Estimating Water Availability in the Shenandoah Valley Using Chemical Hydrograph Separation

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Water Availability

- Availability in the broadest sense—that which is not evaporated or used by vegetation—that which eventually flows out the streams
- Different from “How much can I extract?”
- Estimated by quantifying the hydrologic cycle

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Methods

- Simple water balance within the hydrologic cycle—several components
- Relating measurements at specific sites to climate and geology allows extrapolation to entire area
- Chemical hydrograph separation to get at runoff versus baseflow and recharge

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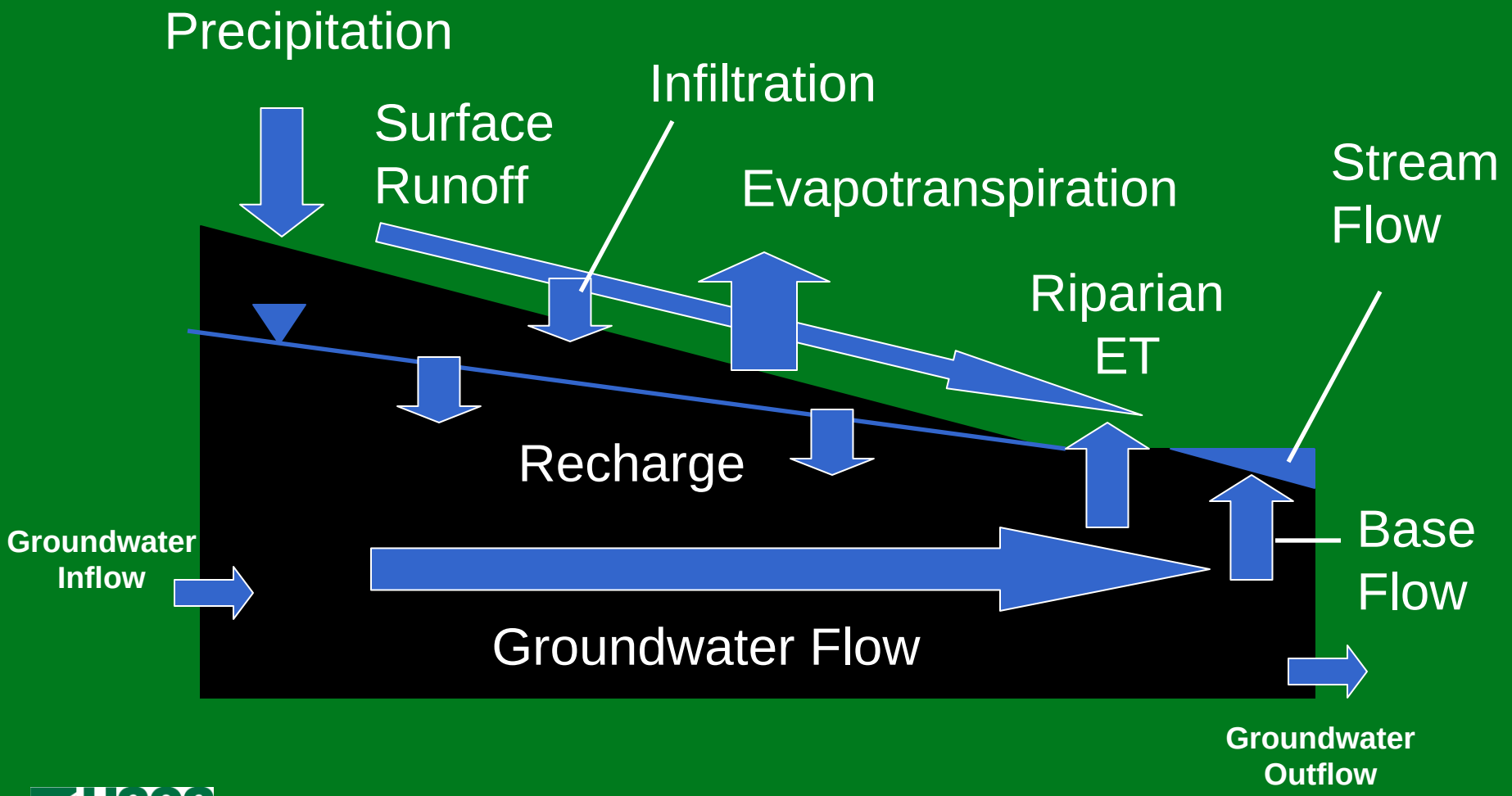
Hydrologic Cycle Components



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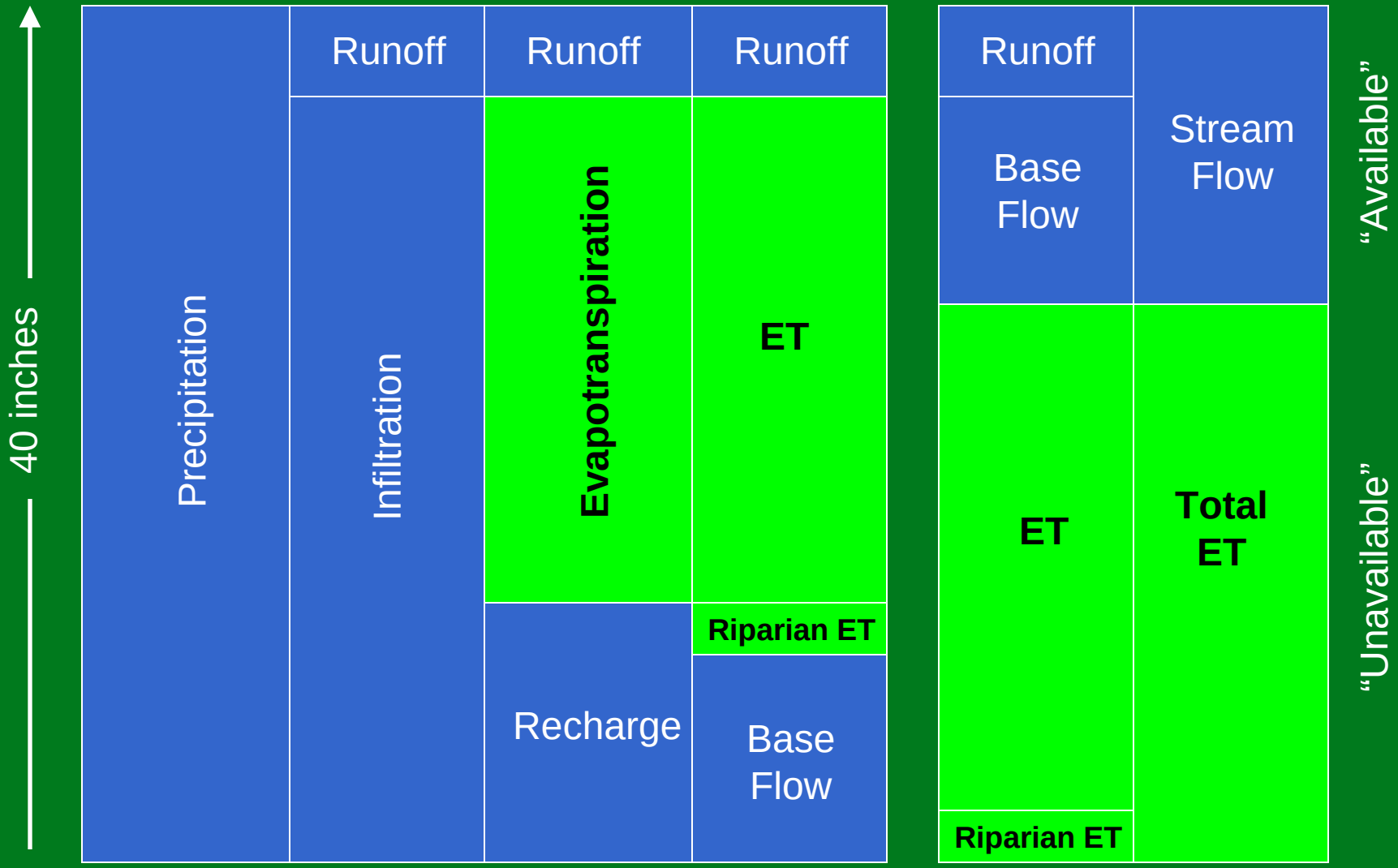

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Real-Time Stream Gages in Virginia

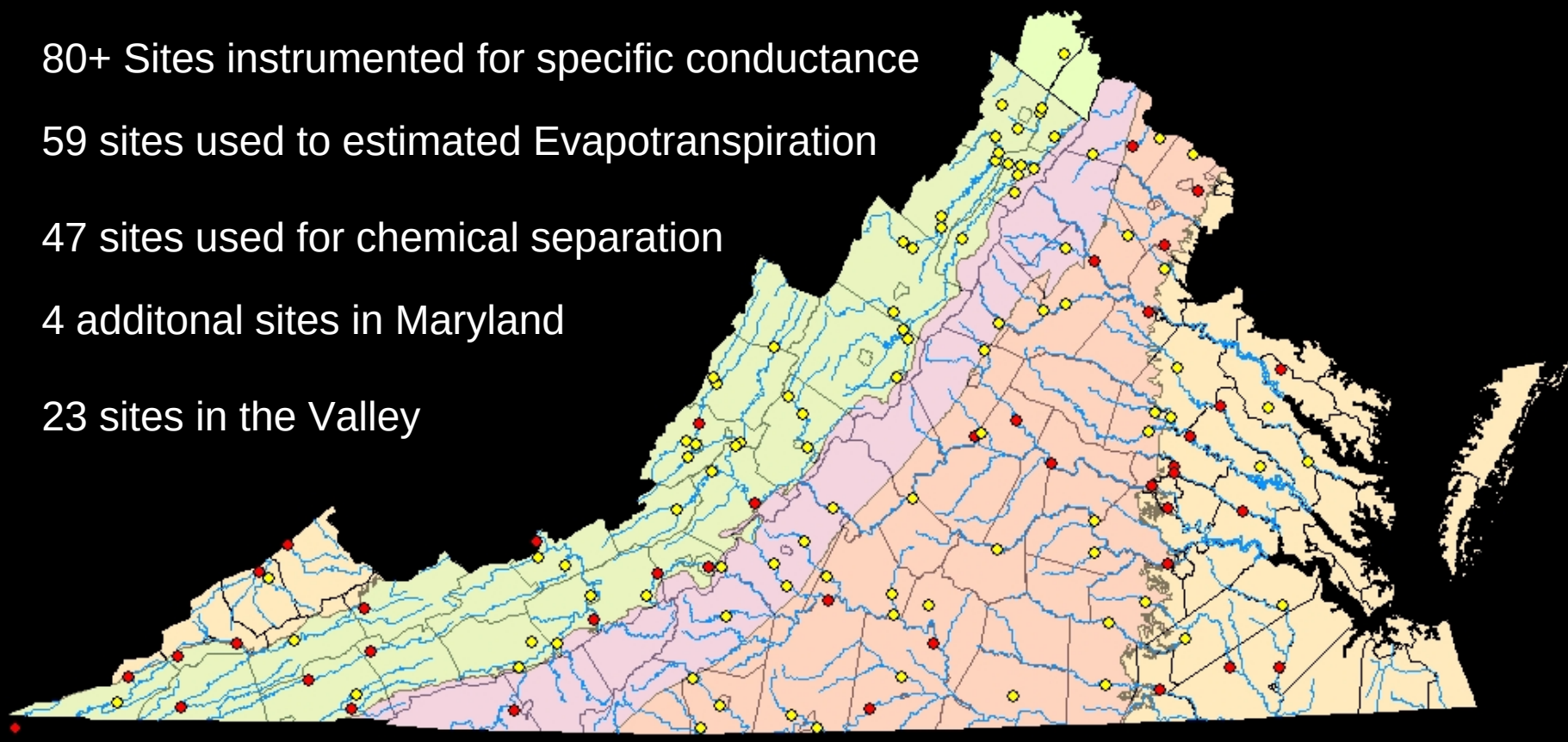
80+ Sites instrumented for specific conductance

59 sites used to estimated Evapotranspiration

47 sites used for chemical separation

4 additonal sites in Maryland

23 sites in the Valley



Funding provided by VA Dept of Environmental Quality, USGS Office of Groundwater, USGS Eastern Regional Office and USGS National Research Program, Water

Evapotranspiration

- Comparing Streamflow with Precipitation
- ET = Precipitation*Area – Streamflow
- PRISM Climate Data Set, 1971-2000
- Is ET a function of Temperature as well?

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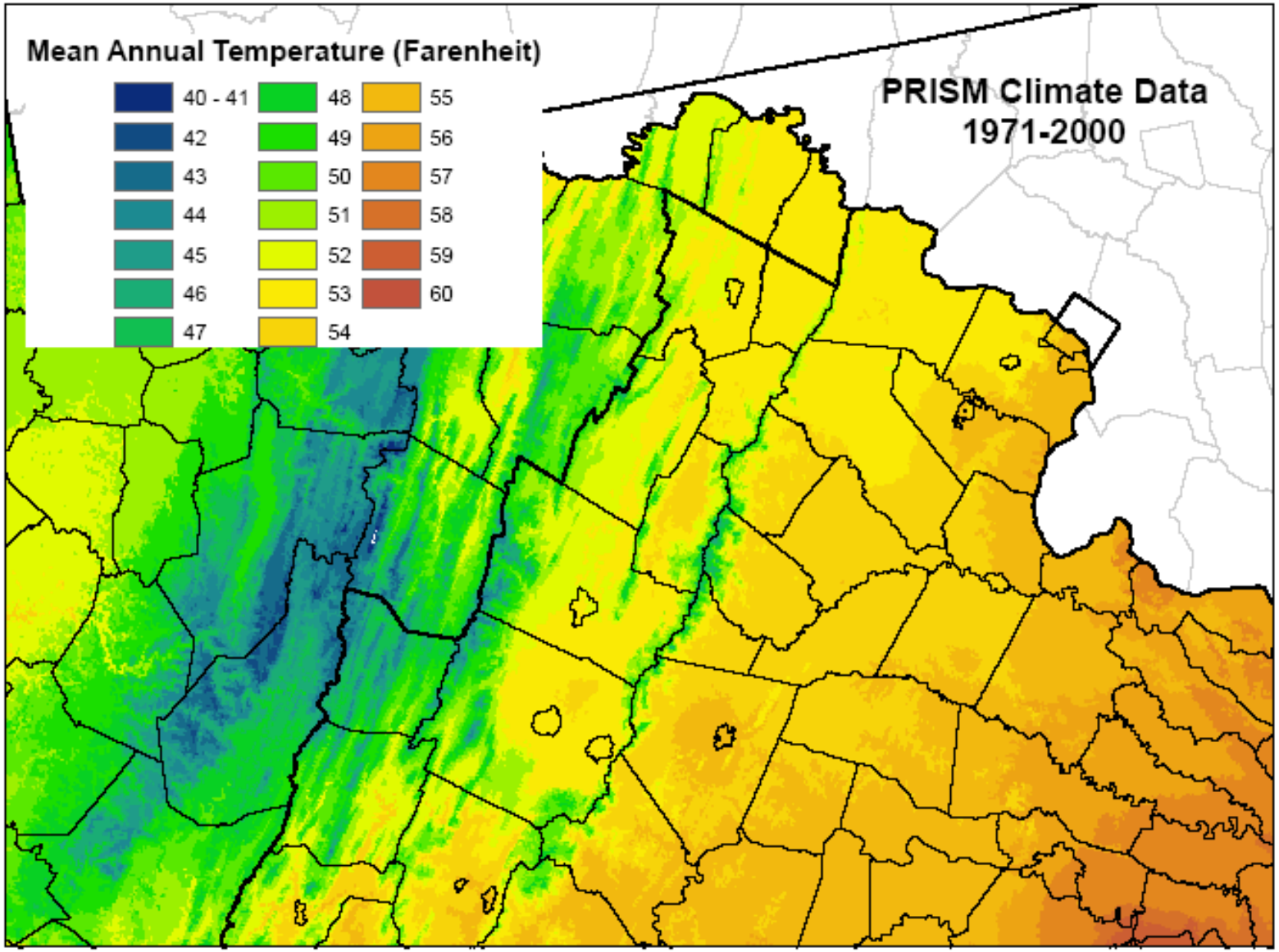

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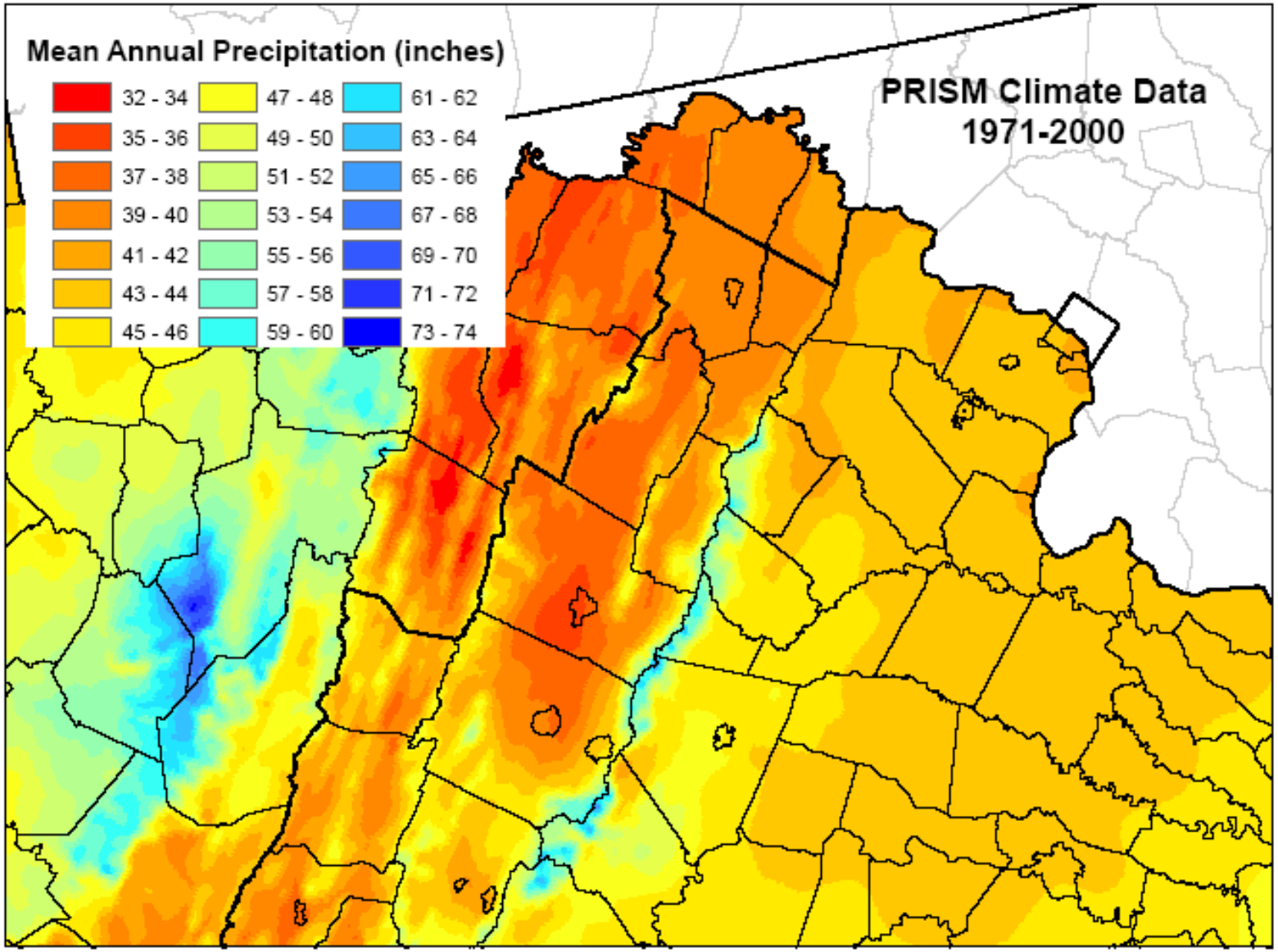

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Evapotranspiration

Watershed	Flow in CFS	Area sq miles	Precip inches	Flow in inches	ET total inches	ET % of precip	Temp F
01613900 Hogue Creek near Hayfield, VA	17.3	15.9	39.9	14.8	25.1	63.0%	52.5
01615000 Opequon Creek near Berryville, VA	54.1	58.2	39.0	12.6	26.4	67.6%	53.6
01615000 Opequon Creek at Martinsburg, WV	281.5	273.0	39.4	14.0	25.4	64.5%	53.6
01622000 North River near Burketown, VA	425.7	376.0	40.0	15.4	24.6	61.6%	51.1
01625000 Middle River near Grottoes, VA	362.4	373.0	40.4	13.2	27.2	67.3%	53.1
01626000 South River near Waynesboro, VA	169.3	127.0	48.2	18.1	30.1	62.4%	52.7
01627500 South River at Harriston, VA	288.6	212.0	47.6	18.5	29.1	61.2%	53.1
01631000 S F Shenandoah at Front Royal, VA	1790.0	1634.0	42.1	14.9	27.2	64.7%	52.6
01632000 N F Shenandoah at Cootes Store, VA	221.4	210.0	39.4	14.3	25.1	63.7%	51.0
01632900 Smith Creek near New Market, VA	82.6	93.6	39.6	12.0	27.6	69.7%	53.1
01633000 N F Shenandoah at Mt Jackson, VA	457.3	508.0	38.7	12.2	26.5	68.4%	52.3
01634000 N F Shenandoah near Strasburg, VA	682.8	770.0	38.7	12.0	26.7	68.9%	52.4
01634500 Cedar Creek near Winchester, VA	115.8	102.0	40.3	15.4	24.9	61.7%	52.1
01635500 Passage Creek near Buckton, VA	79.7	86.5	41.4	12.5	28.9	69.8%	52.6

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Evapotranspiration Equation

$$ET = 0.363 * Precip + 0.985 * Tmax - 0.377 * Tmin - 35.995$$

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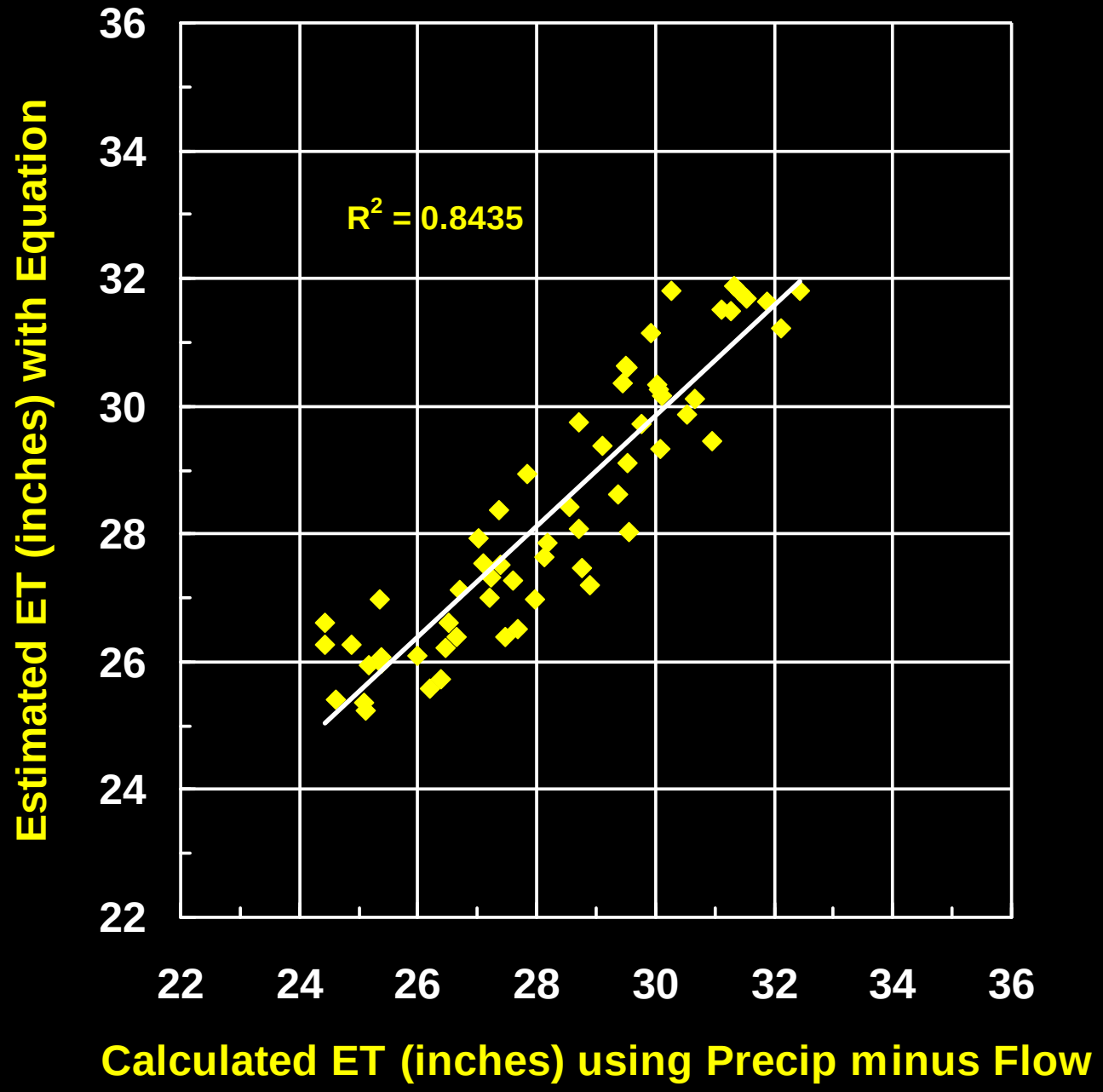

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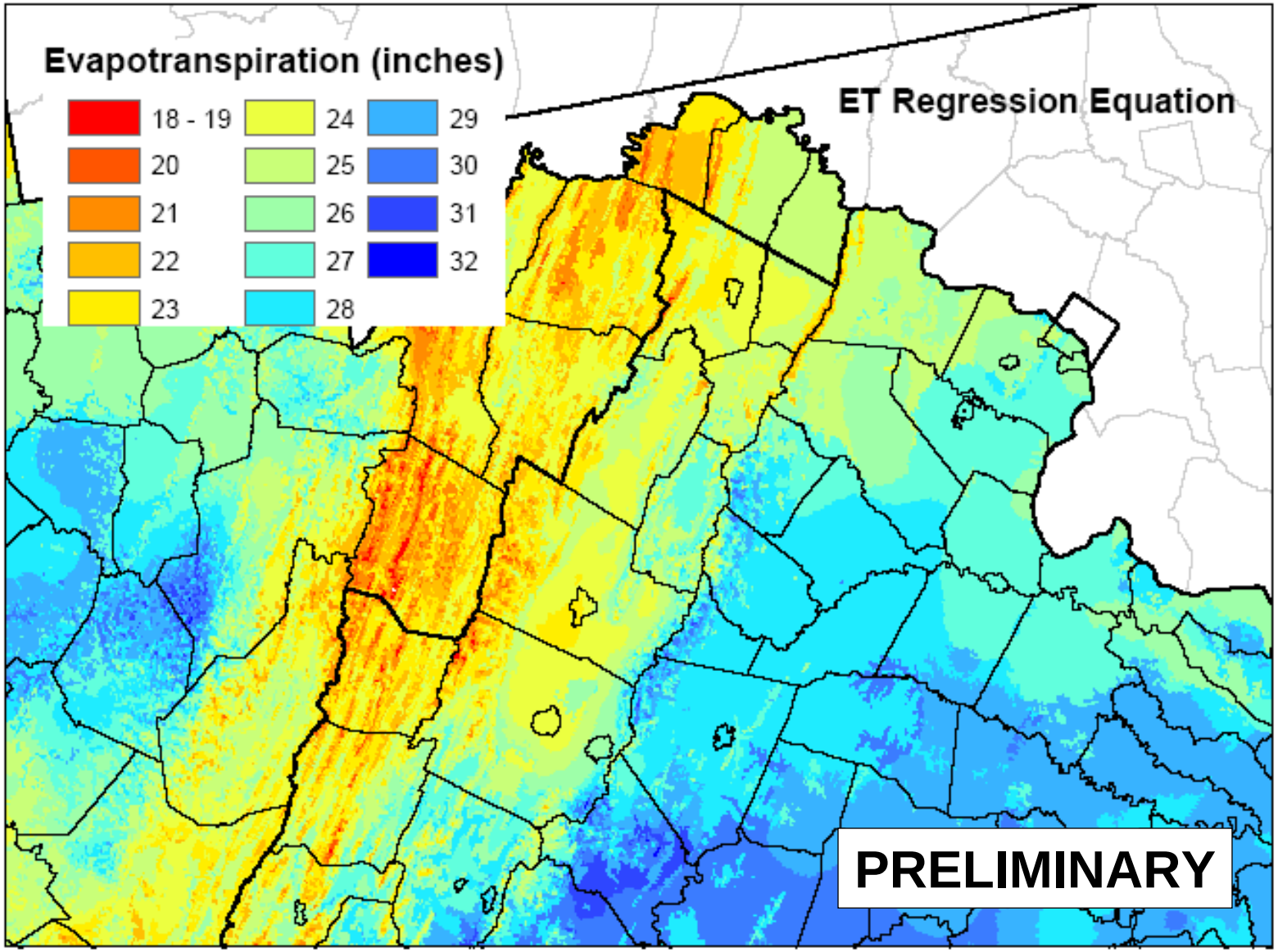

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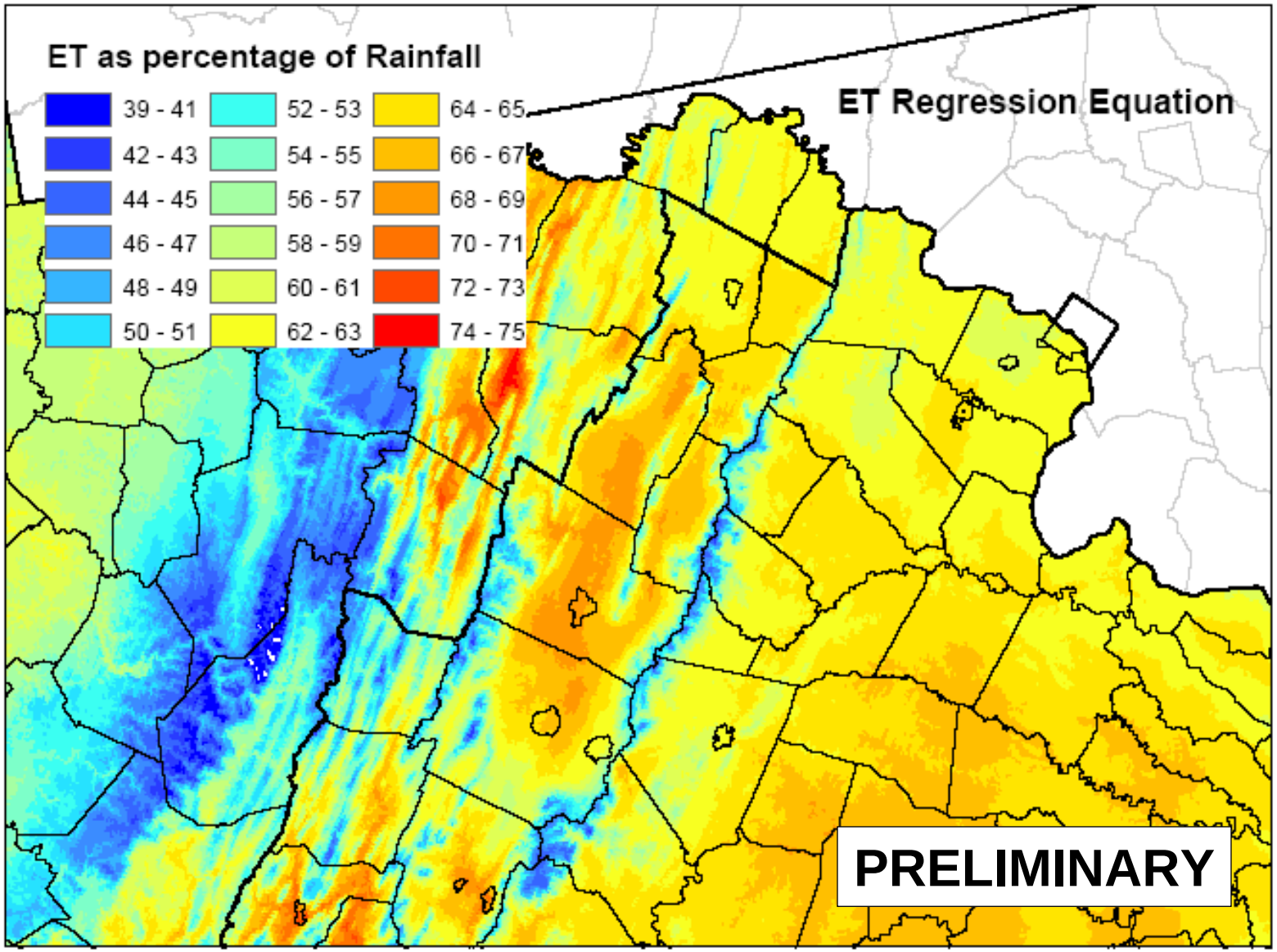

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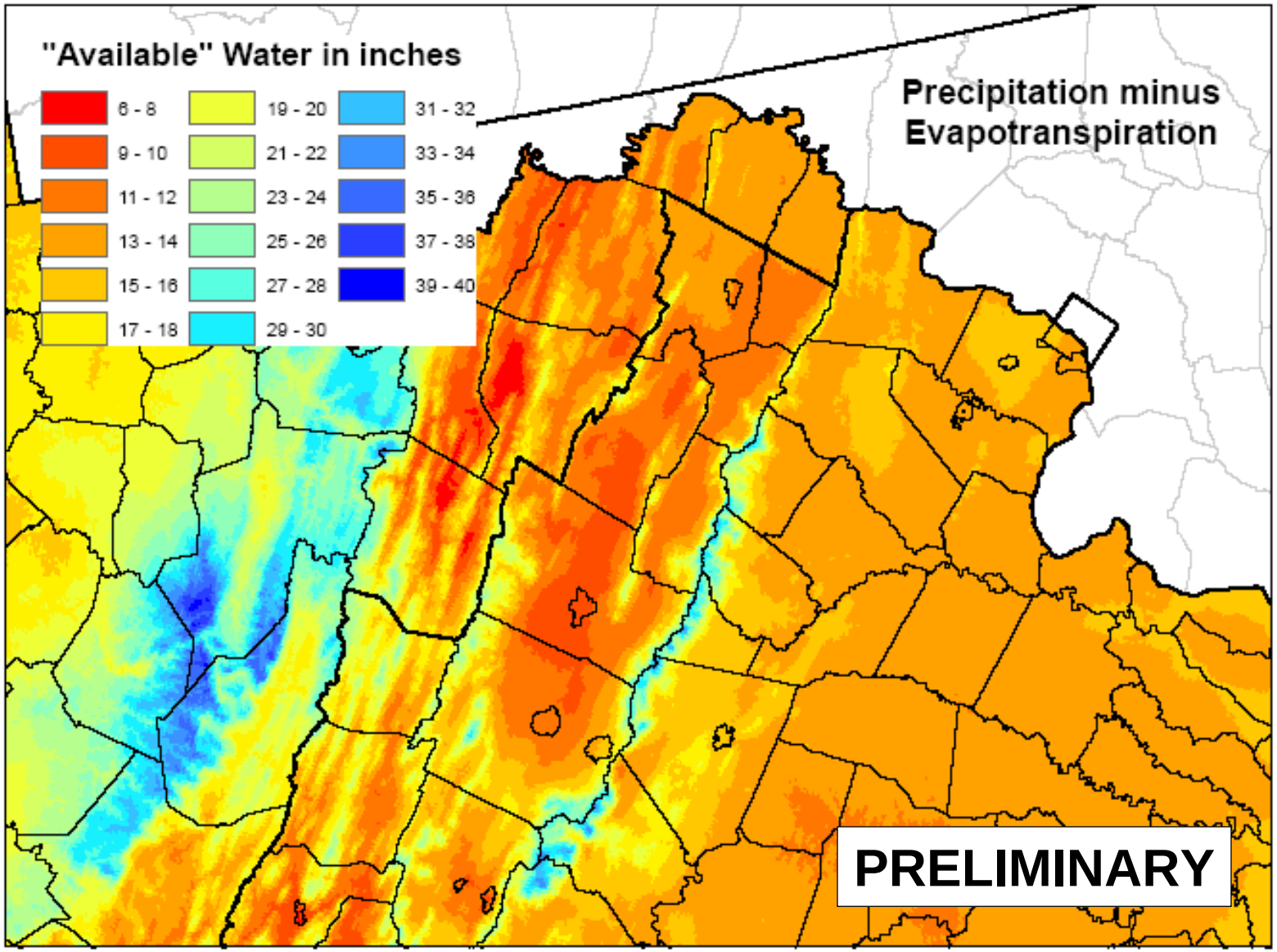

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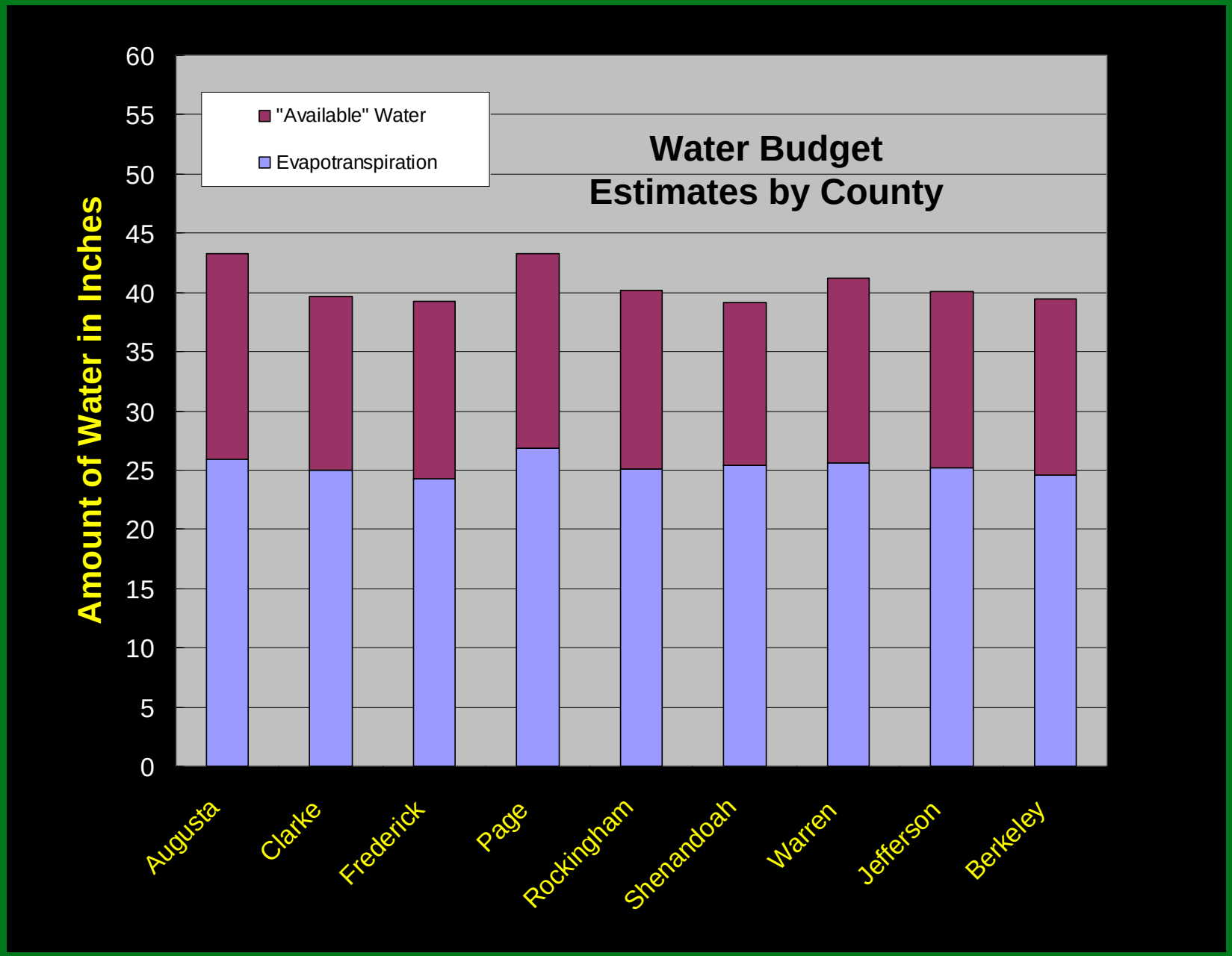
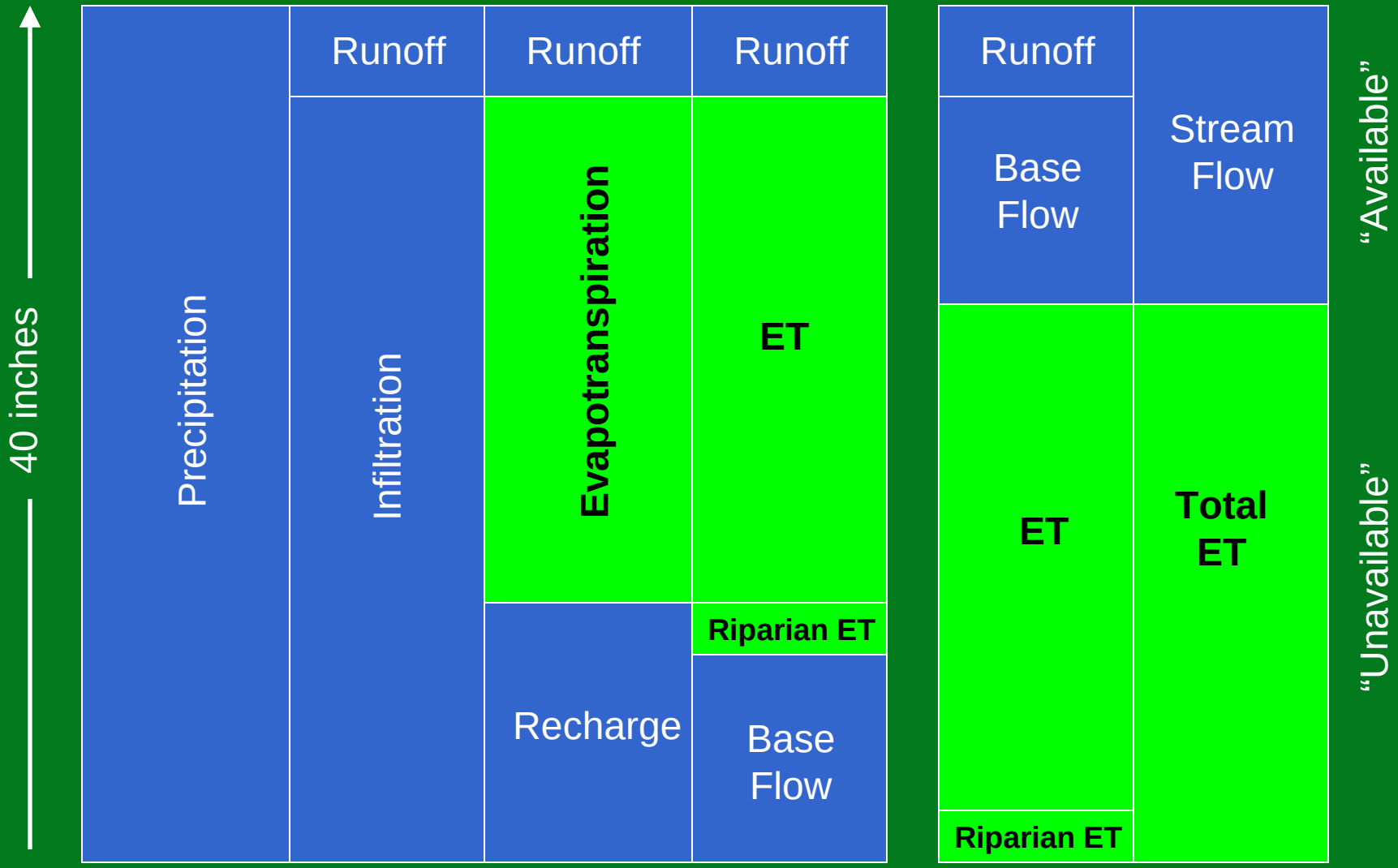

Water Budget
Estimates by County
"Available" Water
Evapotranspiration
Amount of Water in Inches
60
55
50
45
40
35
30
25
20
15
10
5
0
Augusta
Clarke
Frederick
Page
Rockingham
Shenandoah
Warren
Jefferson
Berkeley



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Baseflow Analysis

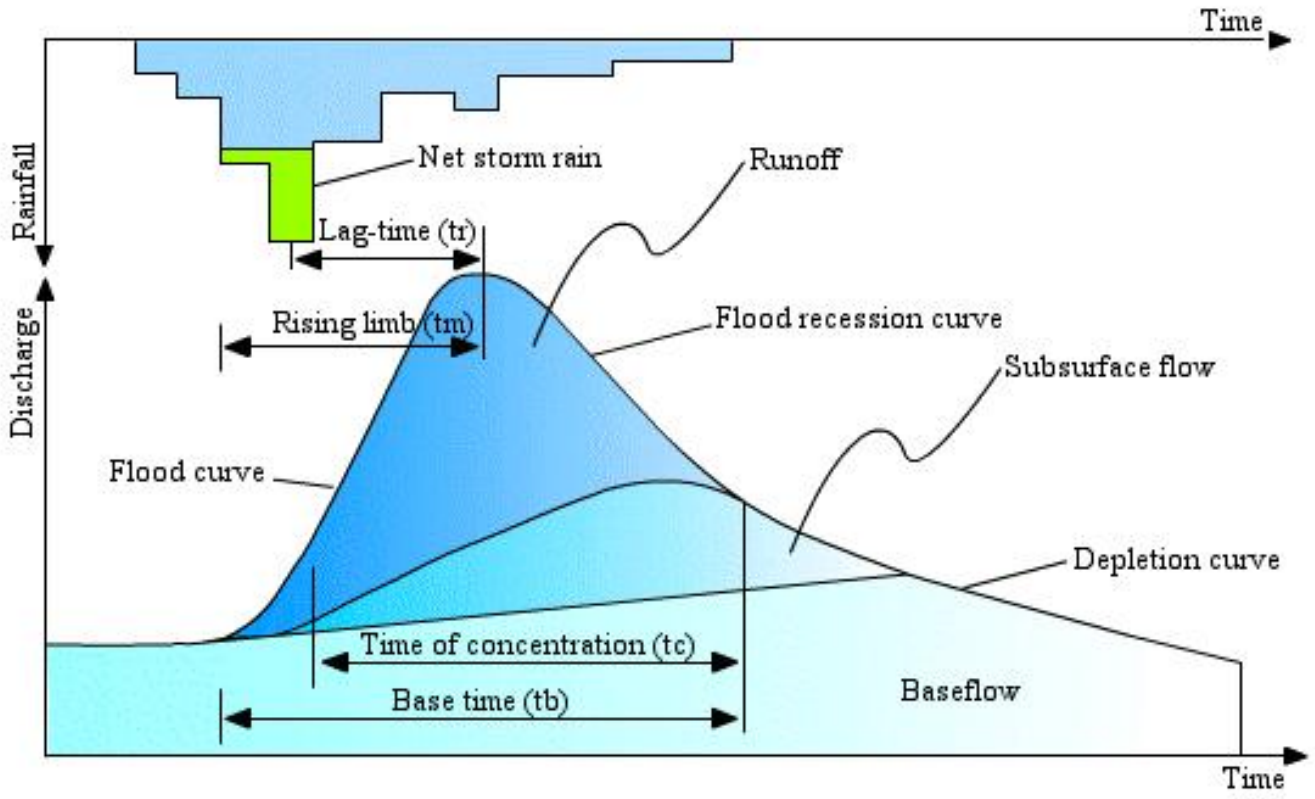

Figure 8.7 Hyetogram and hydrograph resulting from a storm event (rain - flow) [Musy, 2001]

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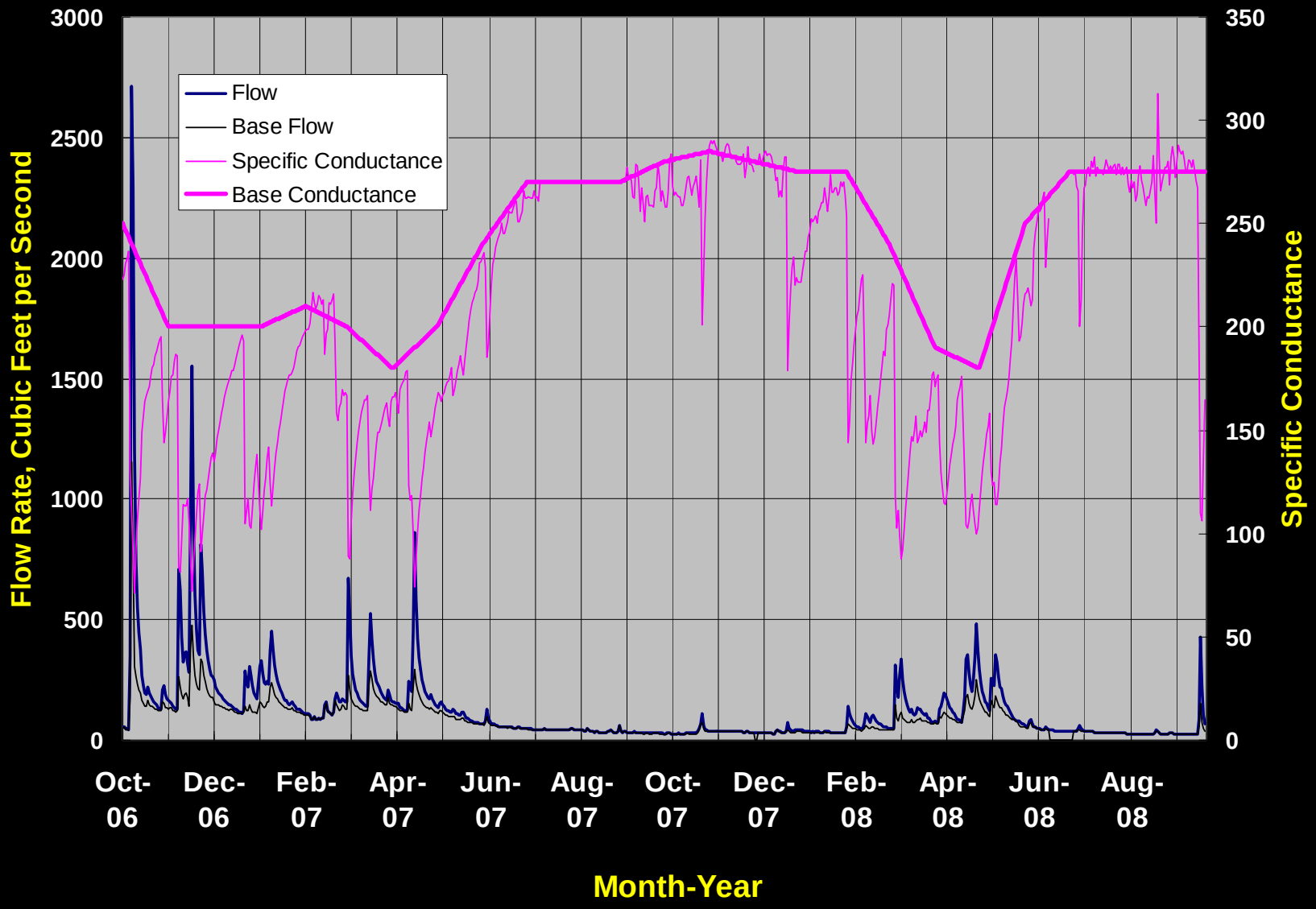
01626000 South River near Waynesboro, VA



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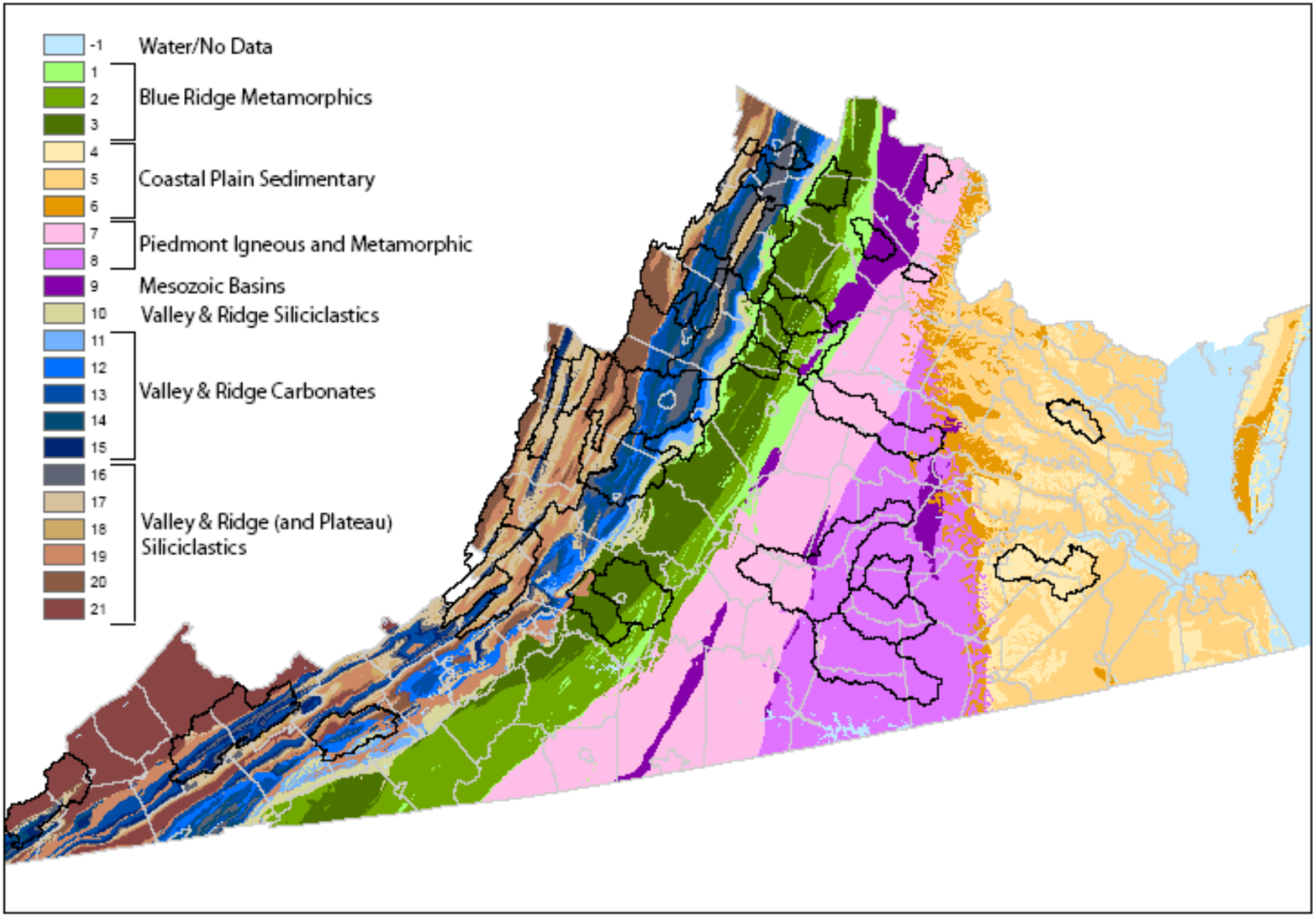
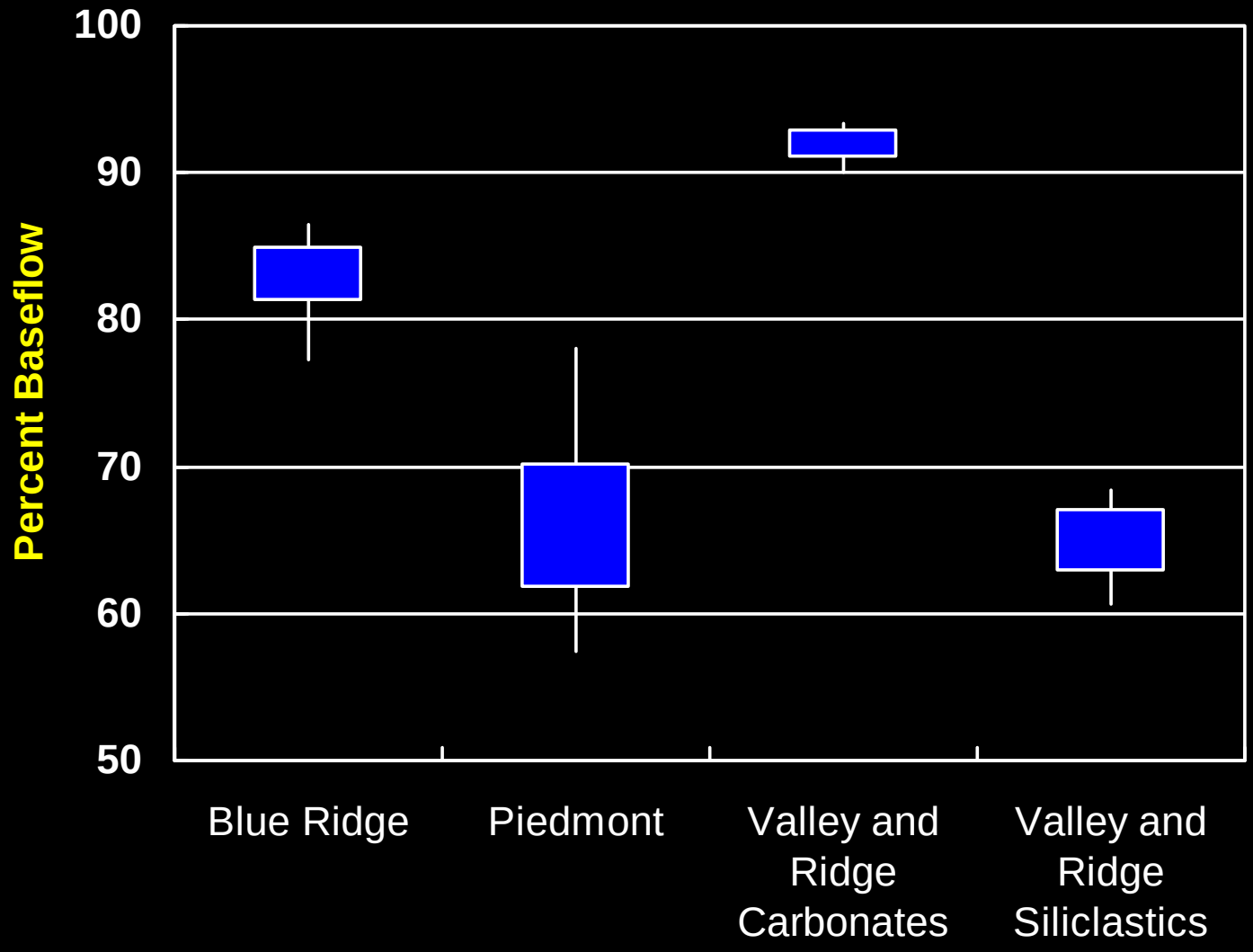
Virginia Geology -- Categories



Version 5, Jason Pope, February 9, 2009

Baseflow in Watersheds by Province and Rock Type



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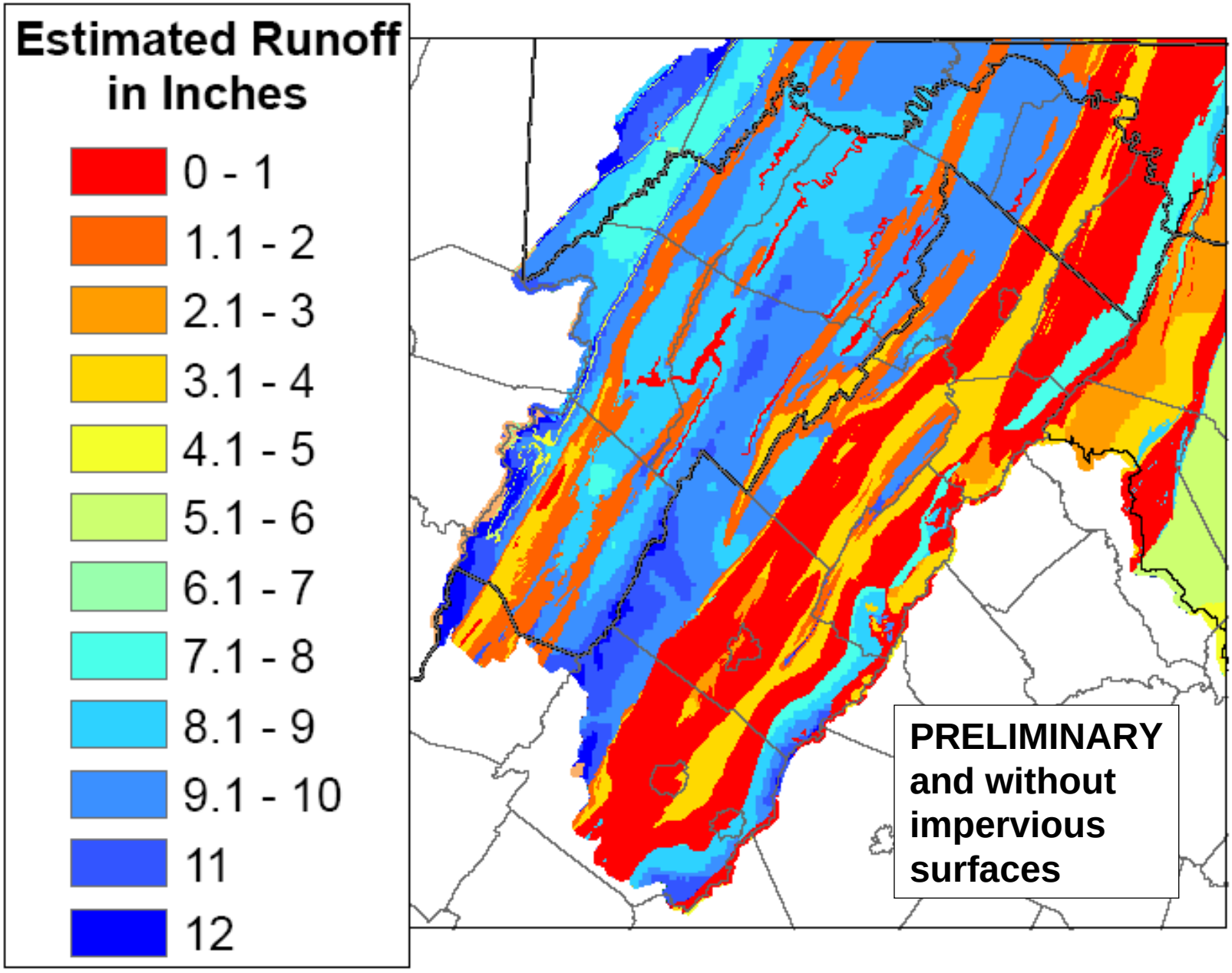
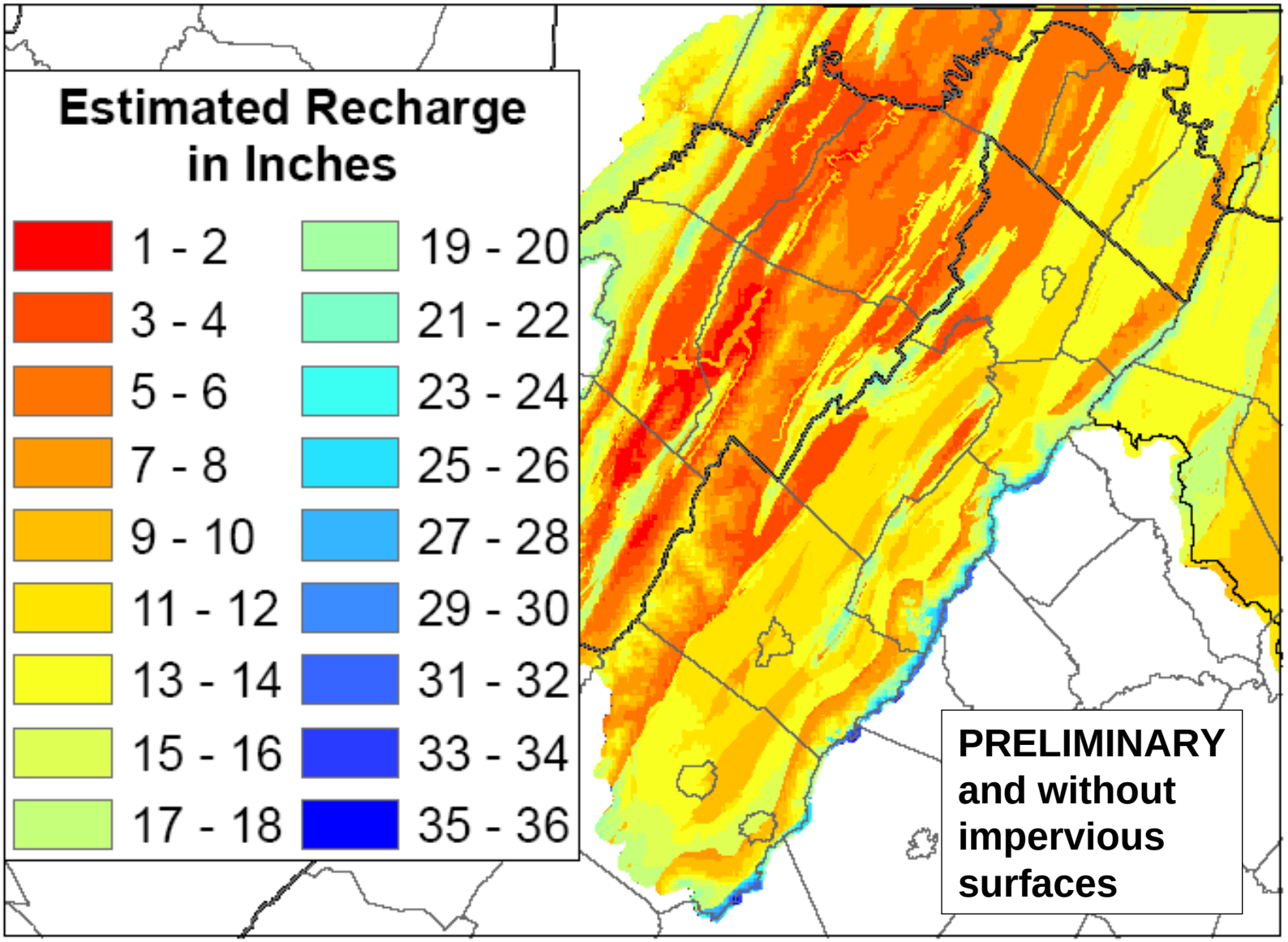

Estimated Runoff in Inches
0 - 1
1.1 - 2
2.1 - 3
3.1 - 4
4.1 - 5
5.1 - 6
6.1 - 7
7.1 - 8
8.1 - 9
9.1 - 10
11
12
PRELIMINARY and without impervious surfaces



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Future Work

- USGS Scientific Investigations Report
- Extension of ET estimates to entire US
- Make estimates for drought years
- Make estimates for rising global temperatures
- Development of an Upper Potomac Basin GW Model – Chesapeake Bay Program

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