# WVDEP's Initial Report[1] on the Quality of the State's Waters for 2016 CWA Reporting Requirements

Probabilistic Data Summary

The goal of WVDEP's probabilistic monitoring program is to provide statistically unbiased estimates of stream condition throughout a particular region (i.e., watershed, ecoregion or state) without assessing every stream mile in that region. This approach can be used to describe various aspects of stream condition including, the proportion of stream miles with biological impairment, the proportion of stream miles with specific water quality criterion violations, and the characterization of the relative importance of stressors such as sedimentation or acid precipitation. The target population for these efforts was small to medium sized (1st - 4th order) wadeable streams. Ninety-eight percent of West Virginia's stream miles are of this size class and approximately 70% of these are wadeable. The probabilistic design used for this summary allows DEP to characterize overall water quality conditions at an ecoregion scale (Figure 1), basin

Figure 1. Ecoregions (Omernick)

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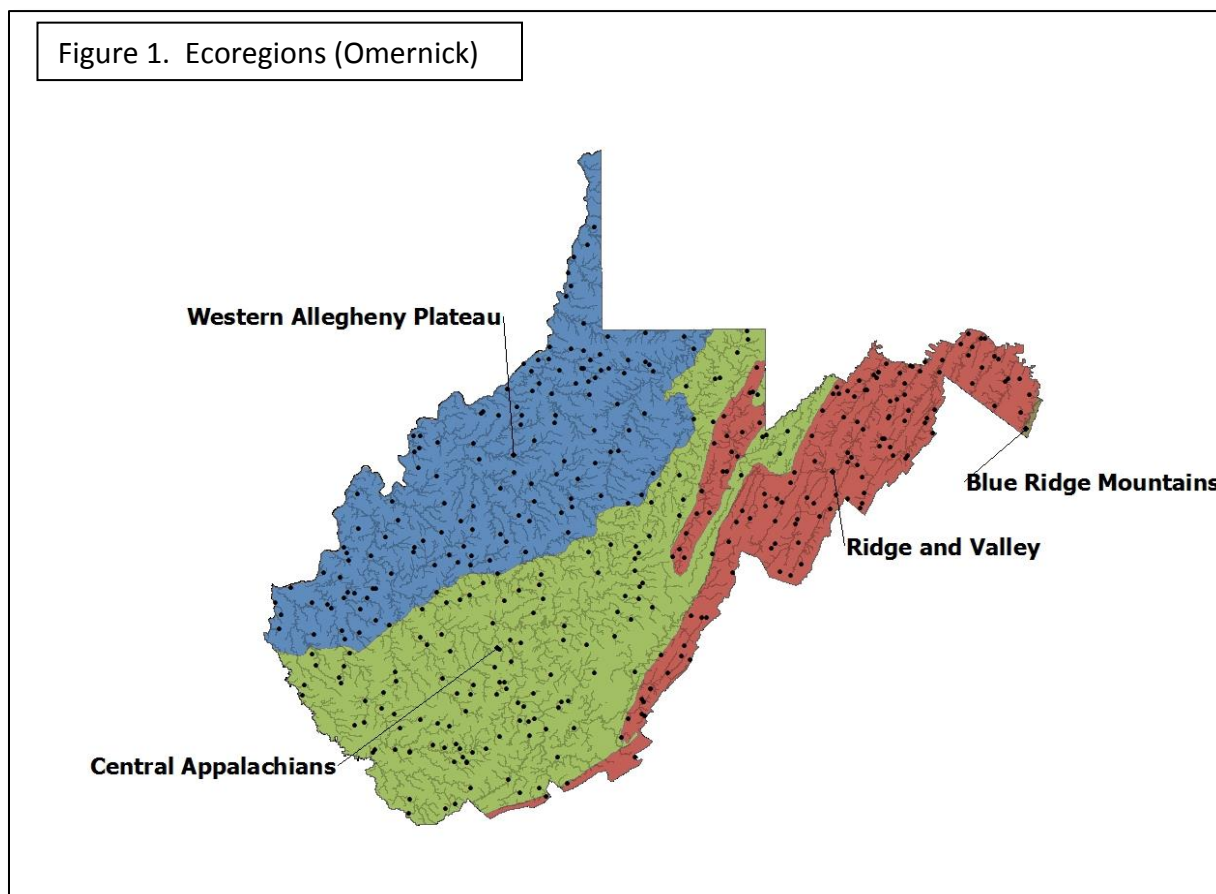
[1] Components of this report will be included in West Virginia's 2016 Integrated Water Quality and Monitoring Report which will be completed later in 2016.

scale (Figure 2), and statewide. The 'basins' are groups of four to six 8-digit HUC watersheds that provide data sufficient to develop estimates of condition with fairly small confidence boundaries. Probabilistic assessment sites were distributed within the three major ecoregions in West Virginia: the Western Allegheny Plateau (70), Central Appalachians (69), and Ridge and Valley (67). Due to its small extent in West Virginia, the Blue Ridge Mountain Ecoregion (66) was combined with Ecoregion 67 for assessments and data analysis. The data used for these analyses are from 313 sites that were sampled at baseflow conditions during the late spring/early summers of 2010 – 2015.

Figure 2. Basins of WV used in this summary
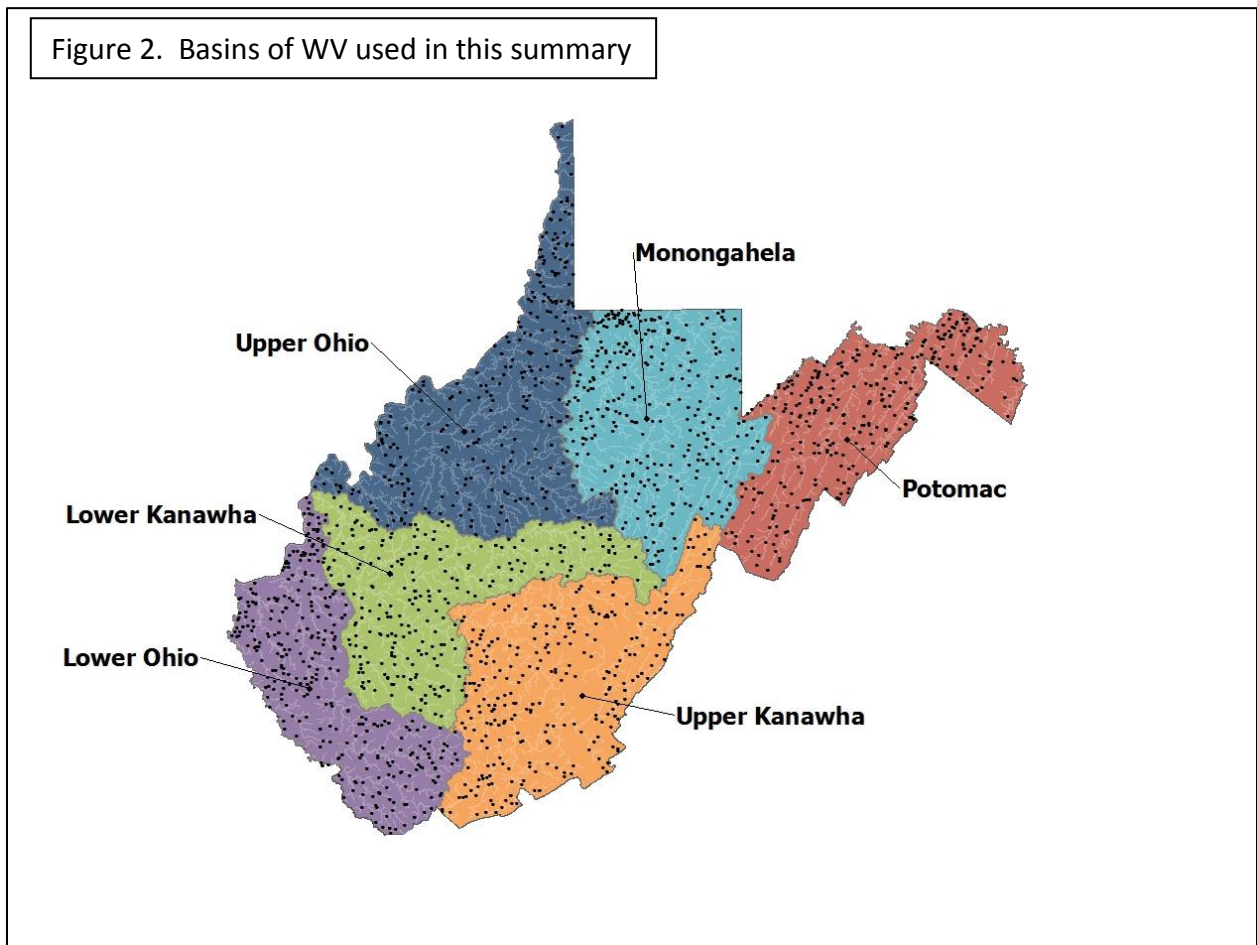
The probabilistically selected sites are assessed using three broad categories of aquatic integrity indicators: biological community quality; water quality; and habitat quality. From these, several individual indicators were chosen to help illustrate the condition of West Virginia's rivers and streams during the period of interest in this report. They are presented for statewide, the three "ecoregions" and six "basins" shown in the figures above.

Indicators of Stream Condition

Biological

- Genus Level Benthic Macroinvertebrate IBI (GLIMPSS)

Water Quality Indicators

- Conductivity – various levels

- Sulfate > 50mg/L

- Acidity: pH < 5.0 and <6.0

- Bacterial Contamination: fecal coliform bacteria > 400 colonies/100mL

- Total Phosphorus – various concentrations

Habitat Quality Indicators

- Overall stream habitat condition

- Relative presence of embeddedness

- Condition of riparian vegetation zones

- Range of human-refuse intensity values (trash index)

Biological Community

The biological communities living in West Virginia streams are exposed to many stressors, including toxic contaminants, sedimentation, nutrient enrichment, and acid precipitation. The DEP uses benthic macroinvertebrates to assess the biological condition of streams in the state. These organisms provide reliable information on water and habitat quality in streams and have been used as indicators all over the world for nearly 100 years. They are extremely diverse and exhibit a wide range of tolerances to pollutants. Furthermore, they serve as an excellent tool for measuring overall ecological health, especially when summarized into a single index of biological integrity.

In West Virginia prior to 2012, the health of benthic macroinvertebrate communities had been rated using a statewide family-level multi-metric index developed for use in wadeable riffle/run streams, the West Virginia Stream Condition Index (WVSCI). Beginning in 1998, the DEP started identifying benthic macroinvertebrates to genus level with the goal of eventually developing a new biotic index. Development of a genus level index was completed in 2011 and is known as GLIMPSS (Genus Level Index of Most

Probable Stream Status). GLIMPSS was developed to account for natural variations of biological communities across seasons and ecoregions. It has been peer reviewed and published and is ready for use in this summary report. GLIMPSS, similar to WVSCI and other indices of biotic integrity, summarizes scores of various metrics into a single index value. The metrics were selected to maximize discrimination between streams with known stressors and reference streams. Reference streams have little or no human disturbances. All identified reference streams were combined and a subsequent reference condition was established based on their benthic macroinvertebrate communities.

Based on the probabilistic data utilized in this summary and a comparison to low-end reference condition (5th percentile of all appropriate season and ecoregion reference sample GLIMPSS scores), 64.3 percent of wadeable stream miles have scores equal to or above this threshold (i.e., are generally in good biological condition) statewide with the remaining 35.7 percent scoring less than this threshold (Figure 3). Breaking this down by ecoregion, the Ridge and Valley has the highest percentage of streams with healthy aquatic ecosystems, with 82.4 percent scoring above the 5th percentile threshold. The Western Allegheny Plateau ecoregion scores lowest with an estimated 55.8 percent of stream miles comparable to reference. The percent of stream miles in the Central Appalachians scoring above the GLIMPSS threshold is estimated to be 63.3. Among basins, the Upper Kanawha had the highest percent of streams miles (70.8) above the reference threshold, while the Lower Ohio had the fewest (45.7).

Figure 3. Biological Health - as measured by Benthic Macroinvertebrate community IBI scores - GLIMPSS*

*Genus level except chironomidae - scores >=100%T generally good condition

Legend: ■ < 85%T ■ 85-100%T ■ 100-110%T ■ >110%T

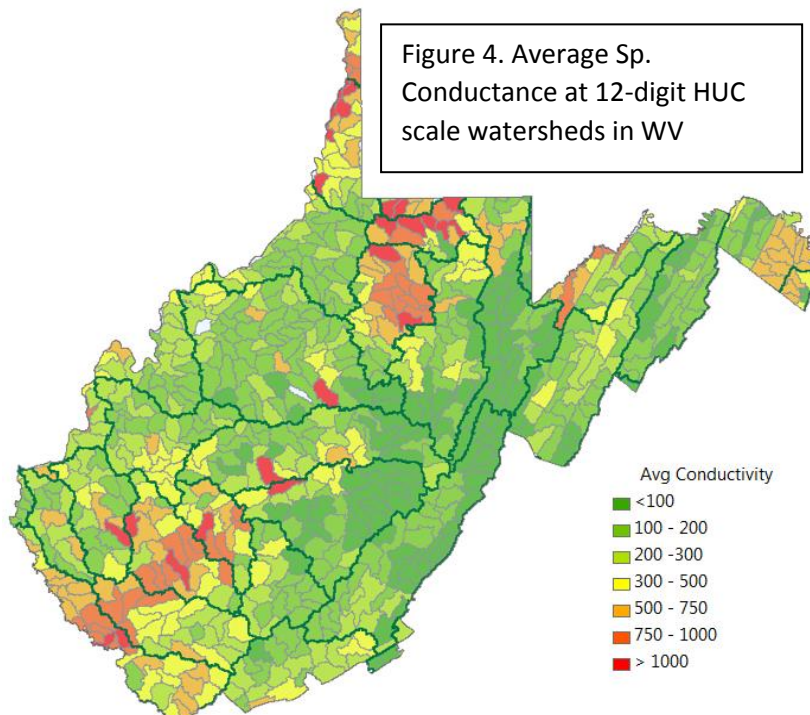| Region	< 85%T	85-100%T	100-110%T	>110%T
Ridge and Valley	10.8	6.7	10.1	72.3
Upper Kanawha	13.8	10.6	4.8	70.8
Potomac	15.9	10.1	12.0	61.9
Upper Ohio	19.3	15.5	15.5	49.7
Lower Kanawha	22.2	12.8	7.5	57.4
StateWide	25.1	10.6	9.6	54.7
W Allegheny Plateau	27.8	16.4	11.1	44.7
Central Appalachians	29.4	7.3	8.1	55.2
Monongahela	32.2	7.5	12.6	47.8
Lower Ohio	41.6	6.7	6.0	45.7

Percent of stream miles
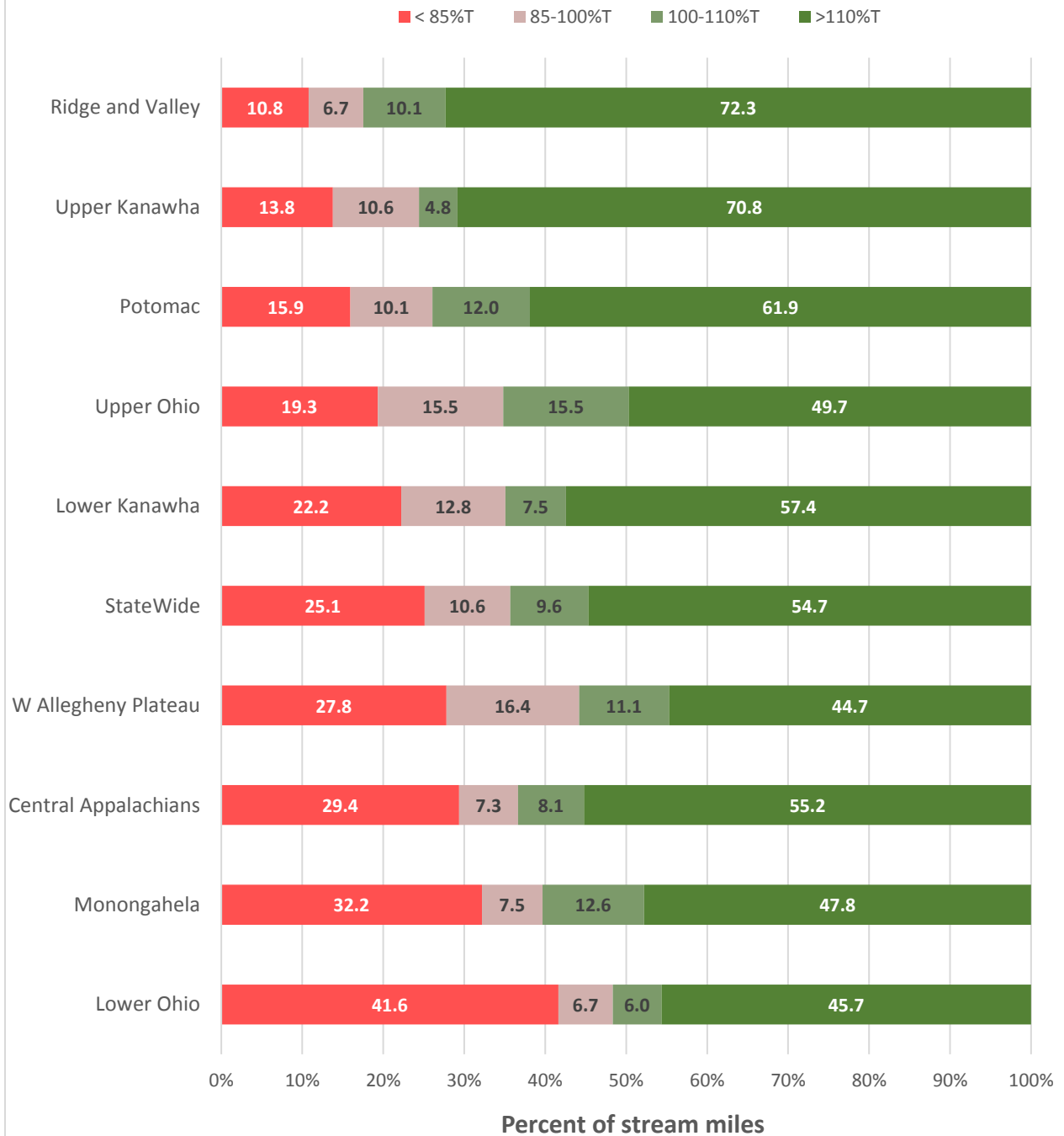
Water Quality Indicators of Aquatic Integrity

The Watershed Assessment Branch analyzes over 20 different water quality parameters at each of the sites sampled as part of the probabilistic monitoring program. Below are the results of five of these parameters.
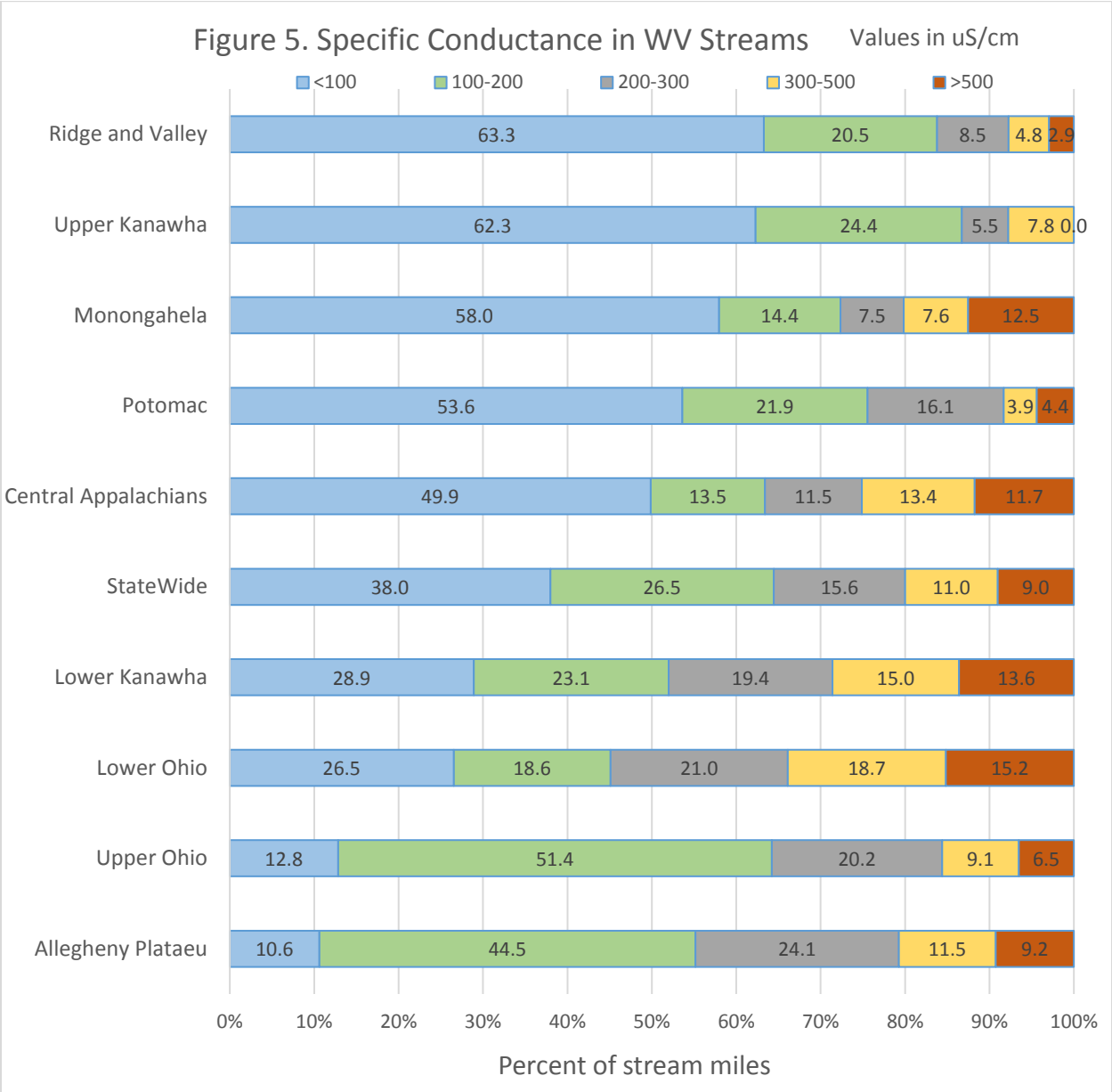
Conductivity

Conductivity, or specific conductance, is a measure of how well water conducts electricity which is determined by what and how much is dissolved in the water. In certain areas, conductivity is naturally elevated because of calcium and other minerals dissolved from limestone and other soluble rocks. In others, it is high because of added pollution from a variety of sources. Large scale surface mining such as mountain top mining and the use of valleys fills results in high conductivity caused by water percolating through fractured rock that had once been solid. High conductivity waters are often associated with degraded benthic macroinvertebrate communities.

In general, West Virginia streams have relatively low conductivity – with 80% of wadeable stream miles statewide having late spring /early summer levels below 300 uS/cm (levels tend to rise as the streamflow drops during summer and fall) and many regions having the majority of their stream miles less than 100 uS/cm (Figures 4 and 5). The Upper Ohio Basin and the closely aligned Western Allegheny Plateau ecoregion have fewer low conductivity (<100 uS/cm) streams, and also includes some areas (northern panhandle) with the high conductance streams associated with coal mining. The Monongahela Basin includes some of lowest conductivity streams (headwaters of Tygart and Cheat river watersheds) as well as some of the highest conductivity streams that are impacted by mining as well as industrial and residential development. The map at left shows average specific conductivity by 12-digit HUC watersheds using all available data (not limited to probabilistic data). The higher conductivity values in the eastern panhandle is attributable to the limestone geology of the area.

Figure 4. Average Sp. Conductance at 12-digit HUC scale watersheds in WV

Avg Conductivity
- <100
- 100 - 200
- 200 -300
- 300 - 500
- 500 - 750
- 750 - 1000
- > 1000

Figure 5. Specific Conductance in WV Streams   Values in uS/cm

Region	<100	100-200	200-300	300-500	>500
Ridge and Valley	63.3	20.5	8.5	4.8	2.9
Upper Kanawha	62.3	24.4	5.5	7.8	0.0
Monongahela	58.0	14.4	7.5	7.6	12.5
Potomac	53.6	21.9	16.1	3.9	4.4
Central Appalachians	49.9	13.5	11.5	13.4	11.7
StateWide	38.0	26.5	15.6	11.0	9.0
Lower Kanawha	28.9	23.1	19.4	15.0	13.6
Lower Ohio	26.5	18.6	21.0	18.7	15.2
Upper Ohio	12.8	51.4	20.2	9.1	6.5
Allegheny Plataeu	10.6	44.5	24.1	11.5	9.2

Percent of stream miles

Sulfate

Streams receiving mine drainage may be impaired by low pH and/or elevated concentrations of metals, including iron, aluminum, and manganese. Other dissolved ions such as sulfate may also be present in concentrations above background levels. A sulfate concentration greater than 50 mg/L was used to identify probabilistic sites influenced by mine drainage. Following this guideline, approximately 18.5 % of the stream miles statewide are influenced by mine drainage (Figure 6). Observed on an ecoregional basis, mine drainage influences a greater proportion of stream miles in the
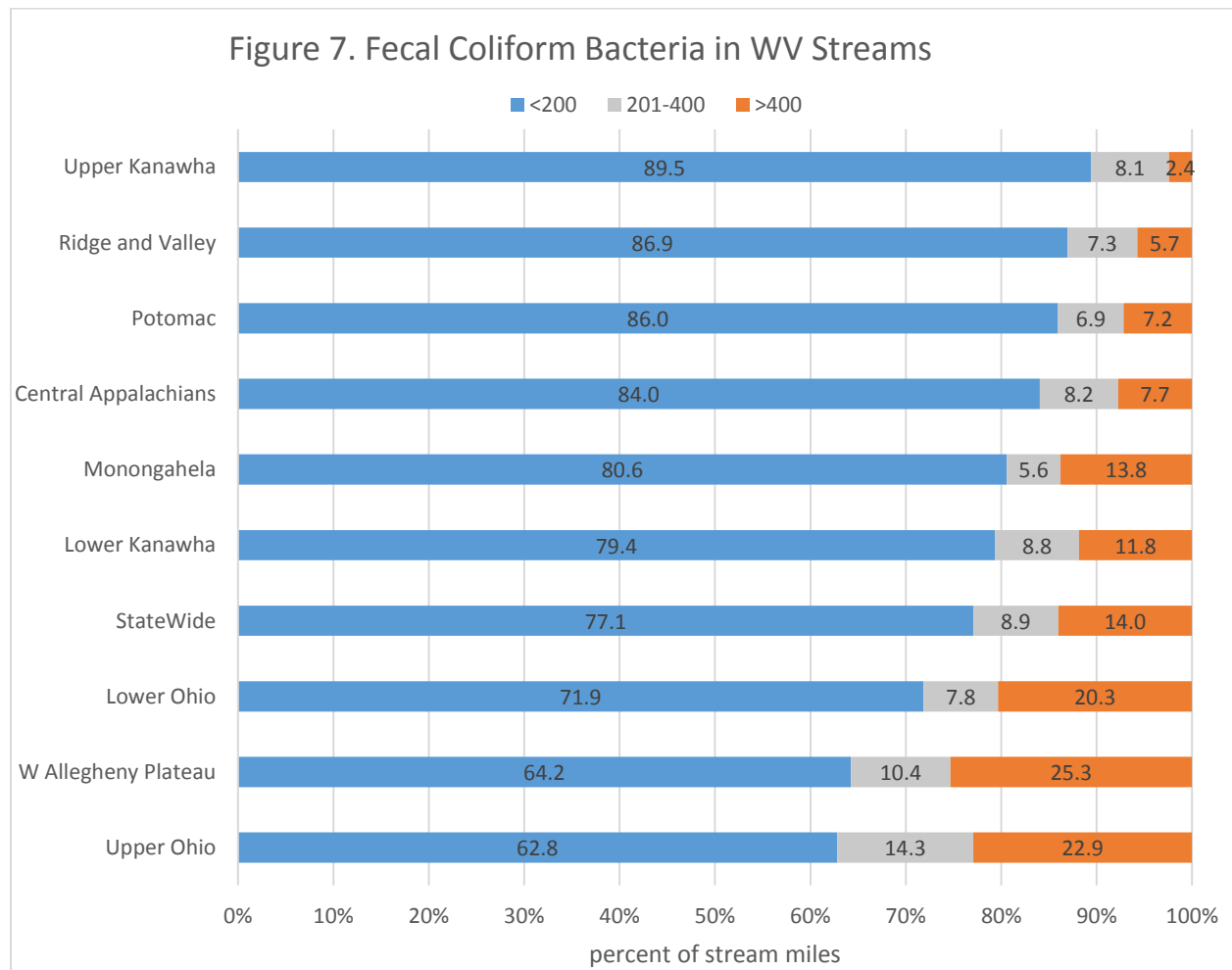
coal rich Central Appalachians (30.5%) than in the Ridge and Valley (1.6%) or Western Allegheny Plateau (14.0%). Among basins, the Lower Ohio (38.2%) and Lower Kanawha (32.5%) had the highest percent of streams miles exceeding the 50 mg/L threshold of sulfate.

Figure 6. Sulfate in WV Streams
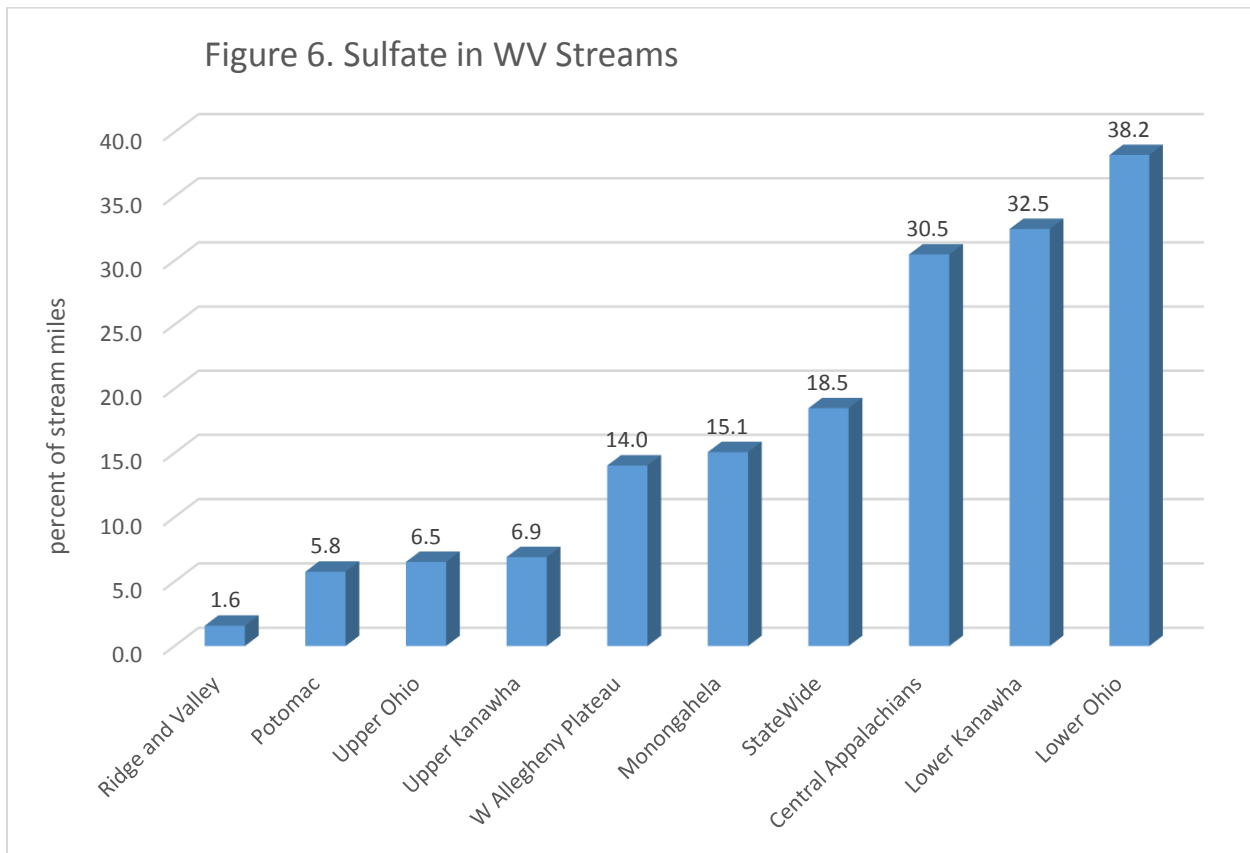
Bacterial contamination

Many West Virginia streams contain elevated levels of fecal coliform bacteria. Contributors to the problem include leaking or overflowing sewage collection systems, illegal homeowner sewage discharges by straight pipes or failing septic systems, and runoff from urban or residential areas and agricultural lands. Based on probabilistic data, 14.0% of stream miles in the state have fecal coliform bacteria levels that exceed the criterion of 400 colonies/100mL (Figure 7). In general, watersheds in the more developed regions of the state had a greater proportion of stream miles exceeding the criterion. Among ecoregions, the proportion of stream miles violating the criterion was highest in the Western Allegheny Plateau with 25.3 % of stream miles exceeding the criterion. The proportions of stream miles exceeding the criterion were considerably

lower in the Central Appalachians at 7.7% and Ridge and Valley Ecoregions at 5.7%. It should be noted that DEP's probabilistic monitoring is performed at baseflow conditions. Because samples are not collected during storm runoff events, bacteria levels that may increase under these higher flow conditions are not represented in the results. The Upper Ohio and Lower Ohio basins had the highest percent of stream miles exceeding the bacteria criterion with 22.9% and 20.3%, respectively.

Figure 7. Fecal Coliform Bacteria in WV Streams

Legend: ■ <200   ■ 201-400   ■ >400

Basin	<200	201-400	>400
Upper Kanawha	89.5	8.1	2.4
Ridge and Valley	86.9	7.3	5.7
Potomac	86.0	6.9	7.2
Central Appalachians	84.0	8.2	7.7
Monongahela	80.6	5.6	13.8
Lower Kanawha	79.4	8.8	11.8
StateWide	77.1	8.9	14.0
Lower Ohio	71.9	7.8	20.3
W Allegheny Plateau	64.2	10.4	25.3
Upper Ohio	62.8	14.3	22.9

percent of stream miles

Acidity

Aquatic life communities in the headwater sections of many West Virginia streams continue to be impacted by low pH, and thus, acidic water quality. The impairment is most prevalent in watersheds with soils of low buffering capacity and most often caused by acid precipitation and less often (but potentially more severely) by acid mine drainage. An evaluation of probabilistic data indicates that approximately 7.9% of the stream miles in the state have pH values below 6.0 (Figure 8). Most of the stream miles identified as impacted by acidic waters are in the Central Appalachians Ecoregion,

representing 14.8% of the stream miles within this area. Specifically, the Forested Hills and Mountains section of this ecoregion are largely susceptible to acid precipitation impacts due to infertile soils and resistant sandstones of the Pottsville group. The Ridge and Valley Ecoregion is less susceptible to the impacts of acid deposition with geologic materials such as limestone and shale providing more buffering capacity to neutralize acid precipitation. Nonetheless, probabilistic data indicates that approximately 7.9% of the stream miles in this ecoregion are impacted by acidic conditions. Although present, the extent of stream miles impacted by acidic waters within the Western Allegheny Plateau Ecoregion is near 0.0%. In fact, their proportion to the overall size of the total population of stream miles is insignificant enough to result in no acidic stream miles based on this cycle's probabilistic analysis. Again, this ecoregion has well buffered soils that limit the impacts of acid precipitation. Furthermore, where they do exist in this ecoregion, acidic waters are more likely the result of acid mine drainage than acid precipitation. The Monongahela had the highest level of low pH waters among basins with nearly 19% of stream miles estimated to be acidic. This basin likely has significant contributions from both acid deposition and acid mine drainage.

Figure 8. Acidic Streams in WV as indicated by pH
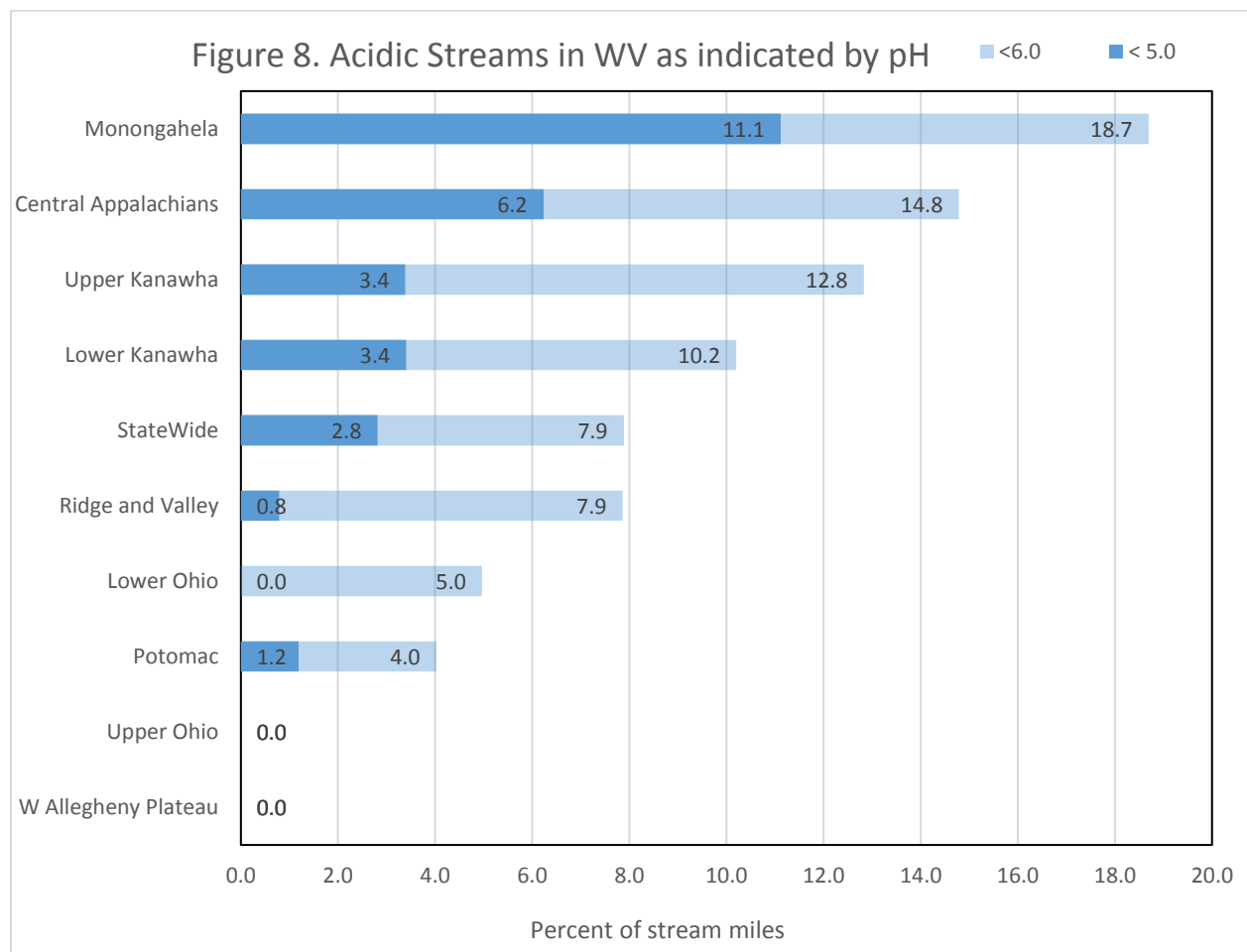
Phosphorus

A large proportion of total phosphorus (TP) from our probabilistic efforts have results that are below quantifiable reporting limits of the analytical labs. With nutrients considered one of the country's most widespread pollutants, having so many results below detectable levels is overall a good thing. Unfortunately, there are several different detection limits used for this sample period preventing the ability to provide a clear comparison of TP levels across regions of the state. However, the results do allow for a comparison of percentage of stream miles with TP that are below those detection limits. From the graph below (Figure 9), we know that the Western Allegheny Plateau has the highest percentage of stream miles with TP greater than 50 ug/L (7.3%) as well as the lowest percentage of stream miles with TP below the lowest detection level (33.1%) and that approximately two thirds of stream miles in the Upper Kanawha basin have TP below the lowest detection limit of 10 ug/L.

Figure 9. Total Phosphorus (ug/L) in WV Streams
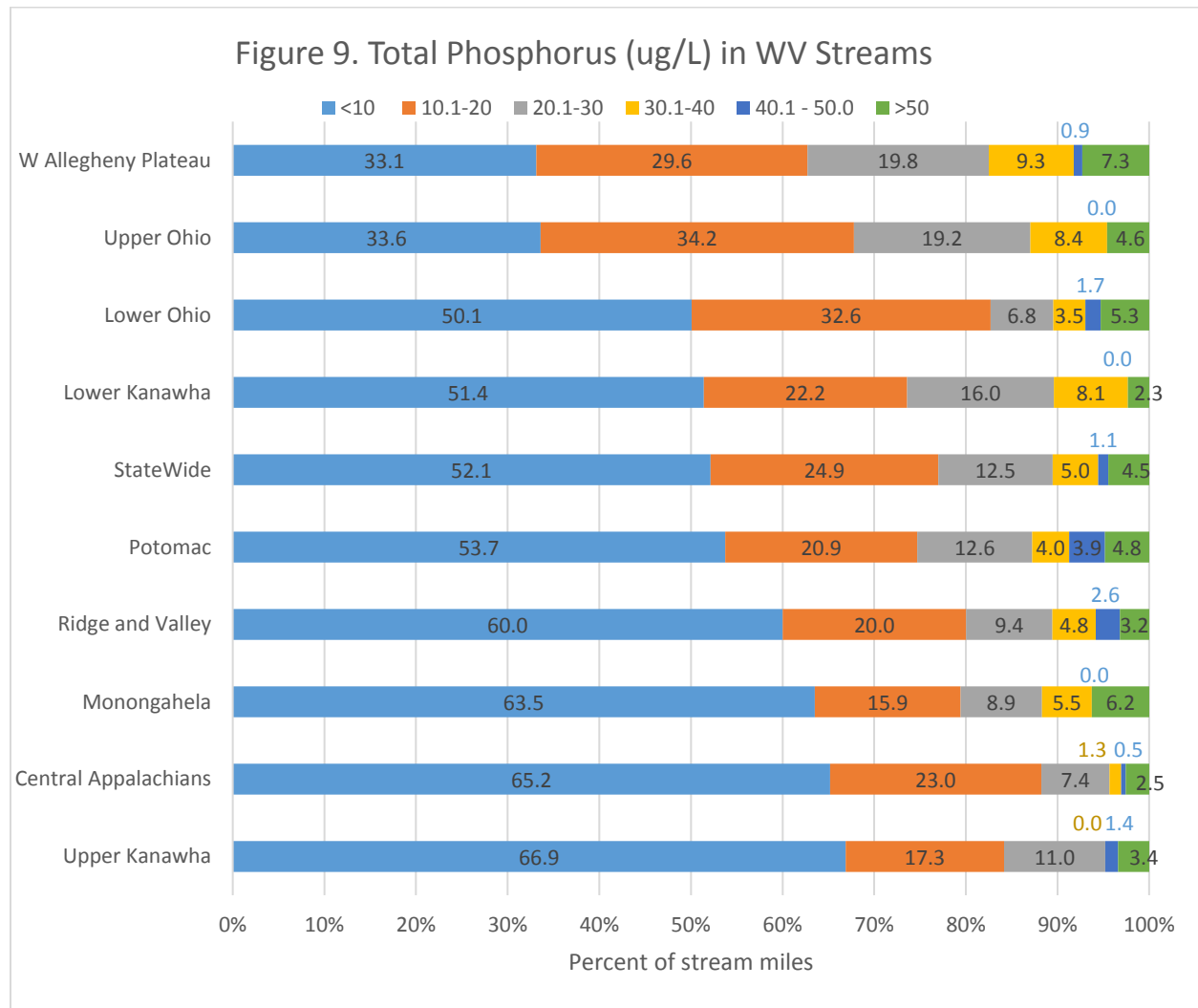
Habitat Indicators of Aquatic Integrity

During the course of probabilistic sampling, DEP personnel collect data on many features of both riparian and instream habitat known to be important to the biological communities of streams. Habitat parameters from EPA's Rapid Bioassessment Protocol (RBP) were measured. These include measures of the amount of sediment and embeddedness in the stream channel as well as measures of the vegetation along the bank and riparian zone in the stream corridor. Specifically, ten parameters are scored (0-20) based on their quality and then combined to assess the overall physical habitat condition of the site. The overall scores (Total RBP Habitat – max score 200 pts.) were categorized as good, moderate, or poor (Figure 10). Based on probabilistic data, just 9.9% of stream miles statewide have good habitat quality (total RBP score of 160 or greater), 73.5% of stream miles have moderate habitat quality (110–159), and 16.6% of stream miles have poor habitat quality (< 110). While these categorical thresholds are somewhat arbitrary, they do provide a good comparison of habitat conditions between geographic areas.

On an ecoregional basis, the Ridge and Valley had the highest proportion of stream miles rated in the good category for overall habitat quality at 19.9%. Additionally, this ecoregion had the least number of stream miles rated as poor for overall habitat quality at only 4.4%.

Total habitat quality scores are lower in the Western Allegheny Plateau. The presence of more widespread development and factors such as higher rates of soil erosion in this ecoregion are potential causes for only 0.5% of its stream miles being rated as good in overall habitat quality. Additionally, the percentage of stream miles with poor habitat quality (28.4%) is substantially higher in this ecoregion.

The Upper Kanawha basin stands out as having the highest percentage of stream miles (35.1%) with good overall habitat. This basin includes large portions of the Monongahela National Forest and several undisturbed wilderness areas. The Upper and Lower Ohio basins have almost no miles in good condition and over a quarter of their stream miles in poor condition.

It is important to consider that approximately 90% of stream miles in the state are in the moderate or poor habitat categories. This indicates that most of the state's stream miles have at least some degree of habitat degradation.
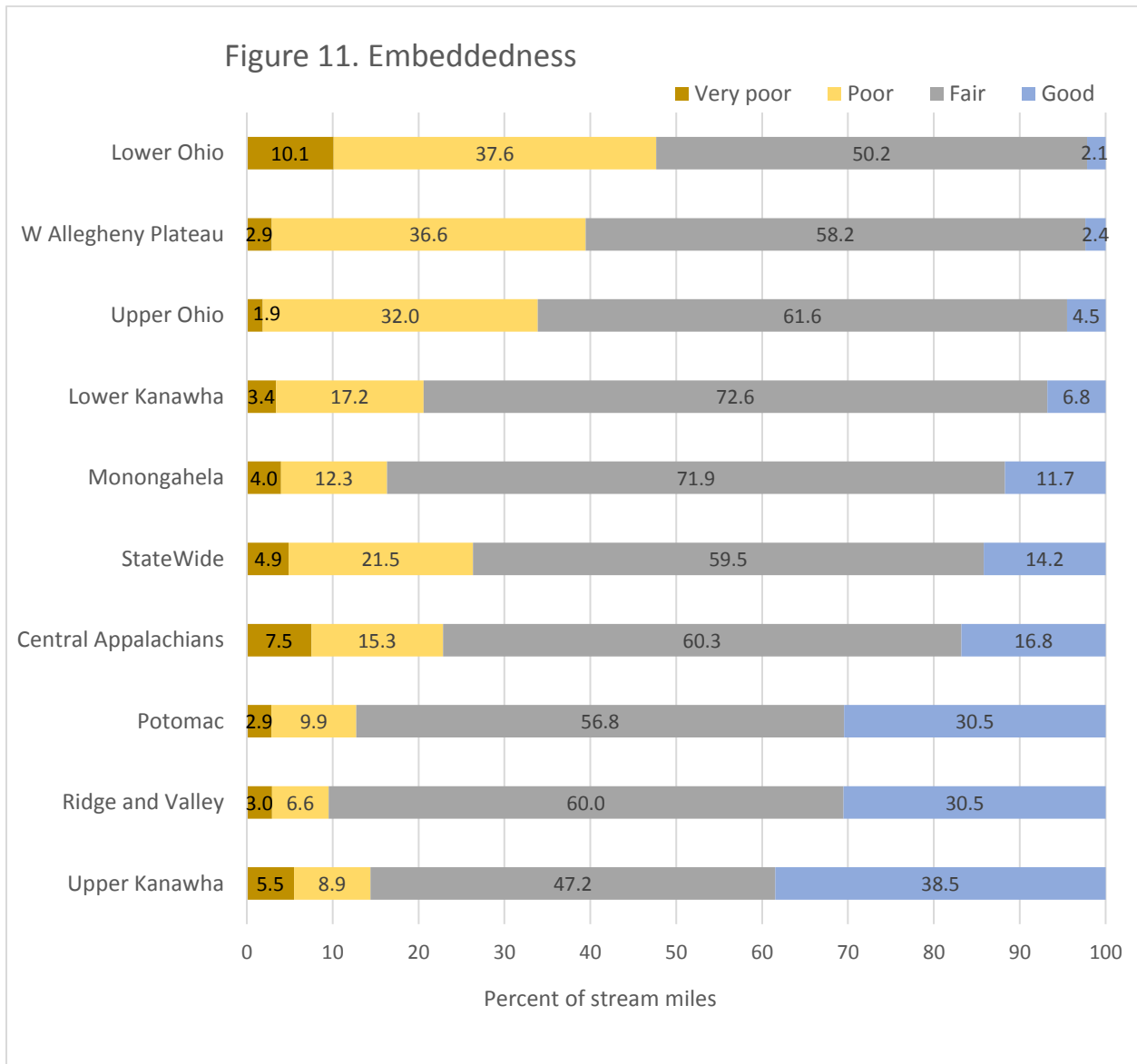
Figure 10. Overall Stream Habitat (RBP Total Score)
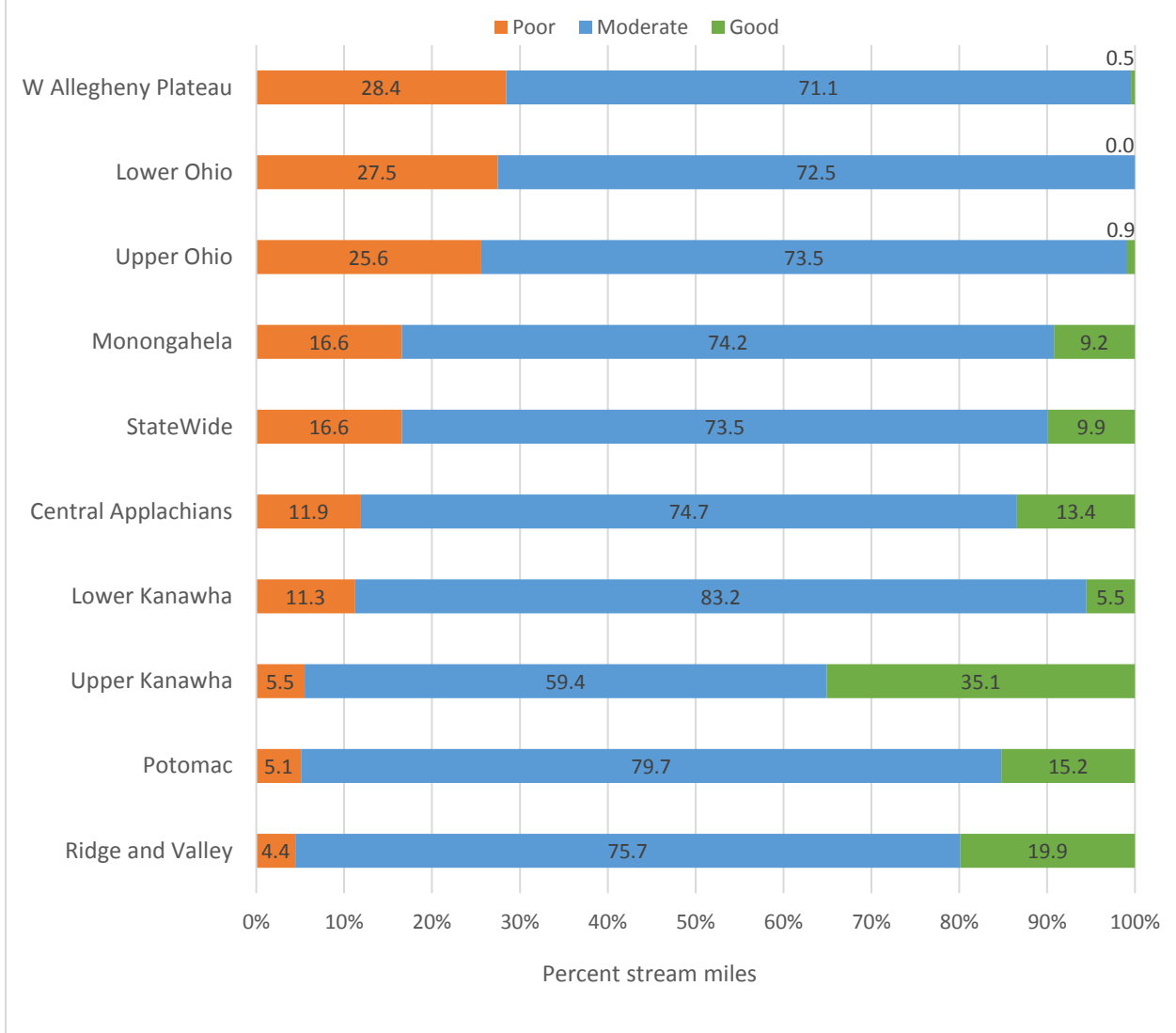
Embeddedness

Although DEP may gain insight into overall habitat conditions by combining the individual measures, it is useful to examine specific habitat characteristics. Sedimentation and the resulting embeddedness is one of the most important problems facing West Virginia streams.   Figure 11 shows the extent to which rocks (gravel, cobble, and boulders) are covered or sunken into the silt, sand, or mud of the stream bottom. Generally, as rocks become embedded, the surface area available to macroinvertebrates and fish for shelter, spawning, and egg incubation is decreased. The Western Allegheny Plateau had the highest percentage of streams with poor or very poor ratings (39.5%) for embeddedness. This is likely because this region has
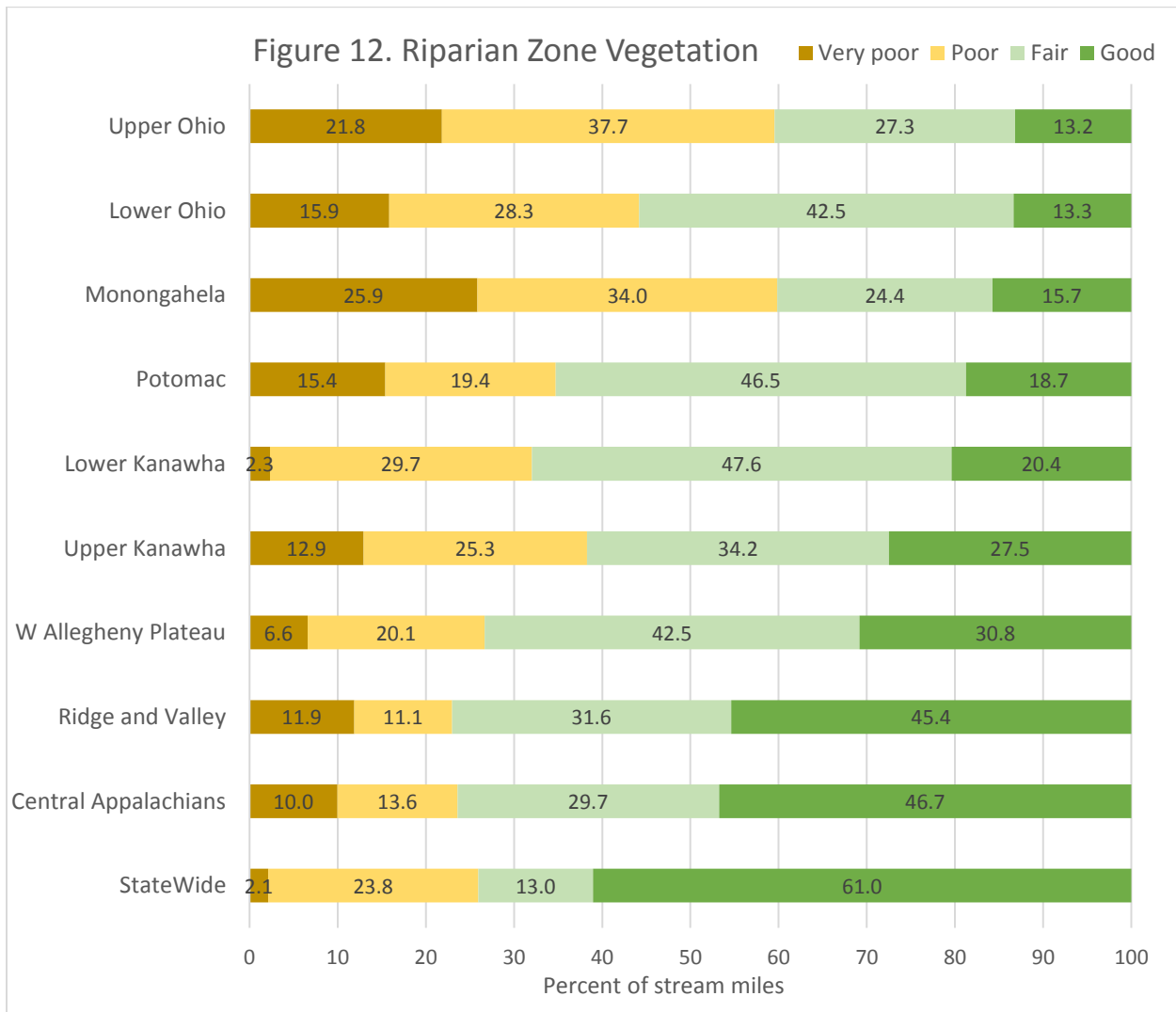
slower, low-gradient streams, has more erodible soils, and more land-disturbing activities than in other areas. The Central Appalachians and Ridge and Valley streams fared better with 22.8% and 9.6% combined poor and very poor ratings, respectively. The Lower Ohio and Upper Ohio basins had the highest percent of stream miles in the poor or very poor category with 47.7% and 33.9%, respectively.

Figure 11. Embeddedness

Legend: Very poor, Poor, Fair, Good

Region	Very poor	Poor	Fair	Good
Lower Ohio	10.1	37.6	50.2	2.1
W Allegheny Plateau	2.9	36.6	58.2	2.4
Upper Ohio	1.9	32.0	61.6	4.5
Lower Kanawha	3.4	17.2	72.6	6.8
Monongahela	4.0	12.3	71.9	11.7
StateWide	4.9	21.5	59.5	14.2
Central Appalachians	7.5	15.3	60.3	16.8
Potomac	2.9	9.9	56.8	30.5
Ridge and Valley	3.0	6.6	60.0	30.5
Upper Kanawha	5.5	8.9	47.2	38.5

Percent of stream miles

Riparian Vegetation Zone

The Ridge and Valley ecoregion had the highest percentage of wide, undisturbed riparian zones at 46.7% (Figure 12). This indicator rates streamside zones on the amount of undisturbed vegetation present, which is desirable for providing shade, creating a more

stable stream bank and minimizing the amount of sediment, excess nutrients and other pollutants entering the stream. In contrast, the Central Appalachians and Western Allegheny Plateau, have a much smaller percentage of riparian zone vegetation rated as excellent with 30.8% and 13.2%, respectively. Among basins, the Upper Kanawha was far better than the others for riparian zone intactness with an estimate of 61% of its stream miles in the good category.

Figure 12. Riparian Zone Vegetation

Legend: ■ Very poor ■ Poor ■ Fair ■ Good

Region	Very poor	Poor	Fair	Good
Upper Ohio	21.8	37.7	27.3	13.2
Lower Ohio	15.9	28.3	42.5	13.3
Monongahela	25.9	34.0	24.4	15.7
Potomac	15.4	19.4	46.5	18.7
Lower Kanawha	2.3	29.7	47.6	20.4
Upper Kanawha	12.9	25.3	34.2	27.5
W Allegheny Plateau	6.6	20.1	42.5	30.8
Ridge and Valley	11.9	11.1	31.6	45.4
Central Appalachians	10.0	13.6	29.7	46.7
StateWide	2.1	23.8	13.0	61.0

Percent of stream miles

Trash/Aesthetic Index

The "Trash/Aesthetic Index" is a measure of the amount of human refuse that is in and around the stream (including that which could be washed into the stream at high flows). Of the three ecoregions, the Ridge and Valley has the highest percentage of "clean" streams, with almost 53.3 percent of stream miles in that category. The Central Appalachians had a slightly lower percentage of clean streams (43.8%) but had the

highest percentage of trashy streams, with more than a fourth of its stream miles moderately trashy or worse. The Upper Kanawha and Potomac were the "cleanest" basins with 68.3% and 55.4% of their stream miles rated as clean, respectively.

Figure 13. Trash / Aesthetics