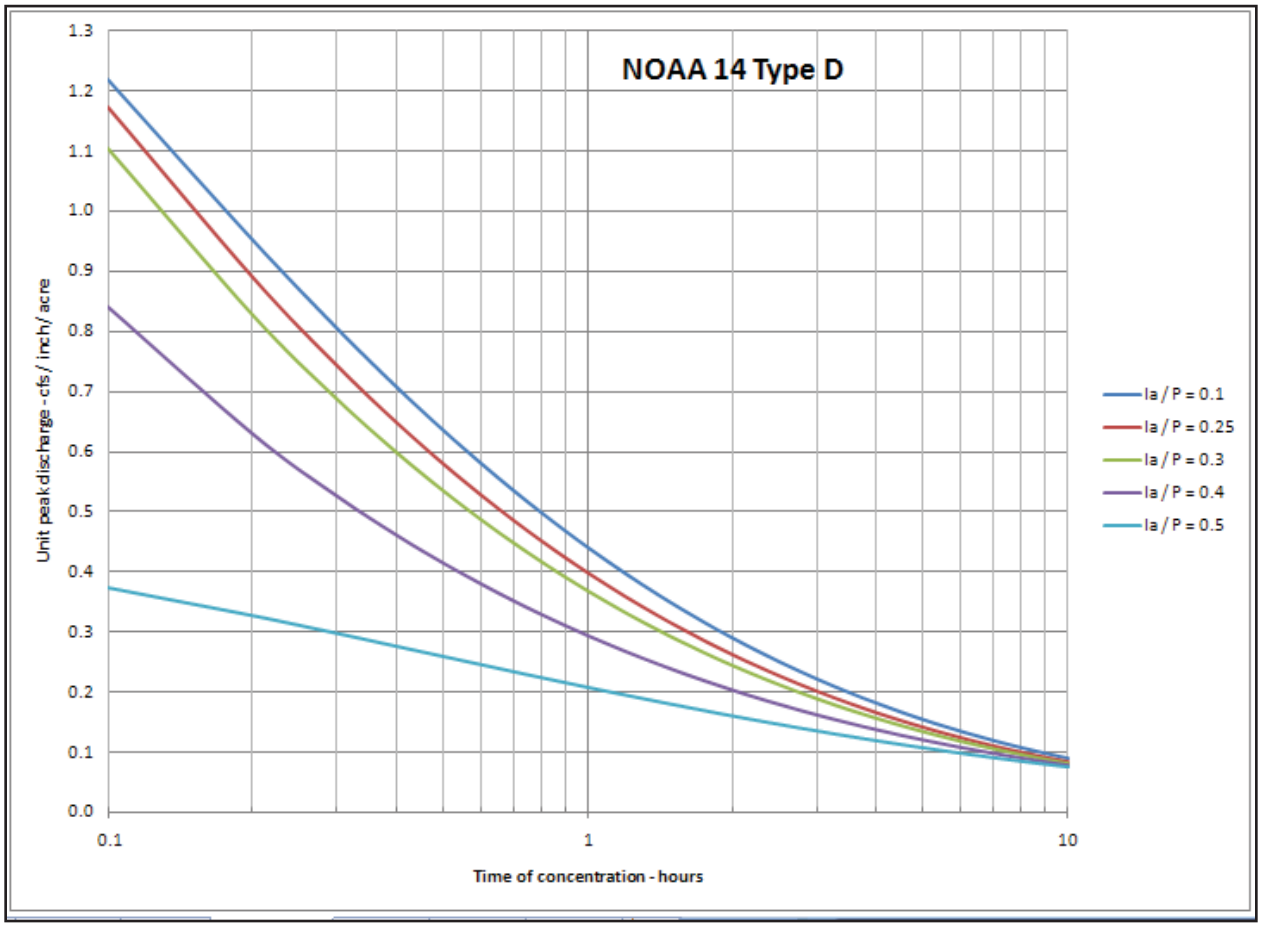


Figure A4-4, EFH-2 Peak Discharge Curves for NOAA-D

Table A4-4, EFH-2 Peak Discharge Equation Coefficients for NOAA-D

I_a/P	Coeff_1	Coeff_2	Coeff_3
0.1	2.4504	-0.5651	-0.1233
0.25	2.4067	-0.5713	-0.1024
0.3	2.3736	-0.5624	-0.0866
0.4	2.2763	-0.5109	-0.056
0.5	2.1265	-0.3442	-0.0908

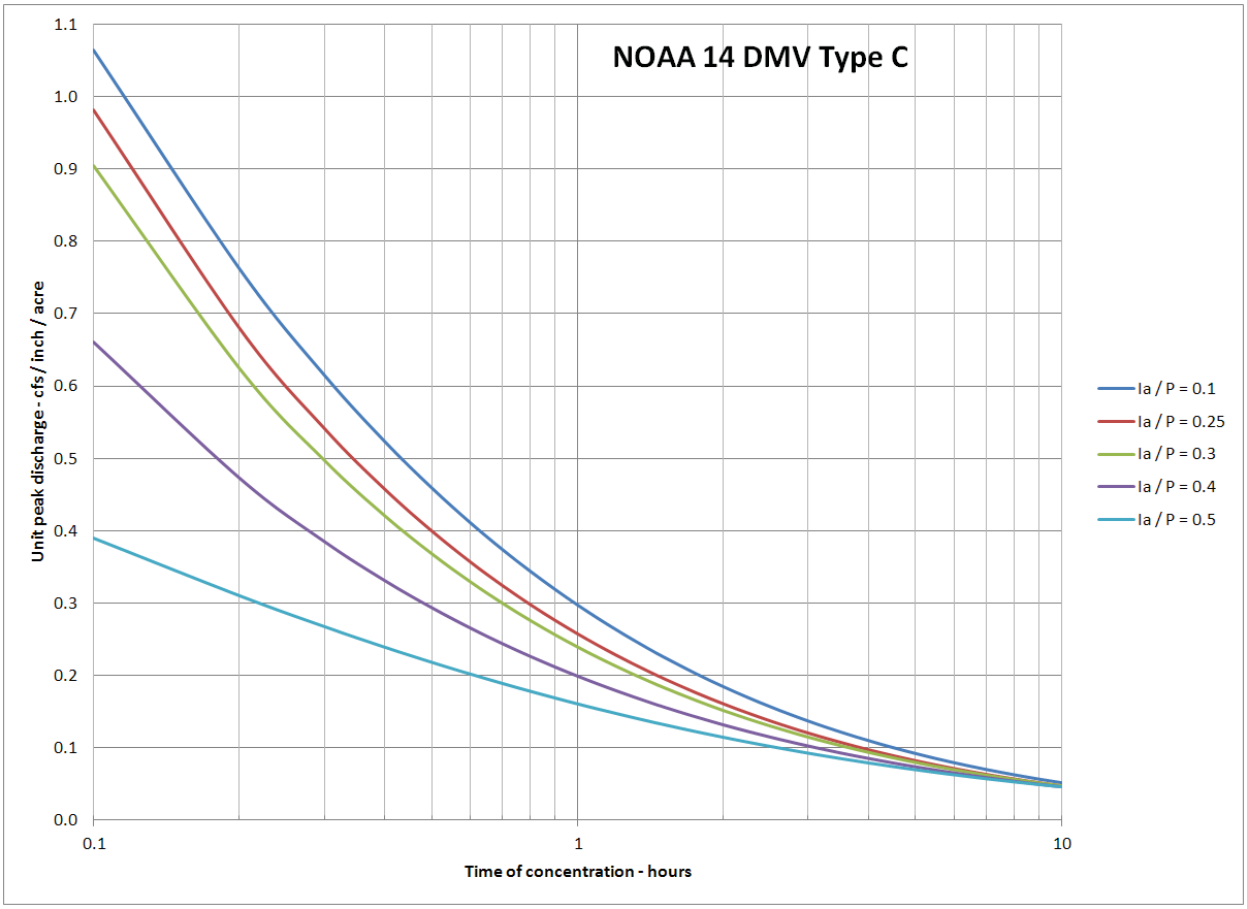


Figure A4-4, EFH-2 Peak Discharge Curves for DMV-C

Table A4-5, EFH-2 Peak Discharge Equation Coefficients for DMV-C

I_a/P	Coeff_1	Coeff_2	Coeff_3
0.1	2.2789	-0.6589	-0.1045
0.25	2.2181	-0.6548	-0.0745
0.3	2.1852	-0.64	-0.0625
0.4	2.1058	-0.5758	-0.0556
0.5	2.0114	-0.4671	-0.0811

The following plots are for use with 24-hour design storms. They represent the accumulated rainfall during the 24-hour storm duration on a non-dimensional basis. The maximum accumulated rainfall in the plot is 1.0 which represents the total storm 24-hour rainfall. These rainfall distributions are represented in WinTR-20 in tabular format at a time interval of 0.1 hour.

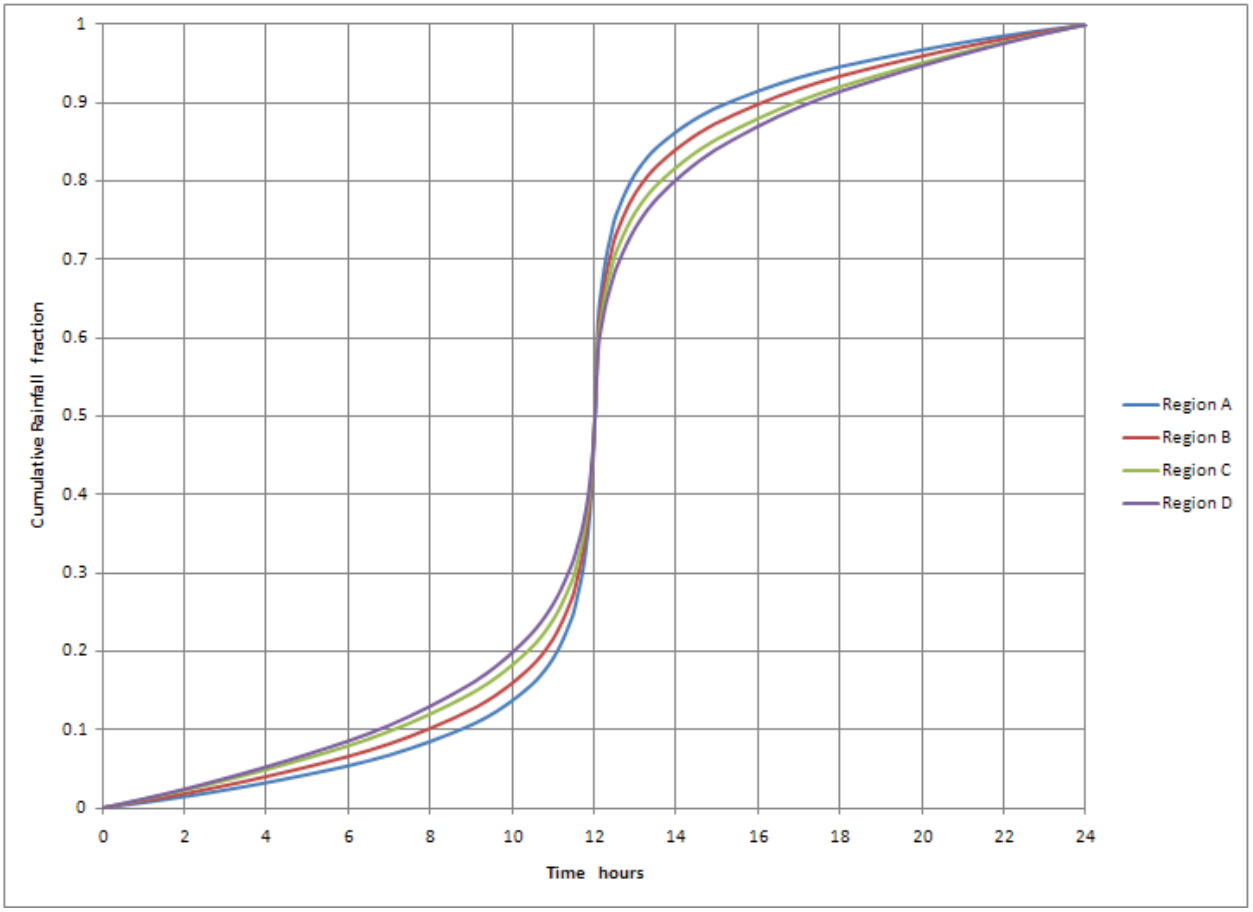


Figure A4-5, Plots of the Ohio Valley and neighboring states rainfall distributions.

Appendix VA650.29-5. Maps of Rainfall Zones in Virginia.

The rainfall maps are located on eDirectives or on the Virginia NRCS Sharepoint Engineering site. Navigate to https://nrcs.sc.egov.usda.gov/east/va/default.aspx . (Virginia > Engineering > Design Aids > Hydrology > Maps of Rainfall Zones in Virginia). There are 19 rainfall maps.

Area 1 Rainfall Maps:

- Area 1 Rainfall Map
- Augusta Co
- Madison Co
- Page Co
- Rockingham Co
- Warren Co

Area 2 Rainfall Maps:

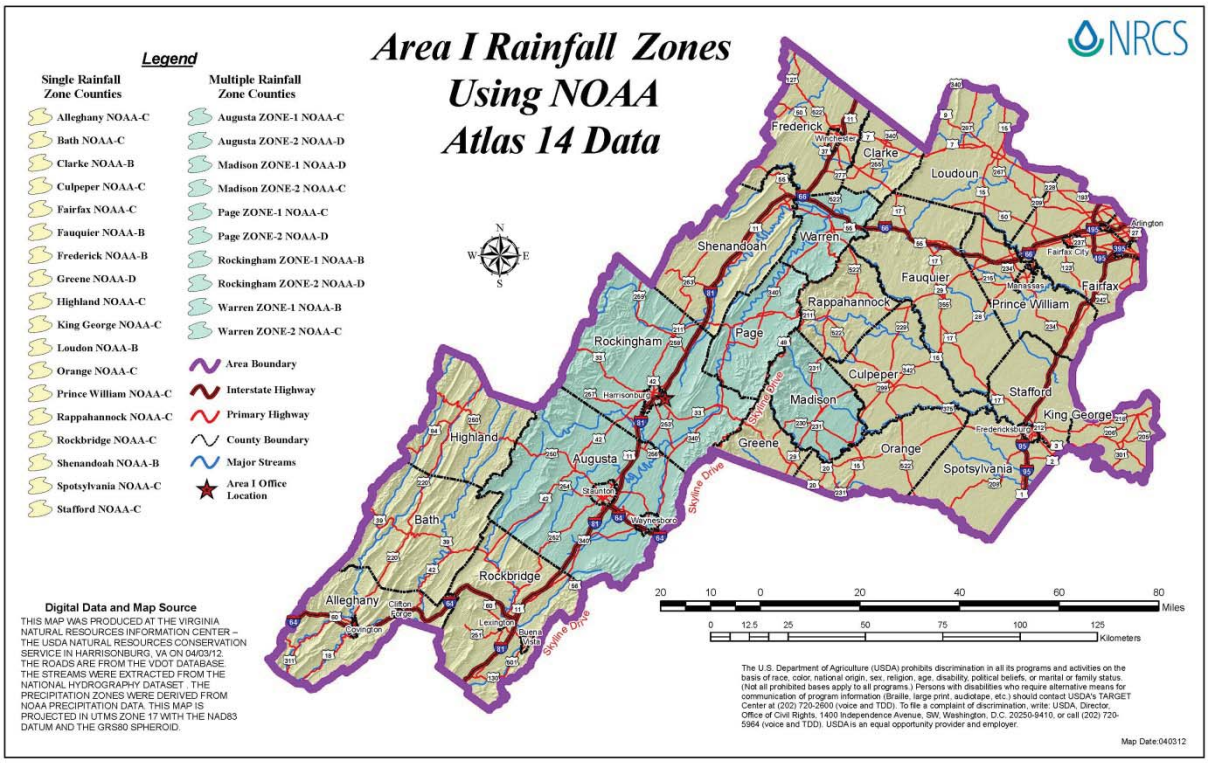
- Area 2 Rainfall Map
- Carroll Co
- Floyd Co
- Giles Co
- Grayson Co
- Montgomery Co
- Patrick Co
- Roanoke Co
- Scott Co

Area 3 Rainfall Maps:

- Area 3 Rainfall Map
- Albemarle Co
- Bedford Co

Area 4 Rainfall Maps:

- Area 4 Rainfall Map


Area I Rainfall Zones Using NOAA Atlas 14 Data
NRCS
Legend
Single Rainfall Zone Counties
Alleghany NOAA-C
Bath NOAA-C
Clarke NOAA-B
Culpeper NOAA-C
Fairfax NOAA-C
Fauquier NOAA-B
Frederick NOAA-B
Greene NOAA-D
Highland NOAA-C
King George NOAA-C
Loudon NOAA-B
Orange NOAA-C
Prince William NOAA-C
Rappahannock NOAA-C
Rockbridge NOAA-C
Shenandoah NOAA-B
Spotsylvania NOAA-C
Stafford NOAA-C
Multiple Rainfall Zone Counties
Augusta ZONE-1 NOAA-C
Augusta ZONE-2 NOAA-D
Madison ZONE-1 NOAA-D
Madison ZONE-2 NOAA-C
Page ZONE-1 NOAA-C
Page ZONE-2 NOAA-D
Rockingham ZONE-1 NOAA-B
Rockingham ZONE-2 NOAA-D
Warren ZONE-1 NOAA-B
Warren ZONE-2 NOAA-C
Area Boundary
Interstate Highway
Primary Highway
County Boundary
Major Streams
Area I Office Location
Digital Data and Map Source
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Frederick
Clarke
Loudoun
Warren
Shenandoah
Fauquier
Rappahannock
Prince William
Fairfax
Page
Rockingham
Culpeper
Madison
Stafford
King George
Highland
Augusta
Greene
Orange
Spotsylvania
Bath
Rockbridge
Alleghany
Skyline Drive
20 10 0 20 40 60 80 Miles
0 12.5 25 50 75 100 125 Kilometers
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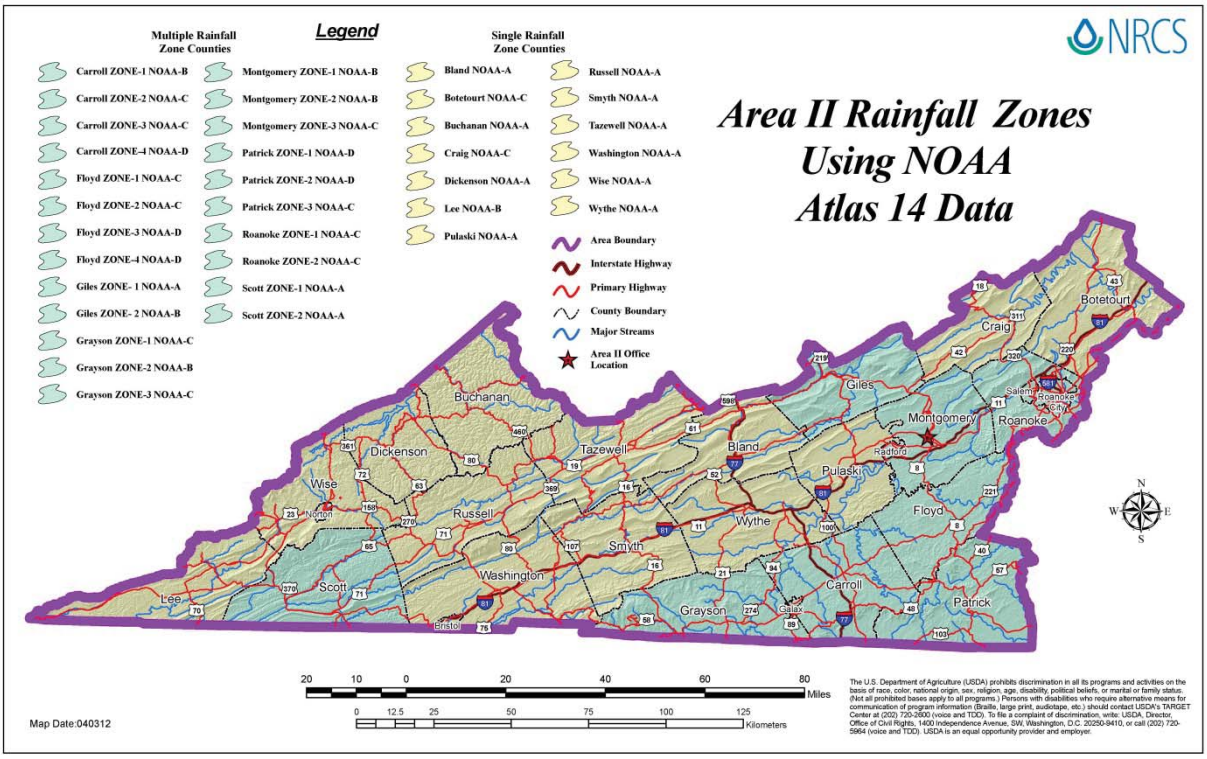
Map Date:040312


Area II Rainfall Zones Using NOAA Atlas 14 Data
NRCS
Legend
Multiple Rainfall Zone Counties
Carroll ZONE-1 NOAA-B
Carroll ZONE-2 NOAA-C
Carroll ZONE-3 NOAA-C
Carroll ZONE-4 NOAA-D
Floyd ZONE-1 NOAA-C
Floyd ZONE-2 NOAA-C
Floyd ZONE-3 NOAA-D
Floyd ZONE-4 NOAA-D
Giles ZONE- 1 NOAA-A
Giles ZONE- 2 NOAA-B
Grayson ZONE-1 NOAA-C
Grayson ZONE-2 NOAA-B
Grayson ZONE-3 NOAA-C
Montgomery ZONE-1 NOAA-B
Montgomery ZONE-2 NOAA-B
Montgomery ZONE-3 NOAA-C
Patrick ZONE-1 NOAA-D
Patrick ZONE-2 NOAA-D
Patrick ZONE-3 NOAA-C
Roanoke ZONE-1 NOAA-C
Roanoke ZONE-2 NOAA-C
Scott ZONE-1 NOAA-A
Scott ZONE-2 NOAA-A
Single Rainfall Zone Counties
Bland NOAA-A
Botetourt NOAA-C
Buchanan NOAA-A
Craig NOAA-C
Dickenson NOAA-A
Lee NOAA-B
Pulaski NOAA-A
Russell NOAA-A
Smyth NOAA-A
Tazewell NOAA-A
Washington NOAA-A
Wise NOAA-A
Wythe NOAA-A
Area Boundary
Interstate Highway
Primary Highway
County Boundary
Major Streams
Area II Office Location
Botetourt
Craig
Giles
Buchanan
Montgomery
Roanoke
Dickenson
Tazewell
Bland
Radford
Pulaski
Wise
Russell
Wythe
Floyd
Smyth
Washington
Carroll
Scott
Lee
Grayson
Patrick
Bristol
20 10 0 20 40 60 80 Miles
0 12.5 25 50 75 100 125 Kilometers
Map Date:040312
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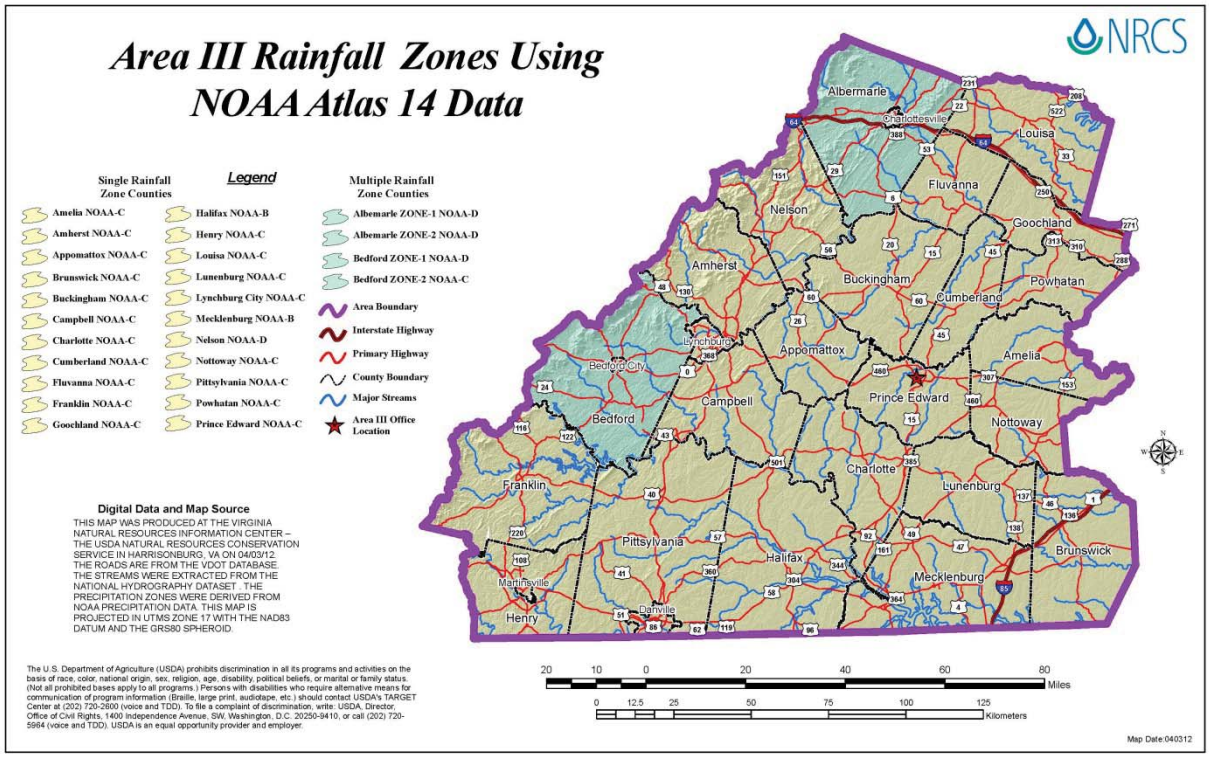
Area III Rainfall Zones Using NOAA Atlas 14 Data
NRCS
Legend
Single Rainfall Zone Counties
Amelia NOAA-C
Amherst NOAA-C
Appomattox NOAA-C
Brunswick NOAA-C
Buckingham NOAA-C
Campbell NOAA-C
Charlotte NOAA-C
Cumberland NOAA-C
Fluvanna NOAA-C
Franklin NOAA-C
Goochland NOAA-C
Halifax NOAA-B
Henry NOAA-C
Louisa NOAA-C
Lunenburg NOAA-C
Lynchburg City NOAA-C
Mecklenburg NOAA-B
Nelson NOAA-D
Nottoway NOAA-C
Pittsylvania NOAA-C
Powhatan NOAA-C
Prince Edward NOAA-C
Multiple Rainfall Zone Counties
Albemarle ZONE-1 NOAA-D
Albemarle ZONE-2 NOAA-D
Bedford ZONE-1 NOAA-D
Bedford ZONE-2 NOAA-C
Area Boundary
Interstate Highway
Primary Highway
County Boundary
Major Streams
Area III Office Location
Digital Data and Map Source
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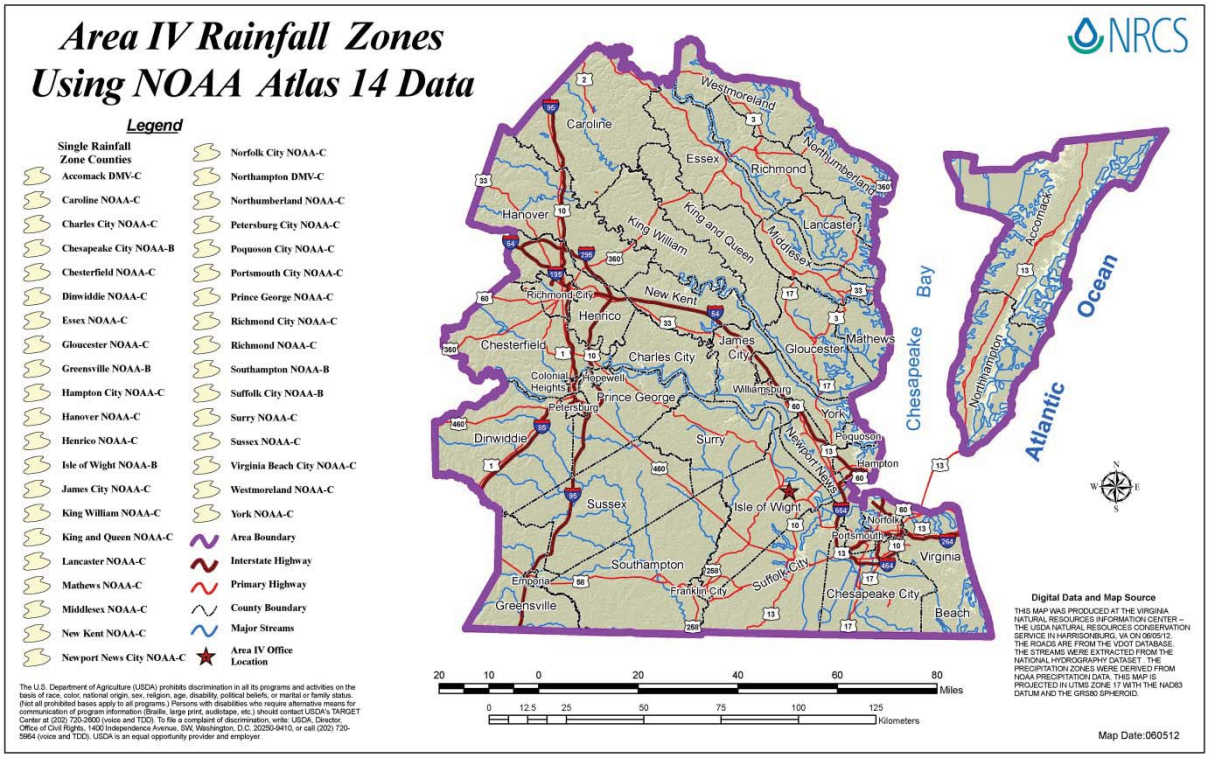
Albemarle
Charlottesville
Louisa
Fluvanna
Nelson
Goochland
Amherst
Buckingham
Cumberland
Powhatan
Lynchburg
Appomattox
Amelia
Bedford City
Campbell
Prince Edward
Bedford
Nottoway
Charlotte
Lunenburg
Franklin
Pittsylvania
Halifax
Brunswick
Martinsville
Mecklenburg
Danville
Henry
20 10 0 20 40 60 80 Miles
0 12.5 25 50 75 100 125 Kilometers
Map Date:040312


Area IV Rainfall Zones Using NOAA Atlas 14 Data
NRCS
Legend
Single Rainfall Zone Counties
Accomack DMV-C
Caroline NOAA-C
Charles City NOAA-C
Chesapeake City NOAA-B
Chesterfield NOAA-C
Dinwiddie NOAA-C
Essex NOAA-C
Gloucester NOAA-C
Greensville NOAA-B
Hampton City NOAA-C
Hanover NOAA-C
Henrico NOAA-C
Isle of Wight NOAA-B
James City NOAA-C
King William NOAA-C
King and Queen NOAA-C
Lancaster NOAA-C
Mathews NOAA-C
Middlesex NOAA-C
New Kent NOAA-C
Newport News City NOAA-C
Norfolk City NOAA-C
Northampton DMV-C
Northumberland NOAA-C
Petersburg City NOAA-C
Poquoson City NOAA-C
Portsmouth City NOAA-C
Prince George NOAA-C
Richmond City NOAA-C
Richmond NOAA-C
Southampton NOAA-B
Suffolk City NOAA-B
Surry NOAA-C
Sussex NOAA-C
Virginia Beach City NOAA-C
Westmoreland NOAA-C
York NOAA-C
Area Boundary
Interstate Highway
Primary Highway
County Boundary
Major Streams
Area IV Office Location
Digital Data and Map Source
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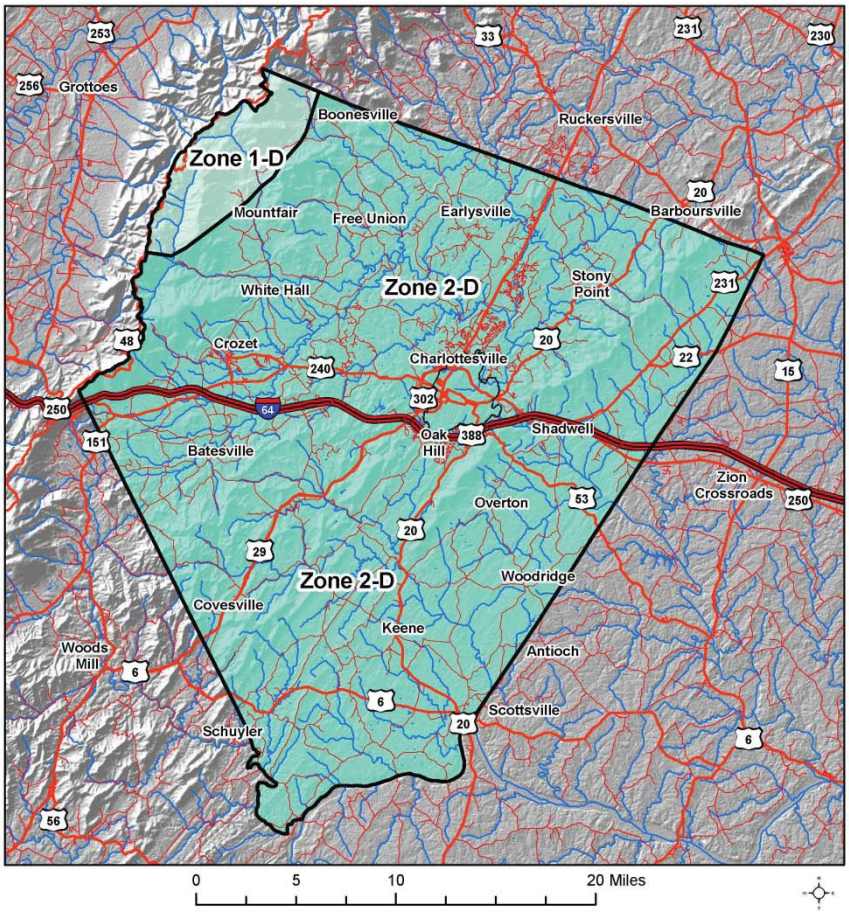
Westmoreland
Caroline
Essex
Richmond
Northumberland
Hanover
King William
King and Queen
Lancaster
Middlesex
Richmond City
New Kent
Henrico
Chesterfield
James City
Gloucester
Mathews
Charles City
Colonial Heights
Hopewell
Williamsburg
Petersburg
Prince George
York
Dinwiddie
Surry
Poquoson
Newport News
Hampton
Sussex
Isle of Wight
Norfolk
Portsmouth
Virginia Beach
Southampton
Suffolk City
Emporia
Franklin City
Chesapeake City
Greensville
Beach
Chesapeake Bay
Atlantic Ocean
Accomack
Northampton
20 10 0 20 40 60 80 Miles
0 12.5 25 50 75 100 125 Kilometers
Map Date:060512



Albemarle County & The City of Charlottesville, Virginia Rainfall Zones Using NOAA Atlas 14 Data

Legend

VA Rainfall Zones

- Albemarle Co ZONE 1-NOAA D
- Albemarle Co ZONE 2-NOAA D
- VDOT Interstate
- VDOT Primary
- VDOT Secondary
- NHD Main Streams
- County Boundary

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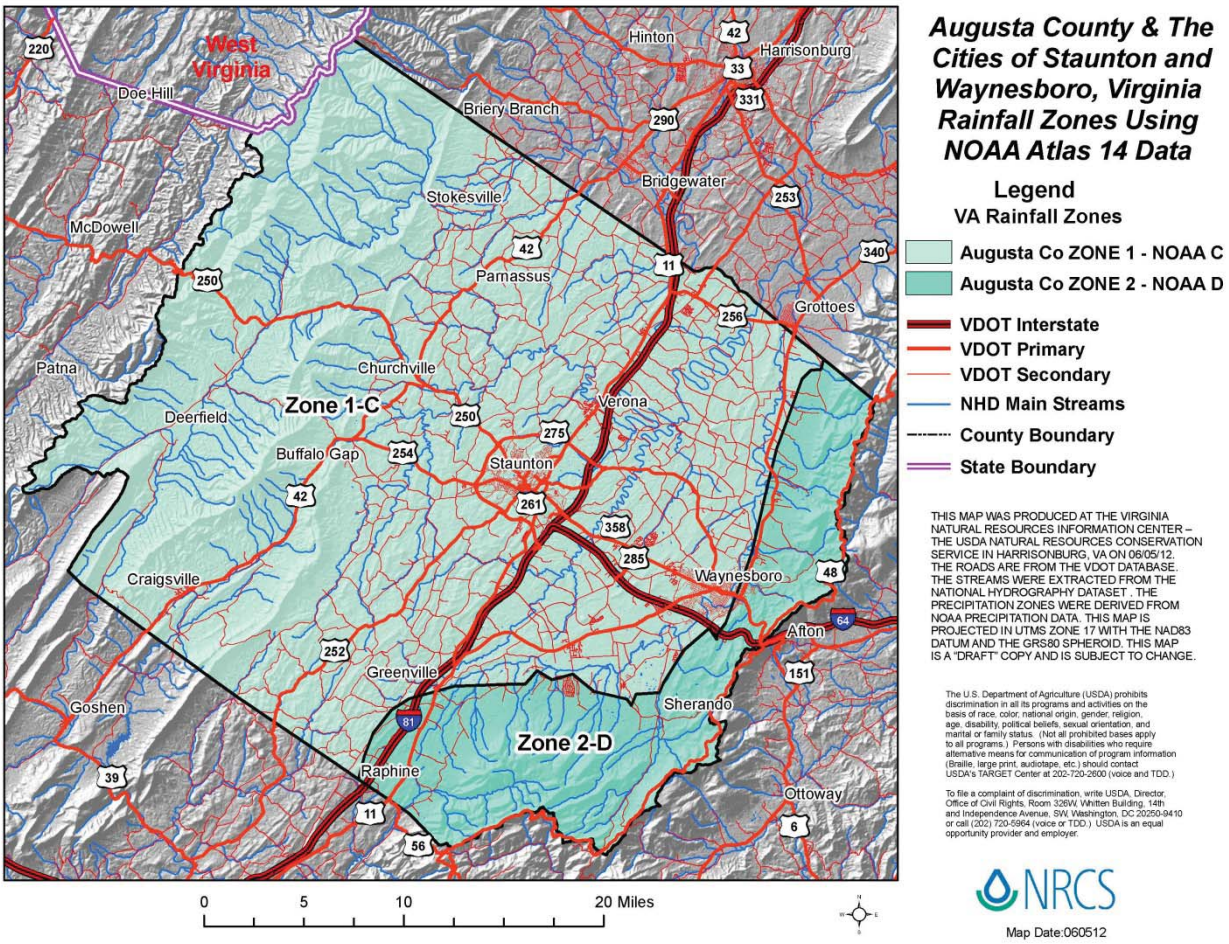
NRCS

Map Date:060512


Augusta County & The Cities of Staunton and Waynesboro, Virginia Rainfall Zones Using NOAA Atlas 14 Data
Legend
VA Rainfall Zones
Augusta Co ZONE 1 - NOAA C
Augusta Co ZONE 2 - NOAA D
VDOT Interstate
VDOT Primary
VDOT Secondary
NHD Main Streams
County Boundary
State Boundary
Zone 1-C
Zone 2-D
West Virginia
Hinton
Harrisonburg
Doe Hill
Briery Branch
Bridgewater
Stokesville
McDowell
Parnassus
Grottoes
Patna
Churchville
Verona
Deerfield
Buffalo Gap
Staunton
Craigsville
Waynesboro
Afton
Greenville
Sherando
Goshen
Raphine
Ottoway
0 5 10 20 Miles
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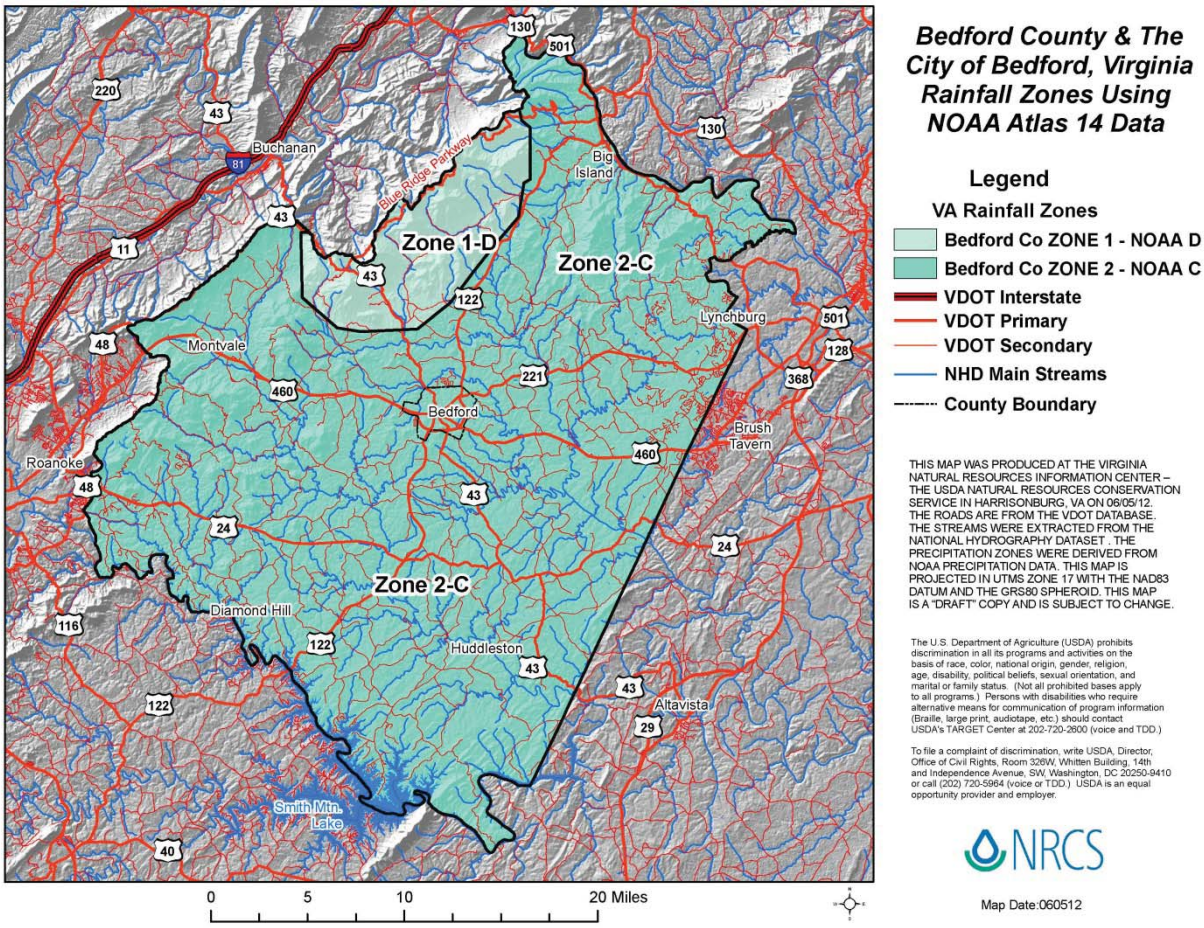
NRCS
Map Date:060512



Bedford County & The City of Bedford, Virginia Rainfall Zones Using NOAA Atlas 14 Data

Legend

VA Rainfall Zones

- Bedford Co ZONE 1 - NOAA D
- Bedford Co ZONE 2 - NOAA C
- VDOT Interstate
- VDOT Primary
- VDOT Secondary
- NHD Main Streams
- County Boundary

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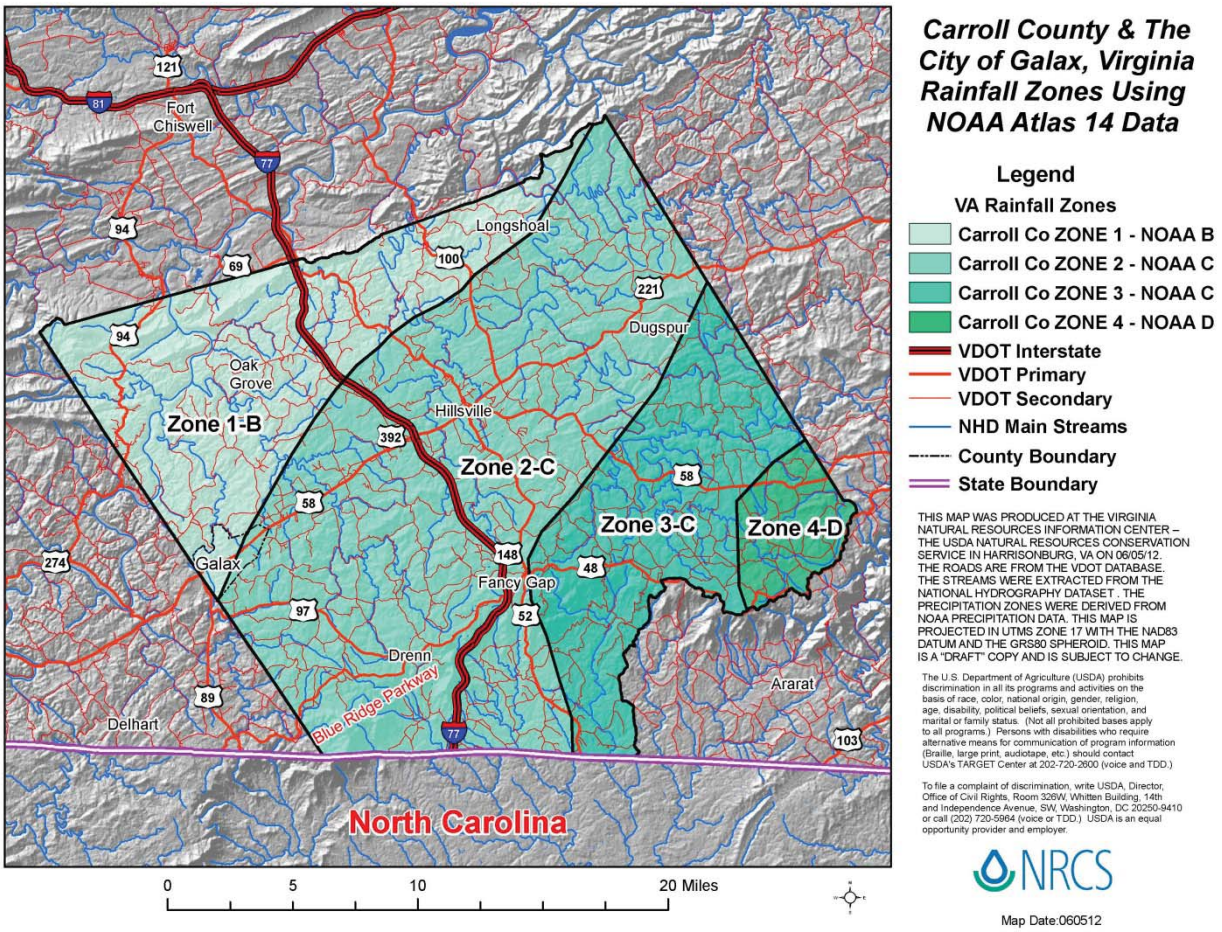
NRCS

Map Date:060512


Carroll County & The City of Galax, Virginia Rainfall Zones Using NOAA Atlas 14 Data
Legend
VA Rainfall Zones
Carroll Co ZONE 1 - NOAA B
Carroll Co ZONE 2 - NOAA C
Carroll Co ZONE 3 - NOAA C
Carroll Co ZONE 4 - NOAA D
VDOT Interstate
VDOT Primary
VDOT Secondary
NHD Main Streams
County Boundary
State Boundary
Zone 1-B
Zone 2-C
Zone 3-C
Zone 4-D
Fort Chiswell
Longshoal
Dugspur
Oak Grove
Hillsville
Galax
Fancy Gap
Drenn
Ararat
Delhart
Blue Ridge Parkway
North Carolina
0 5 10 20 Miles
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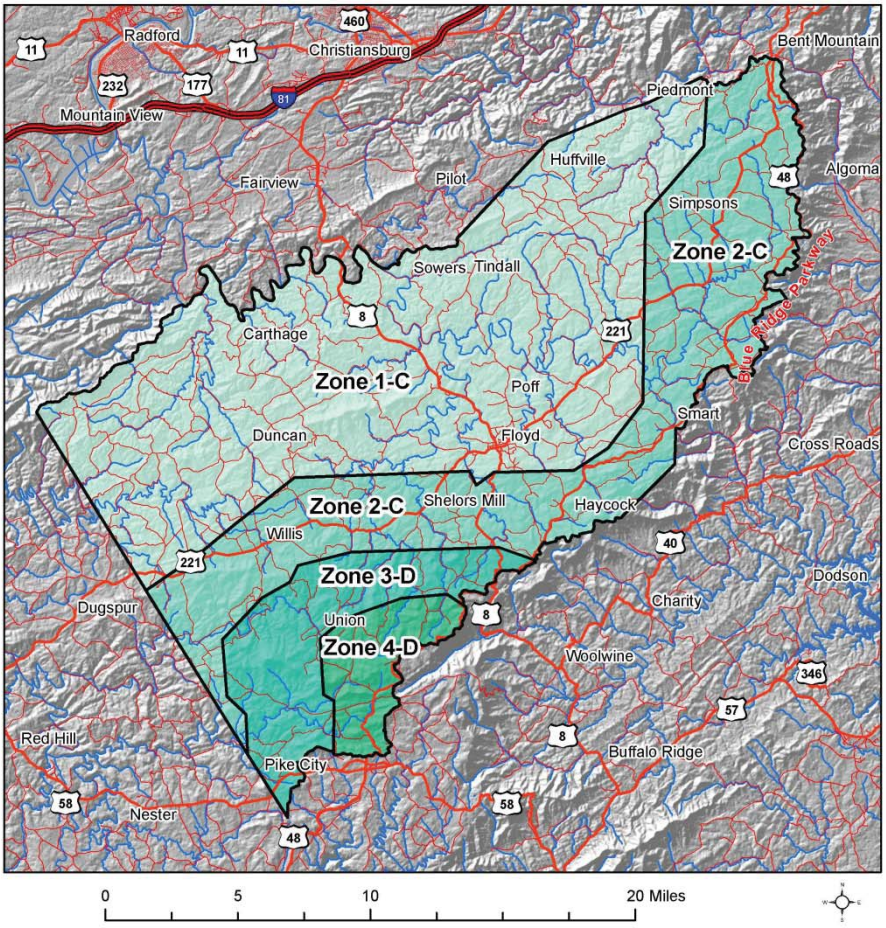

Floyd County, Virginia Rainfall Zones Using NOAA Atlas 14 Data

Legend
VA Rainfall Zones

- Floyd ZONE 1 - NOAA C
- Floyd ZONE 2 - NOAA C
- Floyd ZONE 3 - NOAA D
- Floyd ZONE 4 - NOAA D
- VDOT Interstate
- VDOT Primary
- VDOT Secondary
- NHD Main Streams
- County Boundary

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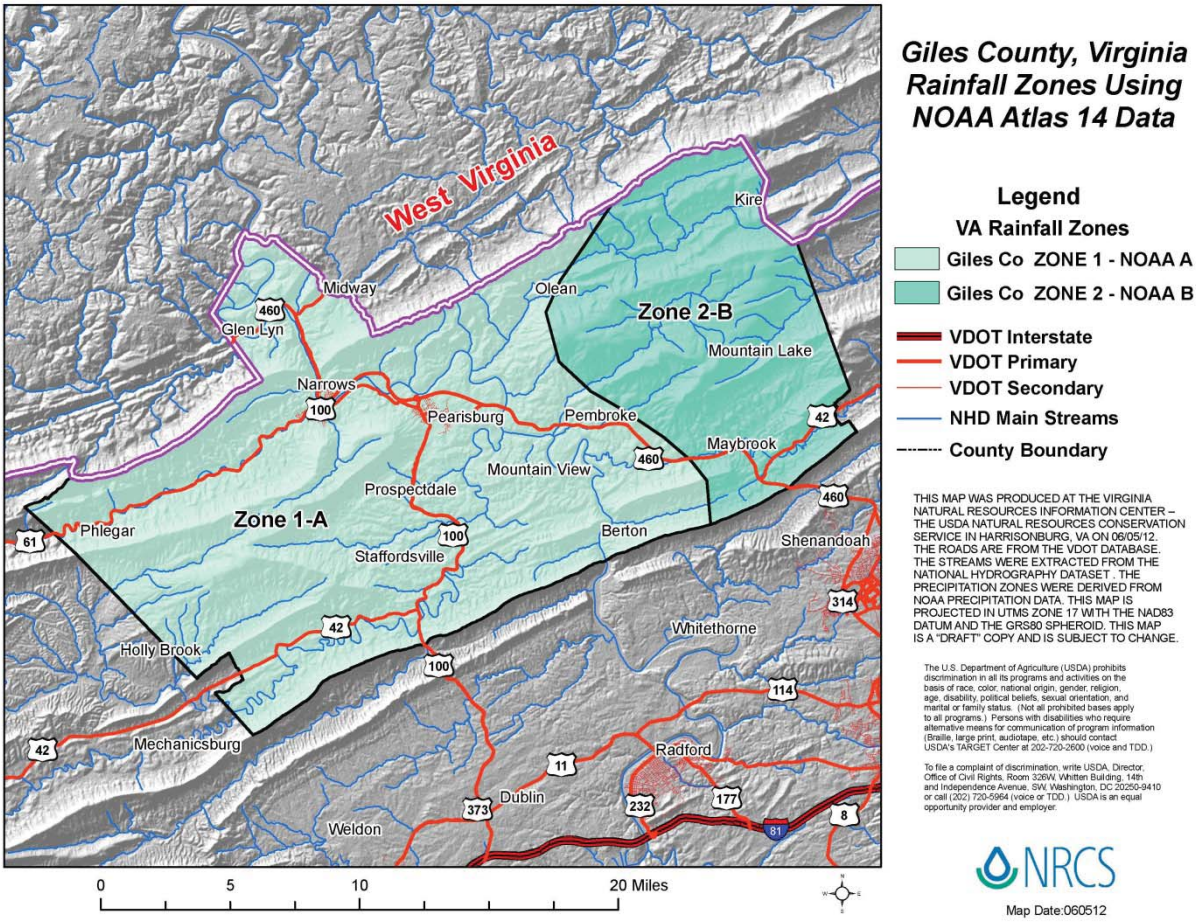
West Virginia
Kire
Midway
Olean
Zone 2-B
Glen Lyn
460
Mountain Lake
Narrows
100
Pearisburg
Pembroke
42
Maybrook
460
Mountain View
Prospectdale
460
Zone 1-A
Phlegar
61
100
Berton
Shenandoah
Staffordsville
314
42
Whitethorne
Holly Brook
100
114
42
Mechanicsburg
Radford
11
Dublin
373
232
177
8
Weldon
81
0
5
10
20 Miles
Giles County, Virginia
Rainfall Zones Using
NOAA Atlas 14 Data
Legend
VA Rainfall Zones
Giles Co ZONE 1 - NOAA A
Giles Co ZONE 2 - NOAA B
VDOT Interstate
VDOT Primary
VDOT Secondary
NHD Main Streams
County Boundary
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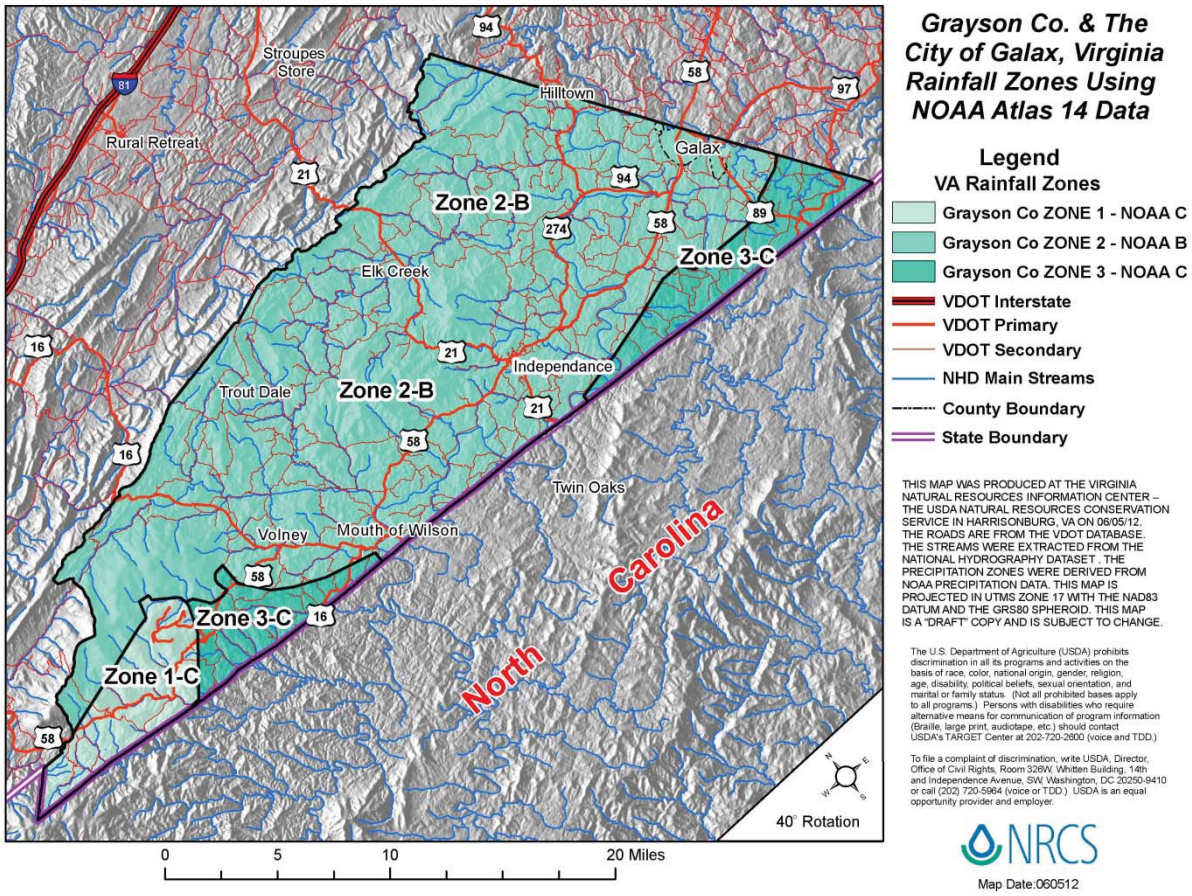
Grayson Co. & The City of Galax, Virginia Rainfall Zones Using NOAA Atlas 14 Data
Legend
VA Rainfall Zones
Grayson Co ZONE 1 - NOAA C
Grayson Co ZONE 2 - NOAA B
Grayson Co ZONE 3 - NOAA C
VDOT Interstate
VDOT Primary
VDOT Secondary
NHD Main Streams
County Boundary
State Boundary
Stroupes Store
Hilltown
Rural Retreat
Galax
Zone 2-B
Zone 3-C
Elk Creek
Independance
Trout Dale
Zone 2-B
Twin Oaks
Volney
Mouth of Wilson
Carolina
North
Zone 3-C
Zone 1-C
40° Rotation
0 5 10 20 Miles
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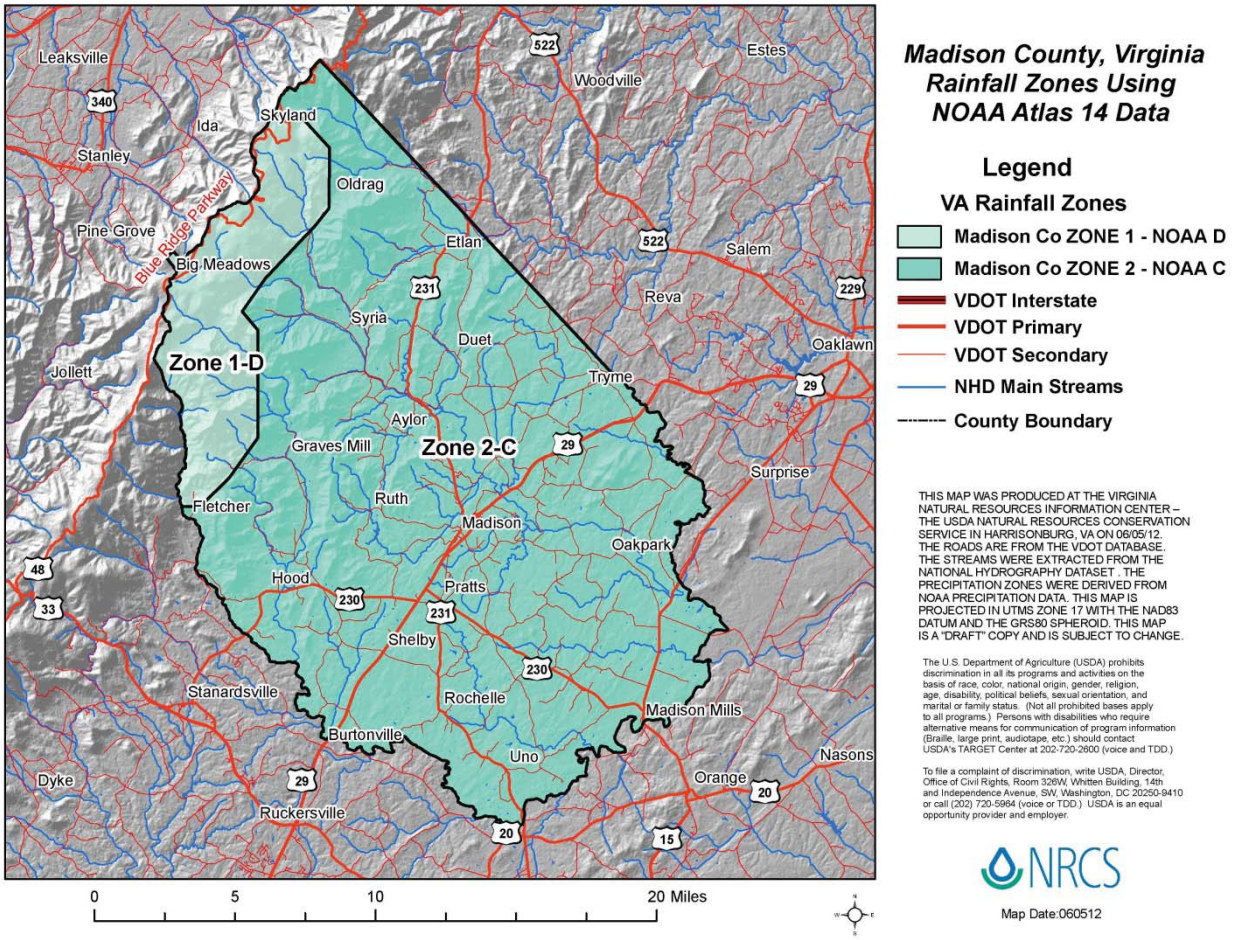
Madison County, Virginia
Rainfall Zones Using
NOAA Atlas 14 Data
Legend
VA Rainfall Zones
Madison Co ZONE 1 - NOAA D
Madison Co ZONE 2 - NOAA C
VDOT Interstate
VDOT Primary
VDOT Secondary
NHD Main Streams
County Boundary
Zone 1-D
Zone 2-C
Leaksville
Skyland
Ida
Stanley
Oldrag
Pine Grove
Blue Ridge Parkway
Big Meadows
Etlan
Syria
Duet
Jollett
Tryme
Aylor
Graves Mill
Fletcher
Ruth
Madison
Oakpark
Hood
Pratts
Shelby
Rochelle
Stanardsville
Burtonville
Uno
Madison Mills
Dyke
Ruckersville
Orange
Nasons
Surprise
Oaklawn
Reva
Salem
Woodville
Estes
0
5
10
20 Miles
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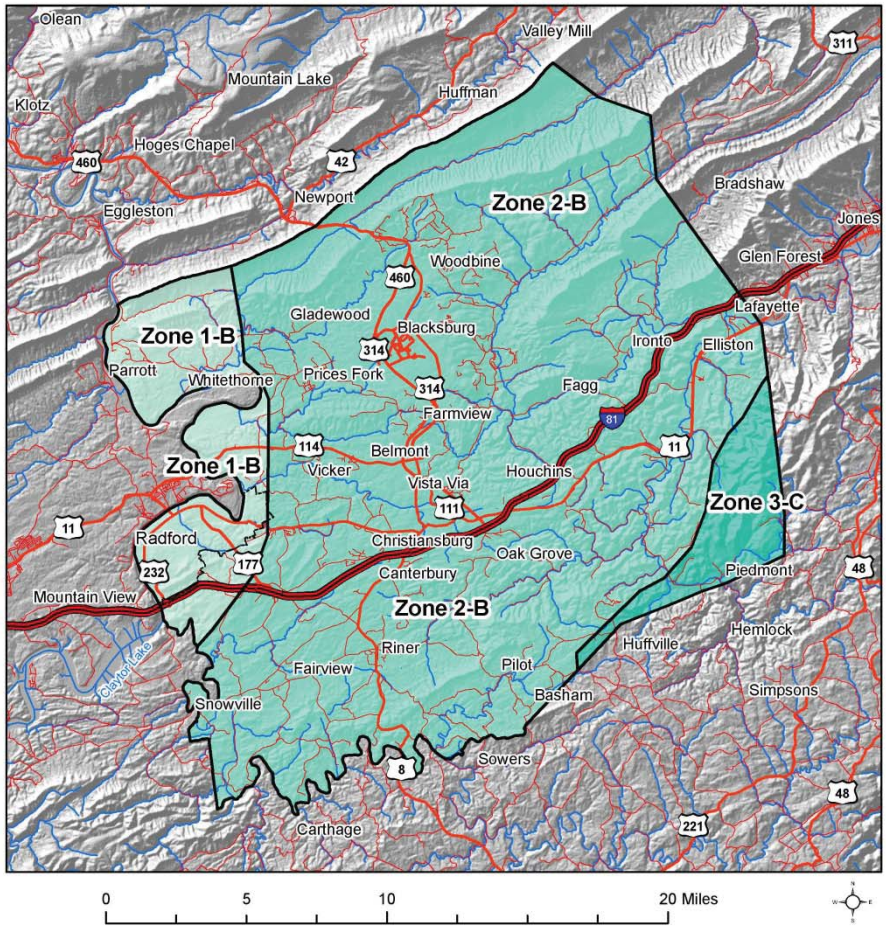

Montgomery County & The City of Radford, Virginia Rainfall Zones Using NOAA Atlas 14 Data

Legend

VA Rainfall Zones

- Montgomery Co ZONE 1 - NOAA B
- Montgomery Co ZONE 2 - NOAA B
- Montgomery Co ZONE 3 - NOAA C
- VDOT Interstate
- VDOT Primary
- VDOT Secondary
- NHD Main Streams
- County Boundary

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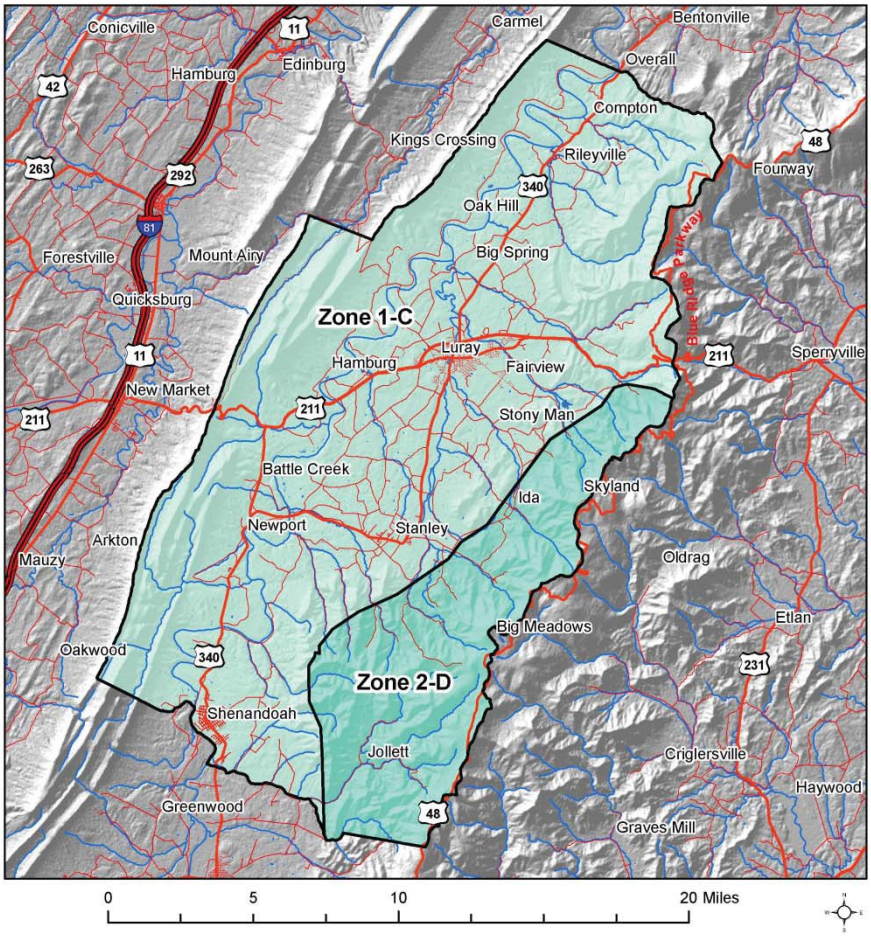
Map Date:060512



Page County, Virginia Rainfall Zones Using NOAA Atlas 14 Data

Legend

VA Rainfall Zones

- Page Co ZONE 1 - NOAA C
- Page Co ZONE 2 - NOAA D
- VDOT Interstate
- VDOT Primary
- VDOT Secondary
- NHD Main Streams
- County Boundary
- State Boundary

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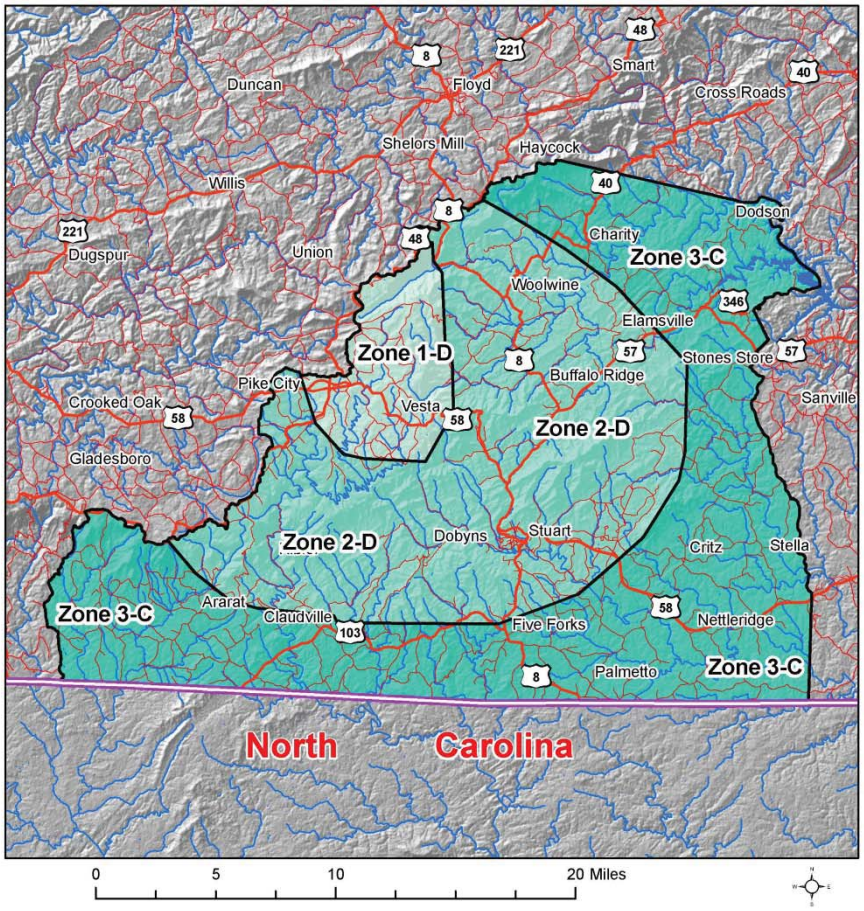

Patrick County, Virginia Rainfall Zones Using NOAA Atlas 14 Data

Legend

VA Rainfall Zones

- Patrick Co ZONE1 - NOAA D
- Patrick Co ZONE 2 - NOAA D
- Patrick Co ZONE 3 - NOAA C
- VDOT Interstate
- VDOT Primary
- VDOT Secondary
- NHD Main Streams
- County Boundary
- State Boundary

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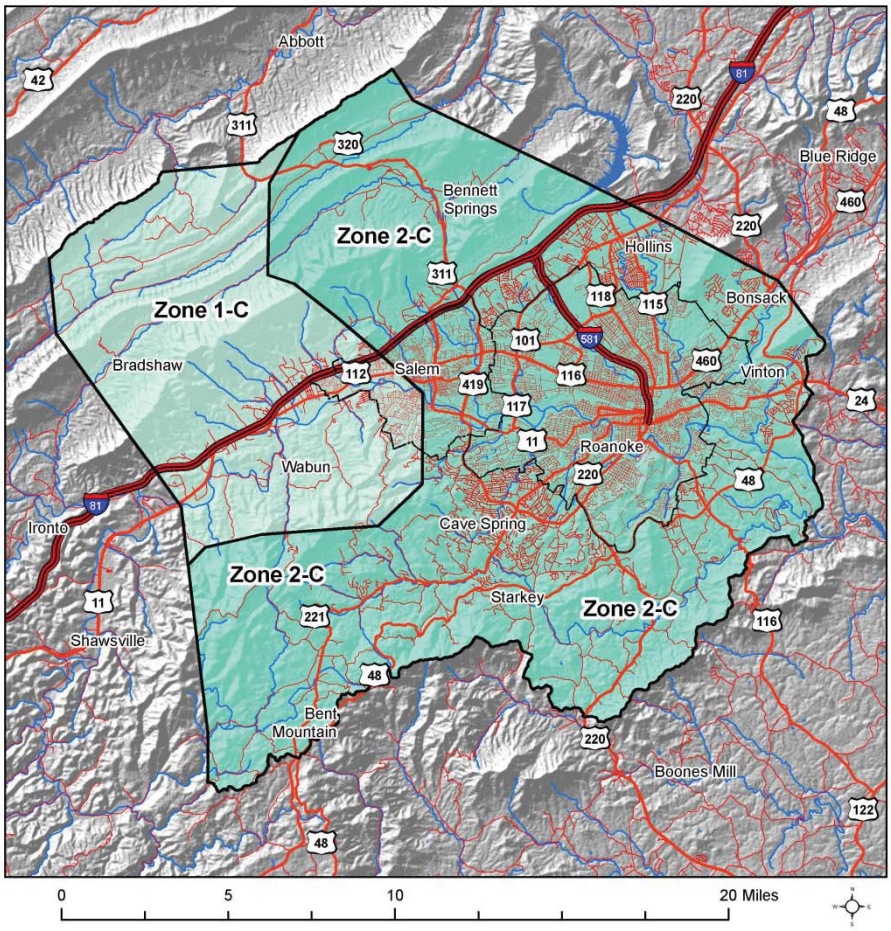

Roanoke County - with Roanoke & Salem Cities, Virginia Rainfall Zones Using NOAA Atlas 14 Data

Legend

VA Rainfall Zones

- Roanoke Co ZONE 1 - NOAA C
- Roanoke Co ZONE 2 - NOAA C
- VDOT Interstate
- VDOT Primary
- VDOT Secondary
- NHD Main Streams
- County Boundary

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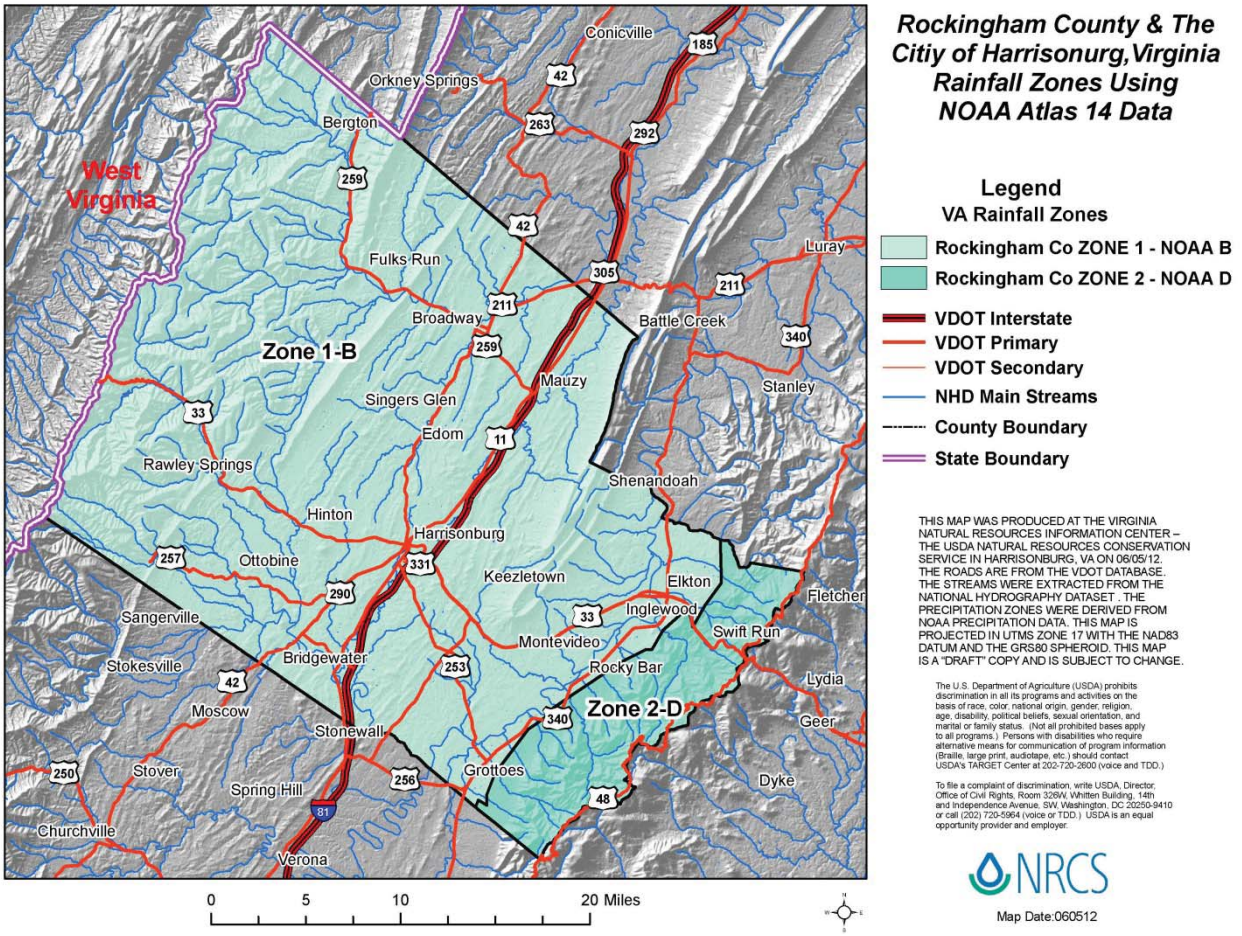
Rockingham County & The Citiy of Harrisonurg,Virginia Rainfall Zones Using NOAA Atlas 14 Data
Legend
VA Rainfall Zones
Rockingham Co ZONE 1 - NOAA B
Rockingham Co ZONE 2 - NOAA D
VDOT Interstate
VDOT Primary
VDOT Secondary
NHD Main Streams
County Boundary
State Boundary
West Virginia
Zone 1-B
Zone 2-D
Conicville
Orkney Springs
Bergton
Fulks Run
Broadway
Singers Glen
Edom
Rawley Springs
Hinton
Harrisonburg
Ottobine
Keezletown
Sangerville
Stokesville
Bridgewater
Moscow
Stonewall
Stover
Spring Hill
Churchville
Verona
Grottoes
Montevideo
Rocky Bar
Mauzy
Battle Creek
Shenandoah
Luray
Stanley
Elkton
Inglewood
Swift Run
Fletcher
Lydia
Geer
Dyke
0 5 10 20 Miles
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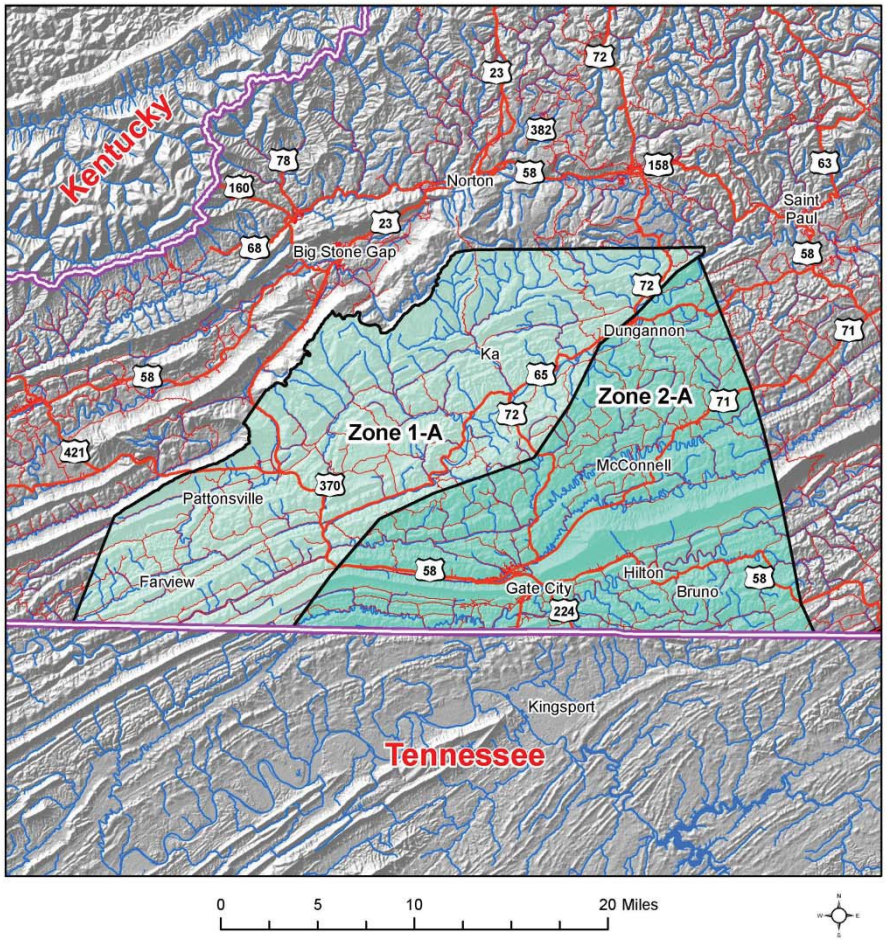

Scott County, Virginia Rainfall Zones Using NOAA Atlas 14 Data

Legend

VA Rainfall Zones

- Scott Co ZONE 1 - NOAA A
- Scott Co ZONE 2 - NOAA A
- VDOT Interstate
- VDOT Primary
- VDOT Secondary
- NHD Main Streams
- County Boundary
- State Boundary

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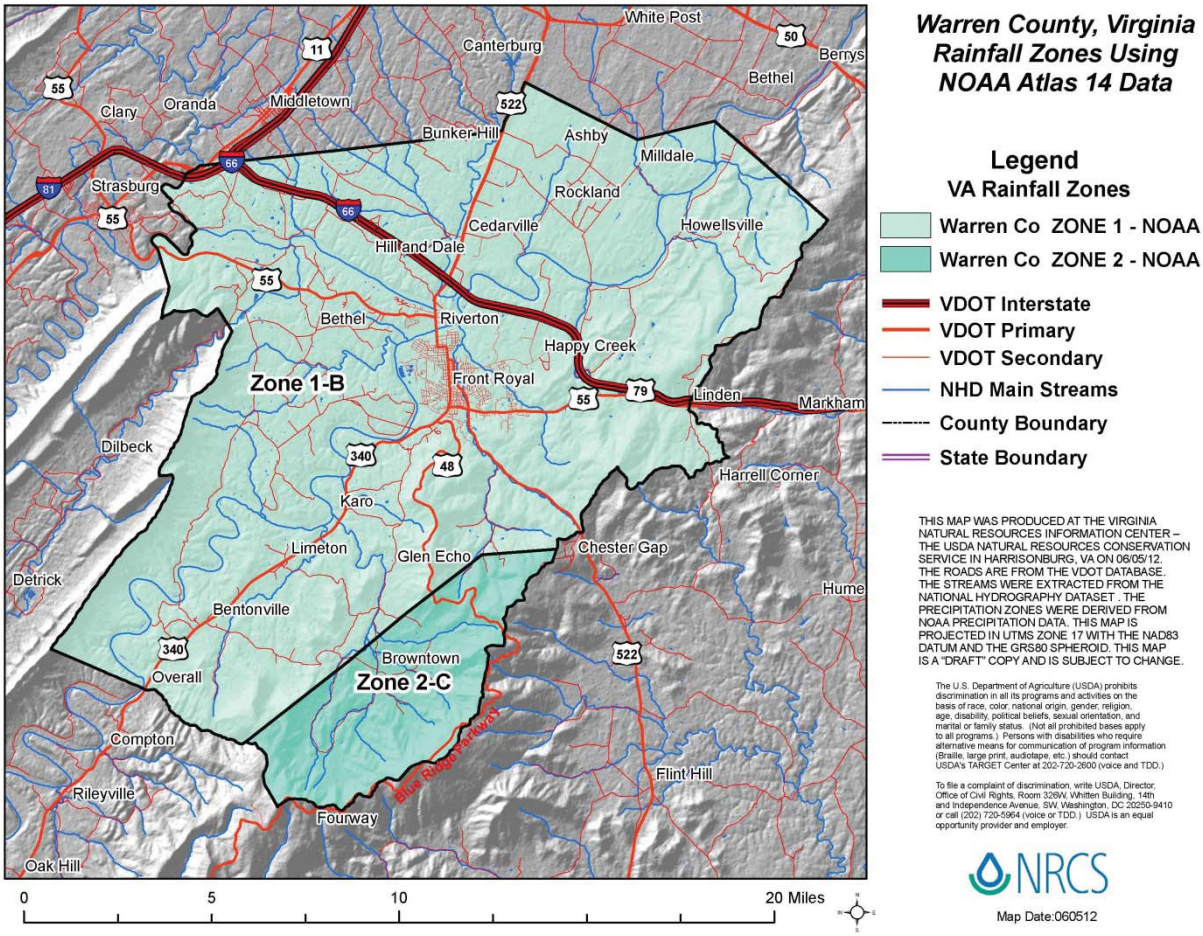
Warren County, Virginia
Rainfall Zones Using
NOAA Atlas 14 Data
Legend
VA Rainfall Zones
Warren Co ZONE 1 - NOAA B
Warren Co ZONE 2 - NOAA C
VDOT Interstate
VDOT Primary
VDOT Secondary
NHD Main Streams
County Boundary
State Boundary
Zone 1-B
Zone 2-C
White Post
Canterbury
Berrys
Bethel
Clary
Oranda
Middletown
Bunker Hill
Ashby
Milldale
Strasburg
Rockland
Cedarville
Howellsville
Hilland Dale
Bethel
Riverton
Happy Creek
Front Royal
Linden
Markham
Dilbeck
Harrell Corner
Karo
Limeton
Glen Echo
Chester Gap
Detrick
Hume
Bentonville
Browntown
Overall
Compton
Flint Hill
Rileyville
Fourway
Blue Ridge Parkway
Oak Hill
0
5
10
20 Miles
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