

Map Set 5: Impact on Water

This series of maps displays information related to the potential environmental impacts of *additional* gas development in *Pennsylvania* if all remaining technically recoverable resources in the Interior Marcellus shale were developed using high volume hydraulic fracturing and horizontal drilling with eight wells per well pad.

This map set includes projections of water usage, water withdrawal, consumptive use of water, and wastewater generation associated with the additional gas development. All results are mapped by watershed using either the HUC-10 or HUC-8 watershed boundaries in the National Hydrography Dataset. The data are presented as average flow rates that reflect the total water usage/withdrawal/consumptive use/wastewater generation divided by the development period. Water use could be significantly higher during periods of rapid development. Some of the metrics are also shown in 'specific' form (e.g. area-averaged water usage per 100 square miles), or cumulative form (i.e. use in each watershed plus all upstream use).

Note: These maps contain *projections* of natural gas development and associated impacts under a particular set of circumstances and assumptions. Changes to the assumptions could change the results. They are not *predictions* of development or impacts, and should not be used for commercial purposes, to guide investment decisions, or for short-range planning decisions. Furthermore, the maps should not be used to inform planning or decision making for geographic units smaller than the primary units of analysis (counties or HUC-10 watersheds).

Water and Wastewater Impact Maps

This map set includes projections of the following impacts:

Map 5.1 - Water Use by Watershed

Map 5.2 - Water Withdrawal by Watershed

Map 5.3 - Consumptive Use by Watershed

Map 5.4 - Wastewater Generation by Watershed

Map 5.5 - Specific Water Use

Map 5.6 - Specific Water Withdrawal

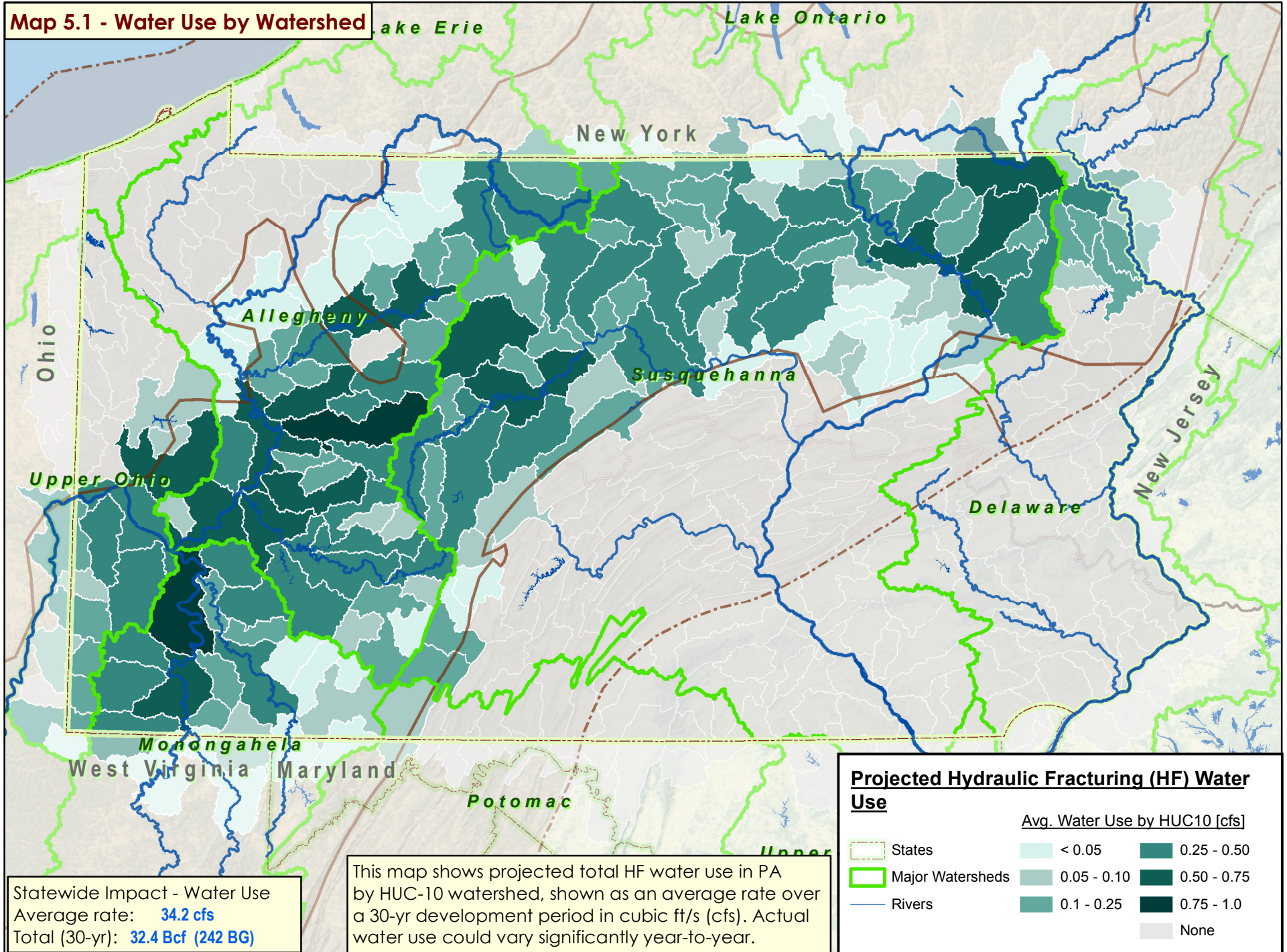
Map 5.7 - Cumulative Water Use

Map 5.8 - Cumulative Consumptive Use

Map 5.9 - Consumptive use by watershed relative to existing consumptive uses

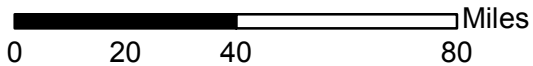
For additional documentation and methodology used to create these maps, as well as discussion of results, please download the research report at: www.cna.org/PA-Marcellus

Map 5.1 - Water Use by Watershed



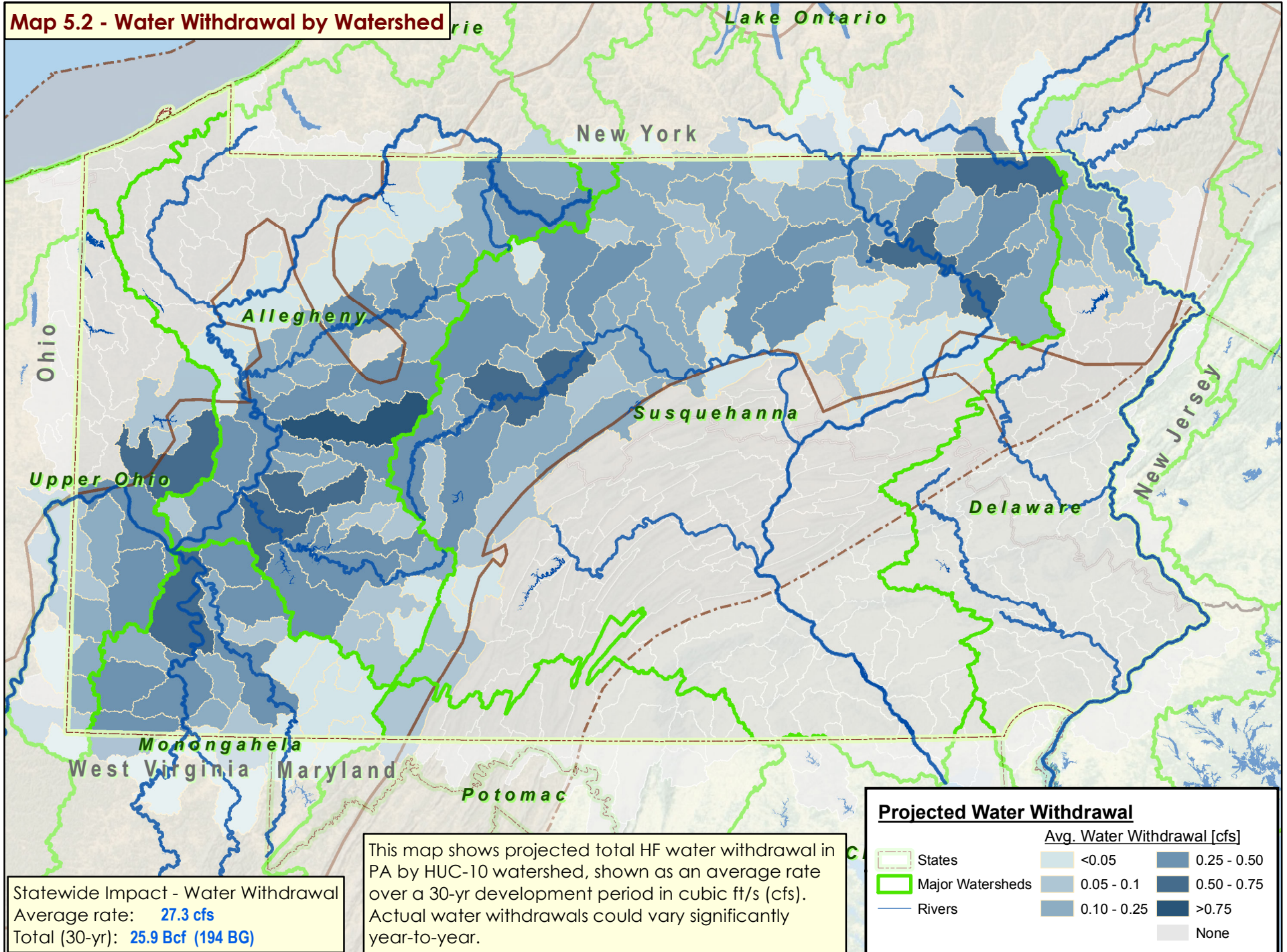
Statewide Impact - Water Use
Average rate: **34.2 cfs**
Total (30-yr): **32.4 Bcf (242 BG)**

This map shows projected total HF water use in PA by HUC-10 watershed, shown as an average rate over a 30-yr development period in cubic ft/s (cfs). Actual water use could vary significantly year-to-year.



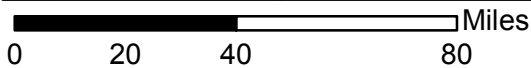
Note: Hydrologic Unit Code (HUC) 10 watersheds are delineated by the US Geological Survey. There are 332 HUC-10s in PA with an average area of 162 square miles.

Map 5.2 - Water Withdrawal by Watershed



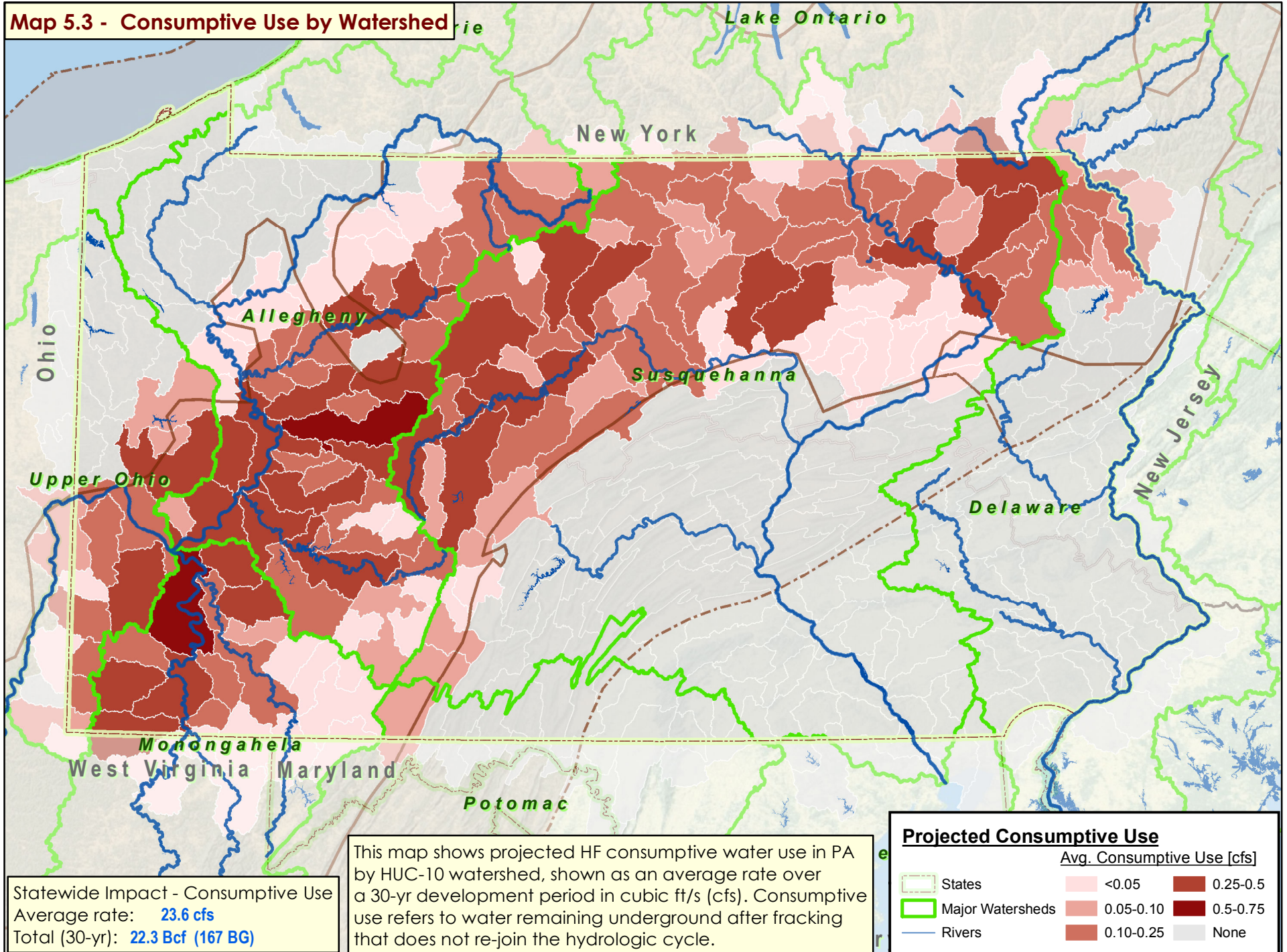
Statewide Impact - Water Withdrawal
 Average rate: **27.3 cfs**
 Total (30-yr): **25.9 Bcf (194 BG)**

This map shows projected total HF water withdrawal in PA by HUC-10 watershed, shown as an average rate over a 30-yr development period in cubic ft/s (cfs). Actual water withdrawals could vary significantly year-to-year.

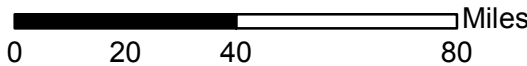


Note: Hydrologic Unit Code (HUC) 10 watersheds are delineated by the US Geological Survey. There are 332 HUC-10s in PA with an average area of 162 square miles.

Map 5.3 - Consumptive Use by Watershed

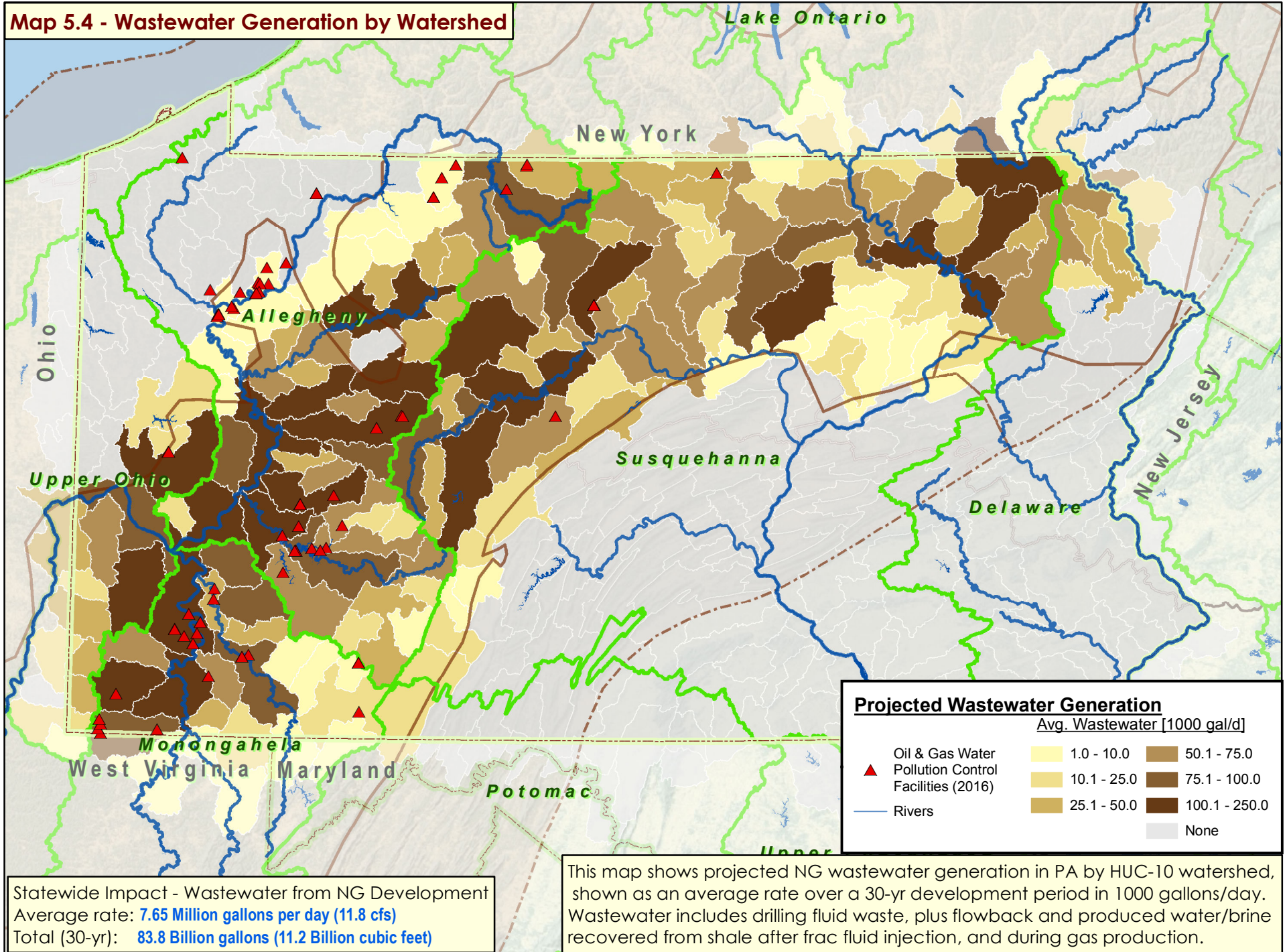


Statewide Impact - Consumptive Use
Average rate: **23.6 cfs**
Total (30-yr): **22.3 Bcf (167 BG)**



Note: Hydrologic Unit Code (HUC) 10 watersheds are delineated by the US Geological Survey. There are 332 HUC-10s in PA with an average area of 162 square miles.

Map 5.4 - Wastewater Generation by Watershed



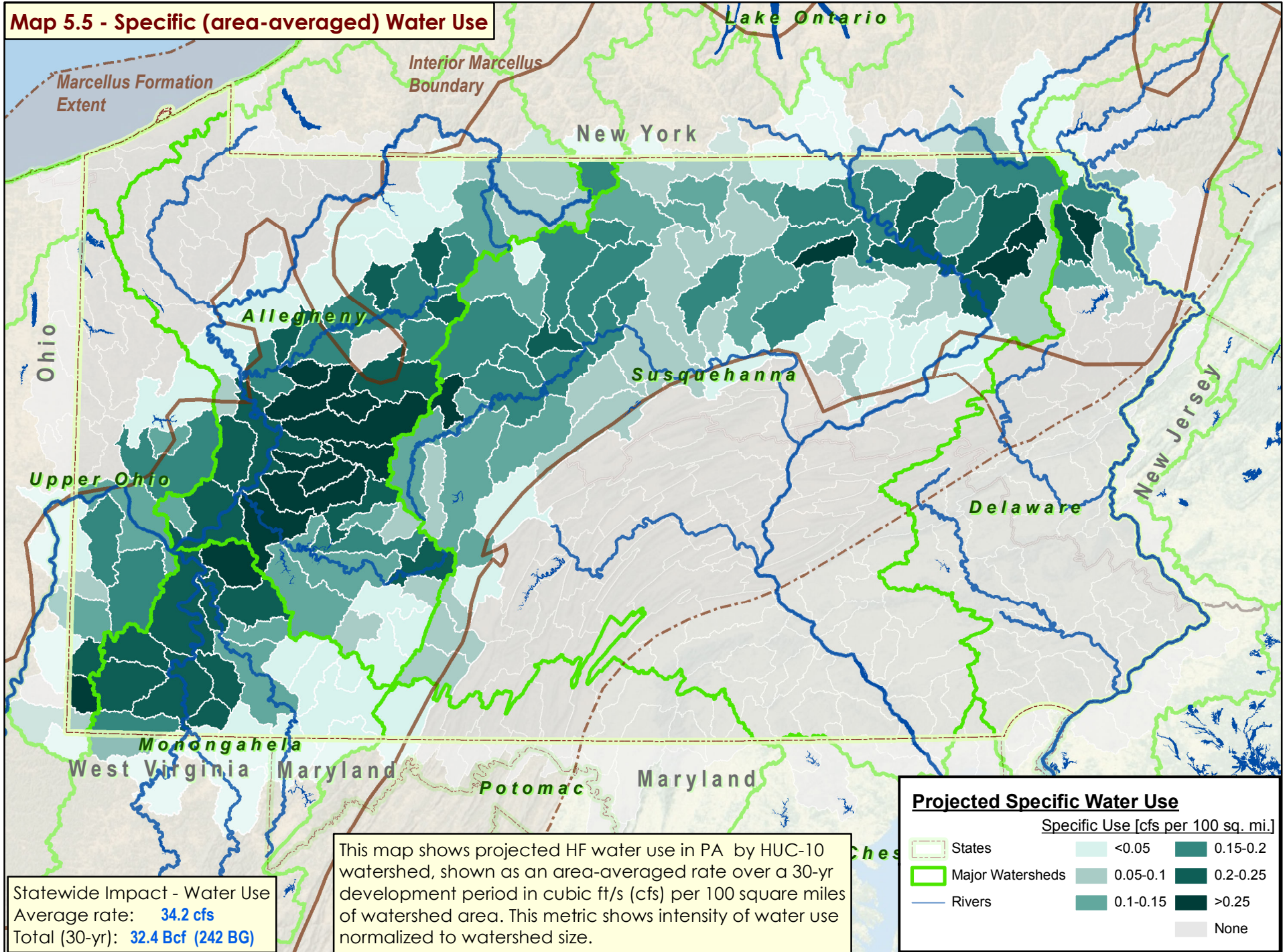
Statewide Impact - Wastewater from NG Development
Average rate: **7.65 Million gallons per day (11.8 cfs)**
Total (30-yr): **83.8 Billion gallons (11.2 Billion cubic feet)**

This map shows projected NG wastewater generation in PA by HUC-10 watershed, shown as an average rate over a 30-yr development period in 1000 gallons/day. Wastewater includes drilling fluid waste, plus flowback and produced water/brine recovered from shale after frac fluid injection, and during gas production.

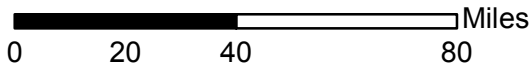
0 20 40 80 Miles

Note: Hydrologic Unit Code (HUC) 10 watersheds are delineated by the US Geological Survey. There are 332 HUC-10s in PA with an average area of 162 square miles.

Map 5.5 - Specific (area-averaged) Water Use

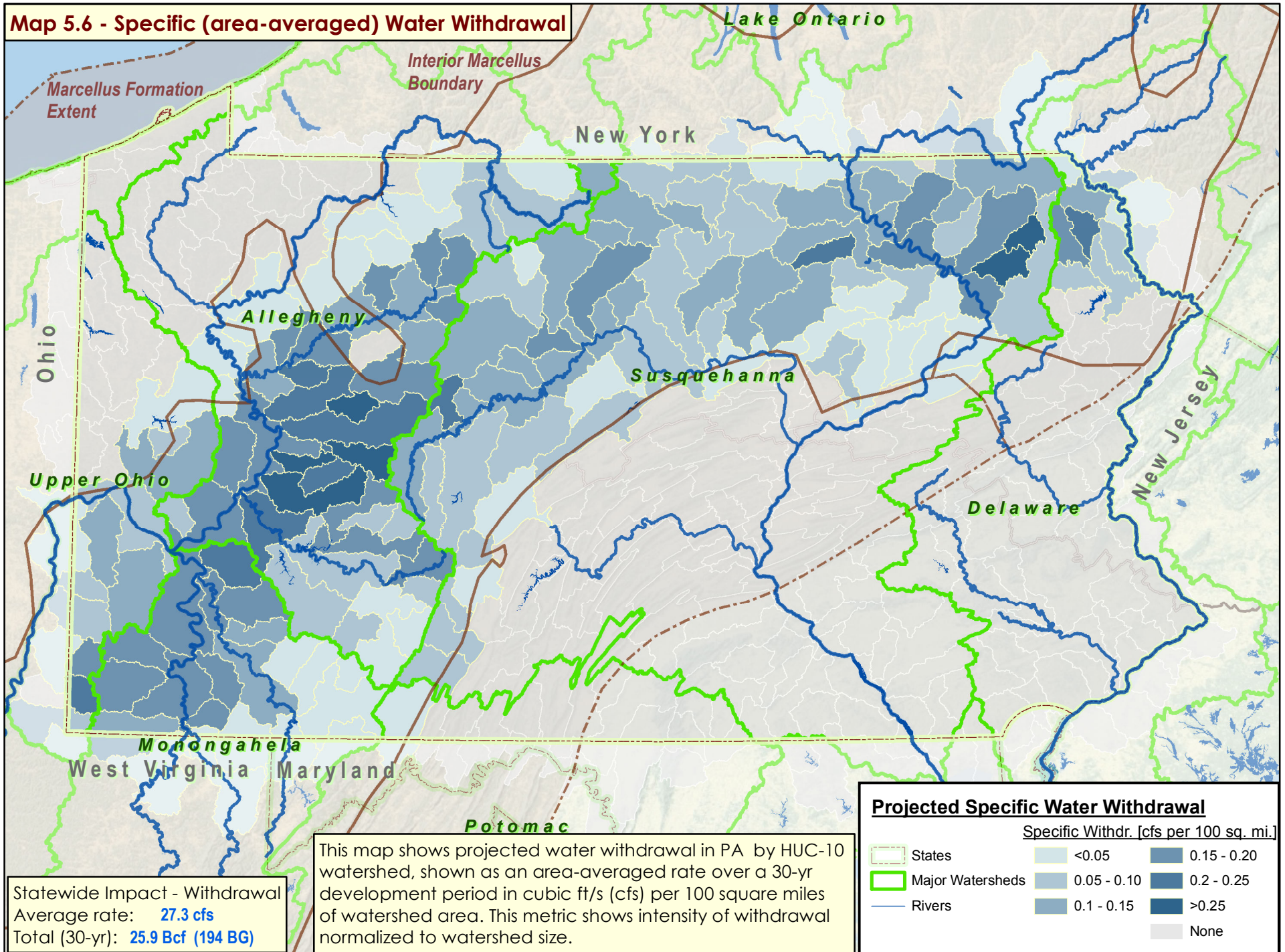


This map shows projected HF water use in PA by HUC-10 watershed, shown as an area-averaged rate over a 30-yr development period in cubic ft/s (cfs) per 100 square miles of watershed area. This metric shows intensity of water use normalized to watershed size.



Note: Hydrologic Unit Code (HUC) 10 watersheds are delineated by the US Geological Survey. There are 332 HUC-10s in PA with an average area of 162 square miles.

Map 5.6 - Specific (area-averaged) Water Withdrawal



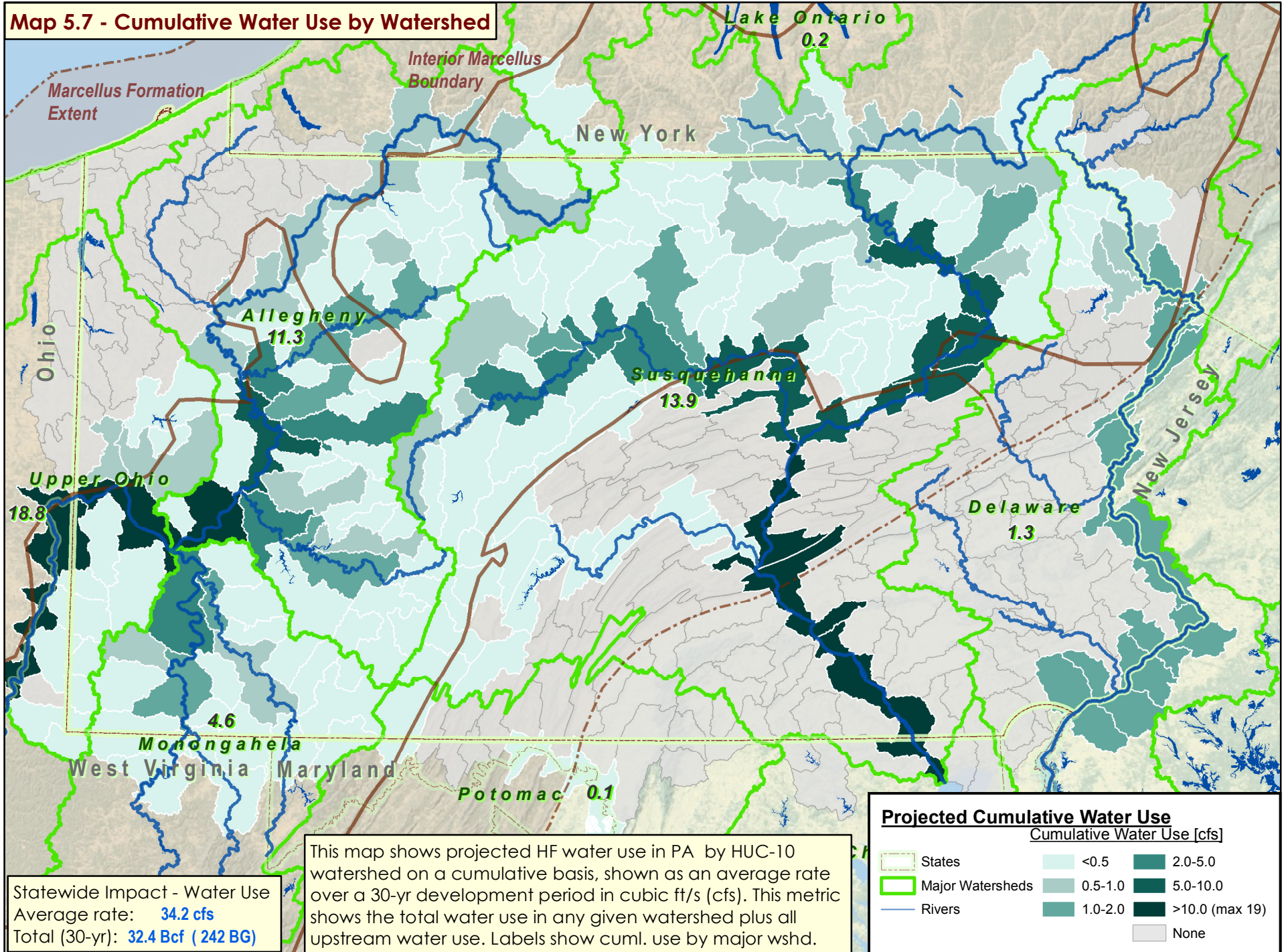
Statewide Impact - Withdrawal
Average rate: **27.3 cfs**
Total (30-yr): **25.9 Bcf (194 BG)**

This map shows projected water withdrawal in PA by HUC-10 watershed, shown as an area-averaged rate over a 30-yr development period in cubic ft/s (cfs) per 100 square miles of watershed area. This metric shows intensity of withdrawal normalized to watershed size.

0 20 40 80 Miles

Note: Hydrologic Unit Code (HUC) 10 watersheds are delineated by the US Geological Survey. There are 332 HUC-10s in PA with an average area of 162 square miles.

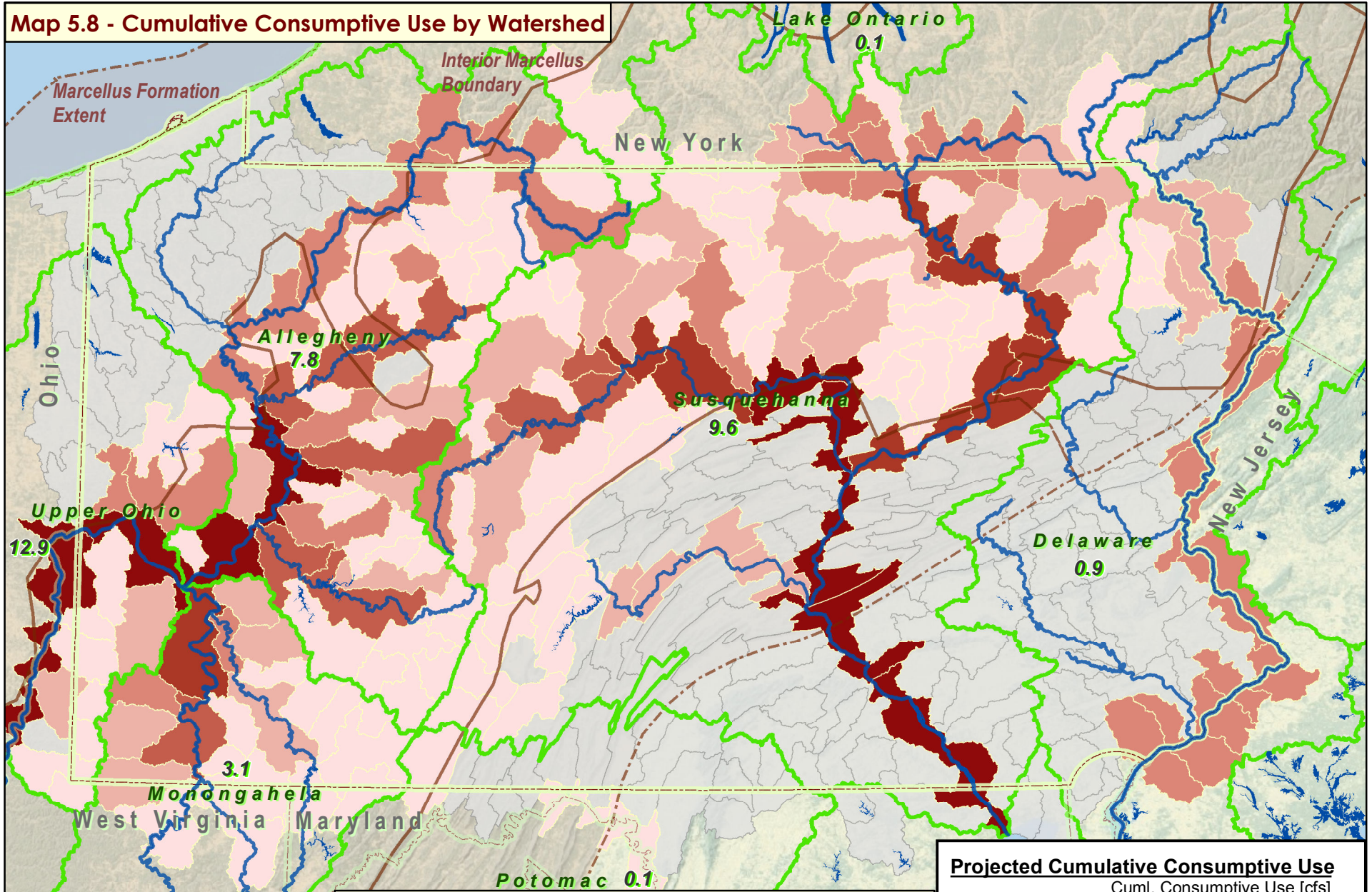
Map 5.7 - Cumulative Water Use by Watershed



0 20 40 80 Miles

Note: Hydrologic Unit Code (HUC) 10 watersheds are delineated by the US Geological Survey. There are 332 HUC-10s in PA with an average area of 162 square miles.

Map 5.8 - Cumulative Consumptive Use by Watershed



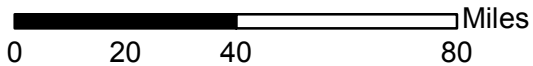
Statewide Impact - Consump. Use
Average rate: **23.6 cfs**
Total (30-yr): **22.3 Bcf (167 BG)**

This map shows projected HF consumptive use in PA by HUC-10 watershed on a cumulative basis, shown as an average rate over a 30-yr development period in cubic ft/s (cfs). This metric shows the total consumptive use (incl. upstream) removed from the watershed. Labels show cuml. use by major wshd.

Projected Cumulative Consumptive Use

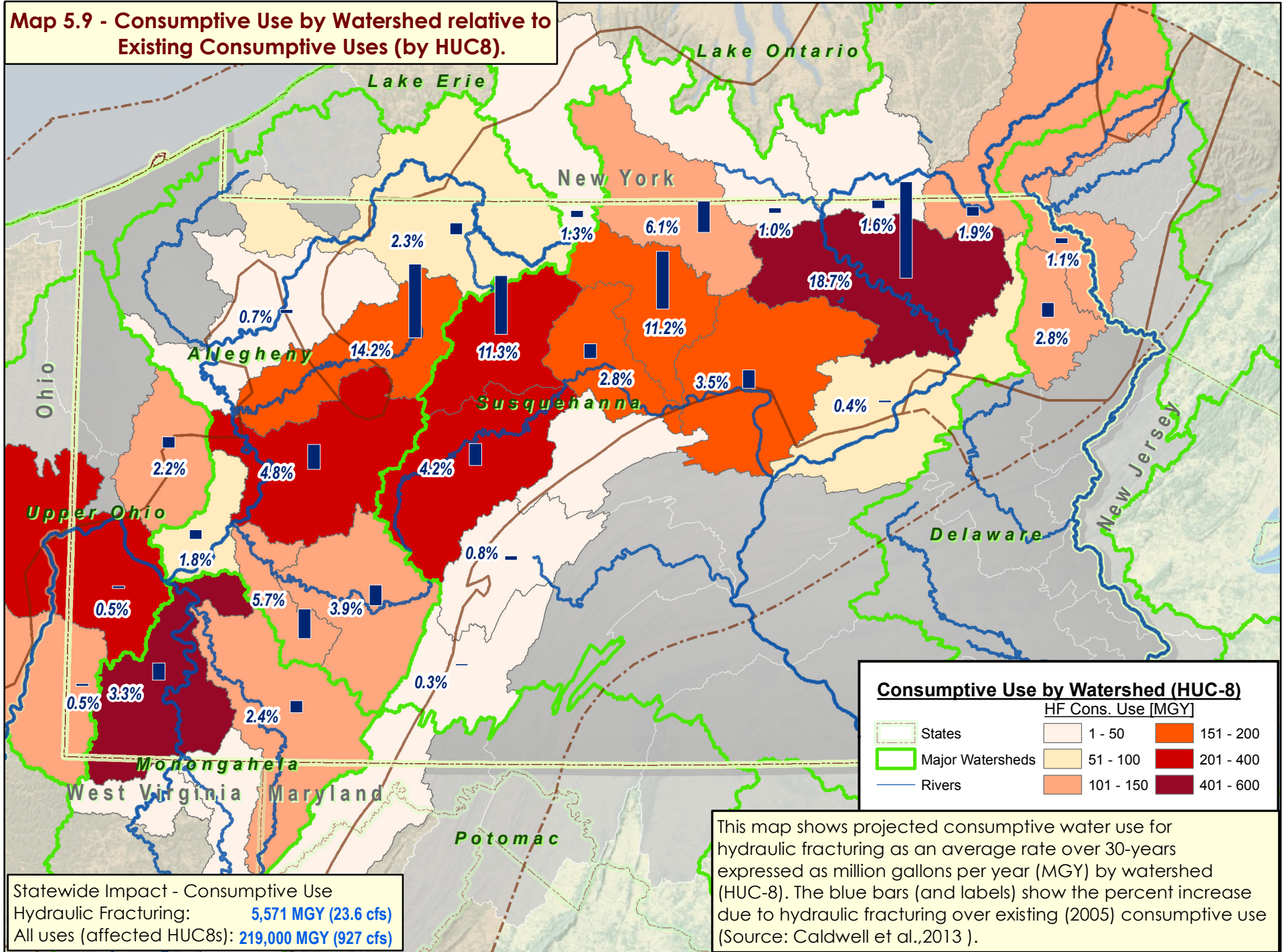
Cuml. Consumptive Use [cfs]	
	< 0.25
	0.25-0.5
	0.5 - 1.0
	1.0 - 2.0
	2.0 - 5.0
	> 5 (Max13)
	None

States
 Major Watersheds
 Rivers



Note: Hydrologic Unit Code (HUC) 10 watersheds are delineated by the US Geological Survey. There are 332 HUC-10s in PA with an average area of 162 square miles.

Map 5.9 - Consumptive Use by Watershed relative to Existing Consumptive Uses (by HUC8).



0 20 40 80 Miles

Note: Hydrologic Unit Code (HUC) 8 watersheds are delineated by the US Geological Survey.