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2018/2020/2022 West Virginia Integrated Water Quality Monitoring and Assessment Report

Prepared to fulfill the requirements of Section 303(d) and 305(b) of the federal Clean Water Act and Chapter 22, Article 11, Section 28 of the West Virginia Water Pollution Control Act for the period of July 2016 through December 2020.

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1.0 INTRODUCTION

The federal Clean Water Act and 40CFR§130.8 contain requirements to report on the quality of a state's waters. Section 305(b) of the Clean Water Act requires a comprehensive biennial report. Section 303(d) requires, from time to time, a list of waters for which effluent limitations or other controls are not sufficient to meet water quality standards, referred to as impaired waters. Section 314 specifies that states will report an assessment of the water quality of all publicly owned lakes, including the status and trends of such water quality. In addition to federal requirements, West Virginia Code Chapter 22, Article 11, Section 28 also requires a biennial report of the quality of the state's waters. The United States Environmental Protection Agency (USEPA) has recommended these requirements be accomplished in a single report, referred to as an Integrated Report, which combines the comprehensive Section 305(b) report on water quality, the Section 303(d) list of waters that are not meeting water quality standards, and Section 314 assessment of publicly own lakes.

The WVDEP has prepared this Integrated Report to communicate the quality of the state's waters, as well as to explain the methods to assess and report on water quality. WVDEP will also be reporting results of the assessments to the USEPA through the recently developed Assessment, Total Maximum Daily Load (TMDL) Tracking and Implementation System (ATTAINS). To remain consist with reporting through ATTAINS, this Integrated Report and data preparation have been organized differently, however, assessment methodologies have remained consistent with past reporting cycles in most instances, unless identified.

While Integrated Reports are normally published for two-year cycles, WVDEP encountered several circumstances that delayed the release of the 2018 and 2020 cycle reports. For this reason, WVDEP is taking advantage of an opportunity to publish a combined Integrated Report that covers three cycles: 2018, 2020, and 2022. This opportunity allows WVDEP to fulfill reporting requirements while streamlining the process to assess data, obtain input from the public, and obtain USEPA approval.

What is new?

Web-based Interactive Resources

ATTAINS is a relatively new internet-based data management system prepared by the USEPA to better track reported water quality, restoration planning, and implementation consistently across all regions and states. The data reported to USEPA through ATTAINS is made available through public information web applications such as How's My Waterway (https://mywaterway.epa.gov/). While these federal tracking systems and applications are undergoing continued development and maintenance, the best source of information regarding the WV water quality and restoration plans remains the WVDEP webpage. To help navigate the webpages and to provide an interactive platform to visualize the data presented in this Integrated Report, WVDEP has prepared an interactive ESRI StoryMap.

Assessment Units

The most significant change to the Integrated Report and assessment methodology is the creation of relatively static assessment units on which all assessments are conducted.

Previously, the Integrated Report presented impairment for individual bodies of water and identified if the impairment/attainment status applied to the “entire length” of stream, “entire lake”, or some portion of the stream or lake. The majority of listed streams were identified as impaired for their entire length. Segmentation occurred only in situations involving streams with impoundments, streams with more than one designated use (ex. partial trout streams), streams when knowledge of a specific pollutant source allowed clear distinction of impaired and unimpaired segments, or streams with multiple monitoring locations with differing results. In the latter scenario, if water quality results from one monitoring location indicated impairment, the stream was considered impaired until data sampled from a downstream or upstream monitoring station indicated attainment of the water quality criterion.

Using the previous strategy for stream segmentation, when new monitoring stations were added between reporting cycles, the segments of a water body could be re-delineated. Tracking changes in impairment or attainment of specific portions of a stream from one cycle to the next was challenging. Moving forward, the newly established assessment units will not be re-delineated between cycles. Instead, any data collected from an existing or new monitoring station anywhere on the assessment unit reach will be assessed to make impairment/attainment determinations. Every assessment unit in the state is tracked in ATTAINS, so understanding changes in assessment status will be more straightforward.

The newly established assessment units were delineated based on designated uses, existing impairments, drainage area size, upland landuse, influence from tributaries, existing loading scenarios from TMDLs, and other site-specific considerations. This strategy for delineating relatively static assessment units will not only conform to data rules in ATTAINS but is also expected to align more appropriately with TMDL model predictions of impairment and attainment. See TMDL Development Process for more information on how assessment units will be used in TMDLs.

In order to retain impairment status and ensure known water quality issues are addressed in the future, if a newly delineated assessment unit includes any segment previously identified as impaired, the entirety of the new assessment unit is considered impaired. There may be exceptions to this general rule when examining a scenario where the original impaired reach comprises a relatively insignificant length of the newly delineated assessment unit. A different attainment call may be made for an assessment unit, if supported by an examination of landuse, pollutant sources, and historical data. These determinations are made on a case-by-case scenario. A crosswalk between the previously listed stream codes and new assessment unit identifiers (AUIDs) is provided in a Google Sheets workbook named “WV 2016_2022 AUID Crosswalk Final” at the following website:

https://dep.wv.gov/wwe/watershed/ir/pages/303d_305b.aspx

Assessment units are identified alphanumerically based on coding from a 1:24,000 scale stream layer obtained and adapted from the National Hydrologic Dataset (NHD). WVDEP has joined data from this refined stream layer to existing stream codes and names originally derived from a 1:100,000 scale stream layer. As a result, the coding system used to identify streams/stream reaches is different. There were approximately 12,000 assessment units in the 2016 Integrated Report. In comparison using the new NHD 1:24,000 scale streamlines to derive the assessment units, there are now nearly 47,500 assessment units loaded to ATTAINS. Because the scales of the streamlines are so different, many more small streams are represented that have not been monitored or assessed. See Figure 1-1 to visualize the difference the change in streamline scales makes.

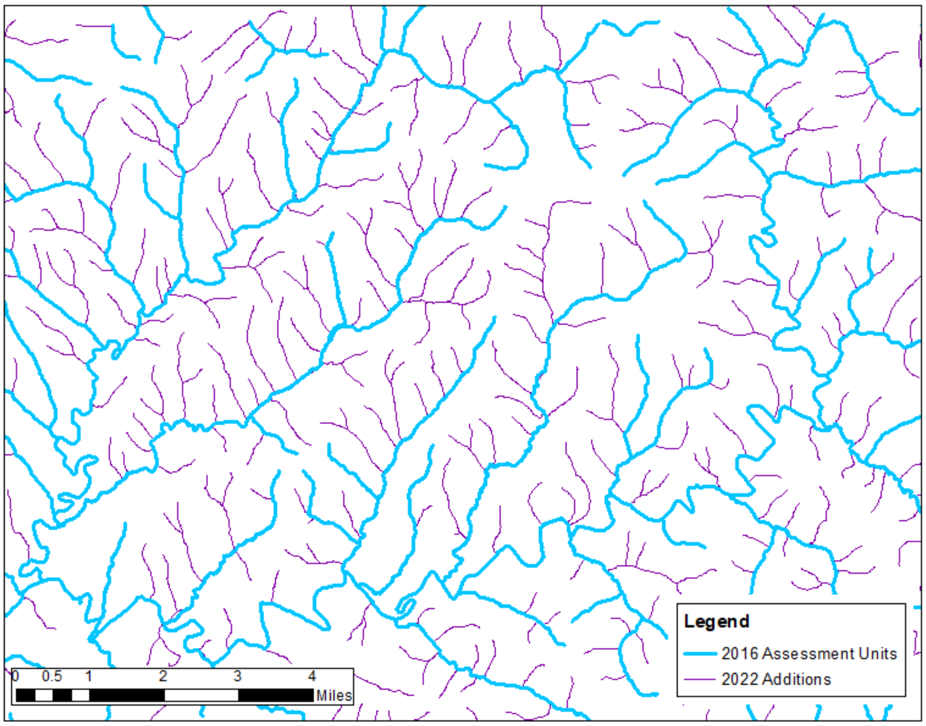


Figure 1-1: Comparison of the streamline resolution in the 2016 Integrated Report with additions for this Combined Integrated Report.

Extended Assessment Periods for Combined Cycles

In order to complete a combined 2018/2020/2022 Integrated Report, assessments were conducted for data collected between July 1, 2012 and December 31, 2020 by the WVDEP's Division of Water and Waste Management Watershed Assessment Branch, as well as, other federal, state, private and nonprofit organizations. This assessment period was established based on the following rationale: an assessment period for the 2018 report would have normally included data collected through June 30, 2017. Following established protocols, any data collected up to five years prior to that date would be considered in assessment, so July 1, 2012 through June 30, 2017 for the 2018 cycle. To streamline data assessment, all data from July 1, 2012 through the 2022 cycle data cut-off date of December 31, 2020 were assessed at the same time. The 2022 cut-off date for data was established as a result of the monitoring delays due to COVID-19 pandemic travel restrictions. Data collected after December 31, 2020 were considered on a limited basis when additional data were needed to finalize an assessment decision (e.g., when a second biological sample was required). A 2018, 2020, or 2022 cycle year designation for newly identified impairment assessment units was accomplished by examining the monitoring sample date range for each assessment unit.

Data Presentation

This report references an interactive ESRI StoryMap. With nearly 47,500 assessments units, the amount of data to be shown on a map of the entire state can be overwhelming. As demonstrated above, many new assessment units represent small unassessed streams and lakes. In addition, streams that were once identified as "entire length" have been segmented to create the static assessments units, even in situations where no monitoring stations exist. In total there are 40,529 unassessed assessment units. The ESRI StoryMap will provide a layer of unassessed streams and a layer of unassessed lakes. The focus of the ESRI StoryMap will be the assessed stream and lake assessment units to display information regarding use attainment and impairment. The ESRI StoryMap can be accessed here:

https://2018-2022-combined-integrated-report-wvdep.hub.arcgis.com/

2.0 WATER QUALITY STANDARDS

Water quality standards are the basis of the assessment process. In West Virginia, the water quality standards are codified as 47CSR2 – Legislative Rules of the Department of Environmental Protection – Requirements Governing Water Quality Standards. Impairment assessments conducted for the Integrated Report are based only upon water quality standards that have received the EPA's approval and are currently considered effective for Clean Water Act purposes. Information regarding the Water Quality Standards can be found at: http://www.dep.wv.gov/WWE/Programs/wqs/Pages/default.aspx. Standards are expressed as numeric or narrative criteria.

ATTAINS uses the term "parameter" to refer to different criteria for which data are collected and assessed. When assessing parameters, WVDEP determines if a parameter is the cause of impairment for a water body or whether the parameter data meets water quality standards. In some instances, if too few data are available, it may not be possible to determine if a certain parameter is causing impairment or attaining water quality standards. In those instances, WVDEP reports that there were insufficient data to assess. If no data are available, a parameter will be reported as unassessed.

Every waterbody is assigned designated uses, described in detail beginning in Section 6.2 of 47CSR2 and summarized in Table 1. Each of the designated uses has associated water quality criteria that describe specific conditions that must be met to ensure that the waterbody can support that use. For example, Category B1 – Warm water fishery use requires that the pH remain within the range of 6.0 to 9.0 standard units. If water quality monitoring finds that the pH is below 6 or above 9, the waterbody is considered impaired, because it is not supporting its designated use. See the Assessment Methodology section of this Integrated Report for more information on use attainment determination.

Table 1: West Virginia Water Use Designations

Category	Use Subcategory	Use Category	Description
A	Public Water	Human Health	Waters, which after conventional treatment, are used for human consumption.
B1	Warm Water Fishery	Aquatic Life	Propagation and maintenance of fish and other aquatic life in streams or stream segments that contain populations composed of all warm water aquatic life.
B2	Trout Waters	Aquatic Life	Propagation and maintenance of fish and other aquatic life in waters that sustain year-round trout populations. Excluded are those waters which receive annual stockings of trout, but which do not support year-round trout populations.
B4	Wetlands	Aquatic Life	Propagation and maintenance of fish and other aquatic life in wetlands. Wetlands generally include swamps, marshes, bogs, and similar areas.
C	Water Contact Recreation	Human Health	Swimming, fishing, water skiing, and certain types of pleasure boating such as sailing in very small craft and outboard motorboats. In ATTAINS, Category C is split into subcategories: Water Contact Recreation - Recreation and Water Contact Recreation - Fish Consumption. The Fish Consumption subcategory applies specifically to those waters for which the State has published advisories limiting consumption, described in Section 5.7. This distinction is needed to inform How's My Waterway. The Fish Consumption subcategory is applied to all waters in the state in this reporting cycle.
D1	Irrigation	All Other	All stream segments used for irrigation.
D2	Livestock Watering	All Other	All stream segments used for livestock watering
D3	Wildlife	All Other	All stream segments and wetlands used by wildlife.
E1	Water Transport	All Other	All stream segments modified for water transport and having permanently maintained navigation aids.
E2	Cooling Water	All Other	All stream segments having one or more users for industrial cooling.
E3	Power Production	All Other	All stream segments extending from a point 500 feet upstream from the intake to a point one-half mile below the wastewater discharge point.
E4	Industrial	All Other	All stream segments with one or more industrial users. It does not include water for cooling.

Numeric water quality criteria consist of a concentration value, exposure duration and an allowable exceedance frequency. The water quality standards prescribe numeric criteria for all designated uses. For the B1, B4 and B2 Aquatic Life uses, there can be two forms of criteria for each parameter: an acute criterion that prevents lethality, and chronic criterion that prevents retardation of growth and reproduction. The numeric criteria for acute aquatic life protection are specified as one-hour average concentrations that are not to be exceeded more than once in a three-year period. The criteria for chronic aquatic life protection are specified as four-day average concentrations that are not to be exceeded more than once in a three-year period. The exposure time criterion for human health protection (i.e., Category Uses A and C) is specified as an annual geometric mean and there are no allowable exceedances.

Narrative water quality criteria are also referred to as conditions not allowable (CNA). For example, the water quality standards contain a provision stating that wastes, present in any waters of the state, shall not adversely alter the integrity of the waters or cause significant adverse impact to the chemical, physical, hydrologic, or biological components of aquatic ecosystems. WVDEP has a protocol to determine if waters exhibit conditions not allowable for the biological component (CNA-biological), which relies upon index of biological integrity for benthic macroinvertebrates referred to as the West Virginia Stream Condition Index (WVSCI). Narrative criteria are contained in 47CSR2. More information regarding the use of narrative criteria is contained in the Use Assessment Procedures section.

Ohio River Criteria

For the Ohio River, both the Ohio River Valley Water Sanitation Commission (ORSANCO) and West Virginia water quality criteria were considered, as agreed upon in the ORSANCO compact. Where both ORSANCO and West Virginia standards contain a criterion for a particular parameter, instream values were compared against the more stringent criterion. WVDEP supports ORSANCO's efforts to promote consistent decisions by the various jurisdictions with authority to develop 305(b) reports and 303(d) lists for the Ohio River. In support of those efforts, West Virginia has and will continue to work with ORSANCO and the other member states through a workgroup charged with improving consistency of 305(b) reporting among compact states. ORSANCO standards may be reviewed at:

http://www.orsanco.org/programs/pollution-control-standards/

3.0 WVDEP SURFACE WATER MONITORING

This section describes West Virginia's strategy to monitor and assess the surface waters of the state. The Watershed Assessment Branch is responsible for general water quality monitoring and assessing throughout the state. Visit the WV Integrated Report interactive ESRI StoryMap to see the monitoring station locations for the entire state. Planning and monitoring follow the watershed grouping framework, in which the state's 32 USGS 8-digit Hydrologic Unit Code (HUC) watersheds are organized into one of five groups, A-E (Figure 3-1).

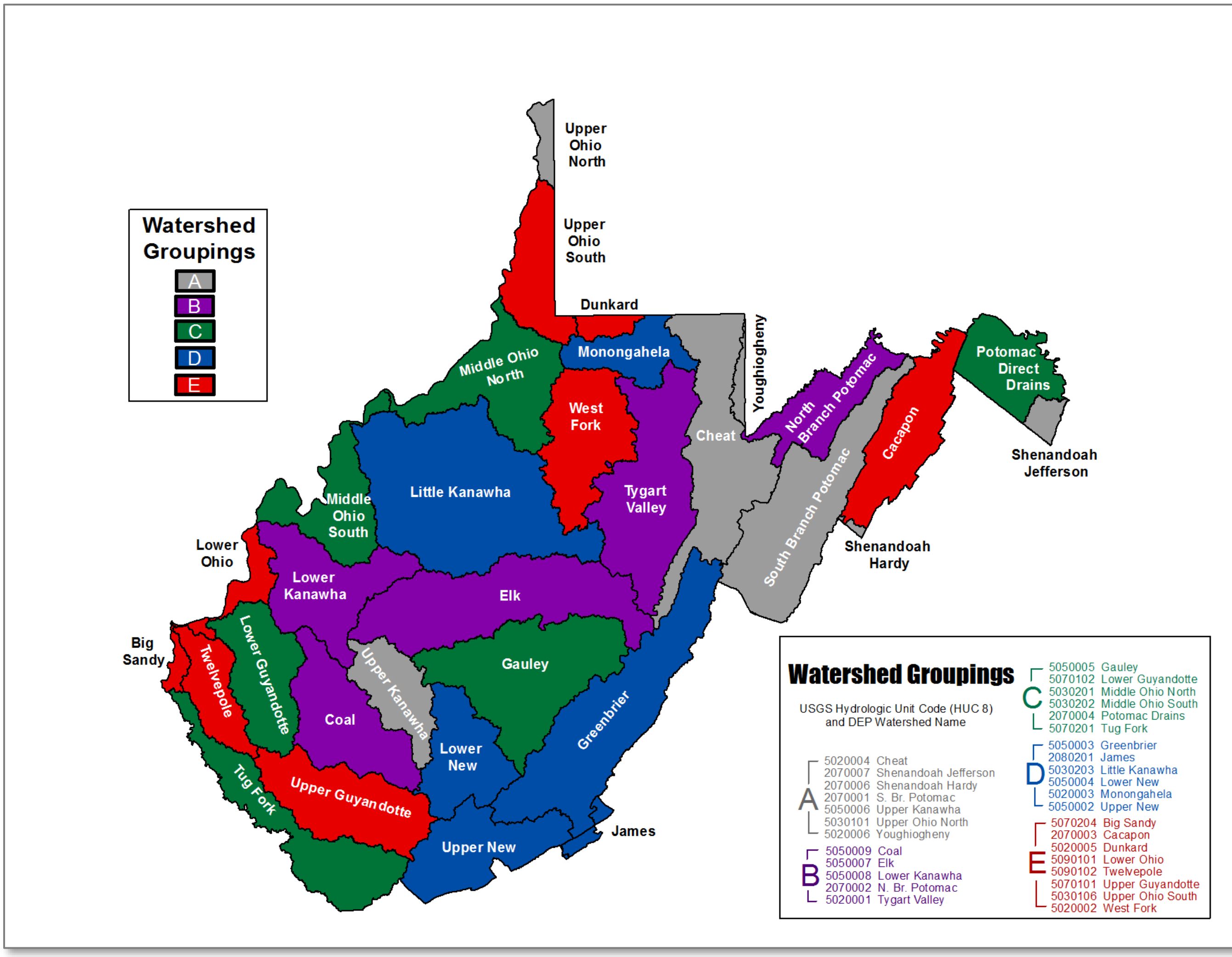


Figure 3-1: West Virginia Watershed Framework Groupings

Using the watershed framework, the focus of several monitoring programs rotates from one grouping to the next each year, while other programs retain a statewide focus every year. At times, given program goals and requirements, the schedule for monitoring has deviated from the rotating framework. This has occurred primarily in the pre-TMDL monitoring program when the priority or quantity of impairments on the 303d list influence a decision to target specific watersheds.

Table 2 provides a summary of monitoring activities that occurred during 2016-2020. The remainder of this section describes each Watershed Assessment Branch monitoring program in detail.

Table 2: Monitoring Activities from 2016-2020

Monitoring	Effort
Ambient	26 Ambient Sites are currently and will continue to be monitored monthly in the Monongahela River Basin Sites or bi-monthly for all other ambient sites. Ambient monitoring resulted in 881 samples being collected between 2016-2020.

Monitoring	Effort
Probabilistic	Probabilistic monitoring is conducted at random locations for statistical comparisons. A fourth round of probabilistic monitoring was completed in 2018. A fifth round was started in 2019. Probabilistic monitoring resulted in 299 samples being collected from 278 streams within 32 major watersheds from 2016-2020.
Pre-TMDL	Pre-TMDL development monitoring was completed in the Upper Guyandotte River Watershed in 2016; for select streams in the Lower Ohio, Big Sandy, and Twelvepole Creek watersheds in 2017; in the Lower Guyandotte River Watershed in 2018; in the Tug Fork River Watershed in 2019 (additional monitoring for the Tug Fork River mainstem continued into 2020), in the Little Kanawha River Watershed in 2020.
Targeted	Targeted Sampling was completed at 388 sites on 309 streams in 25 watersheds representing all five Hydrologic Groups (A-E) from 2016 through 2020.
Lakes	Seven lakes from Group A, 7 lakes from Group B, 9 lakes from Group C, and 7 lakes from Group D were sampled at one or more monitoring locations four times during the May – October assessment seasons in 2016, 2017, 2018, and 2019, respectively. A full round of lake monitoring was not conducted in 2020 due to COVID travel restrictions.
Continuous	Continuous water quality meters were deployed at 133 locations on 106 streams during the 2016-2020 term. Parameters measured include pH, temperature, conductivity, dissolved oxygen, and turbidity.
Long Term	Long Term Monitoring Sites (LTMS) – 318 sites were sampled during the 2016-2020 sampling seasons representing all five Hydrologic Groups.
Wetlands	WVDEP has completed 107 probabilistic West Virginia Wetland Rapid Assessment Method (WVWRAM) assessments during the first two years of its first 5-year-round of stratified probabilistic wetland monitoring.
Harmful Algal Bloom	Harmful Algal Bloom (HAB) monitoring occurs in response to a potential HAB sighting reported to the WVDEP. In addition, in the summer of 2019, the WVDEP Watershed Assessment Branch implemented a Harmful Algal Bloom Long-Term Trend Sampling program. In total, 15 sites were selected with an approximate statewide distribution, focusing on larger waterbodies including rivers, large streams, and lakes.
Filamentous Algae	WVDEP monitors numerous rivers in the state for filamentous algae blooms, including the Greenbrier River, Tygart River, South Branch Potomac River and the Cacapon Rivers. Monitoring generally occurs in late summer - to early fall when flows lower and temperatures begin to rise in the rivers.
Fish Tissue	Monitoring from 2016-2020 resulted in the analysis of 407 samples for PCBs and mercury, and 174 for selenium. These samples were collected from 27 HUC-8 watersheds representing 55 different waterbodies, including 11 lakes.

The Watershed Assessment Branch water quality data and biological data is currently available at: https://apps.dep.wv.gov/dwwm/wqdata/. Data from the Watershed Assessment Branch databases are also being prepared to share on the Water Quality Exchange (WQX) network. The WQX is a mechanism through which data partners can submit water quality data to the USEPA for access publicly through the Water Quality Portal. Currently, a limited amount of the Watershed Assessment Branch data has been uploaded to WQX.

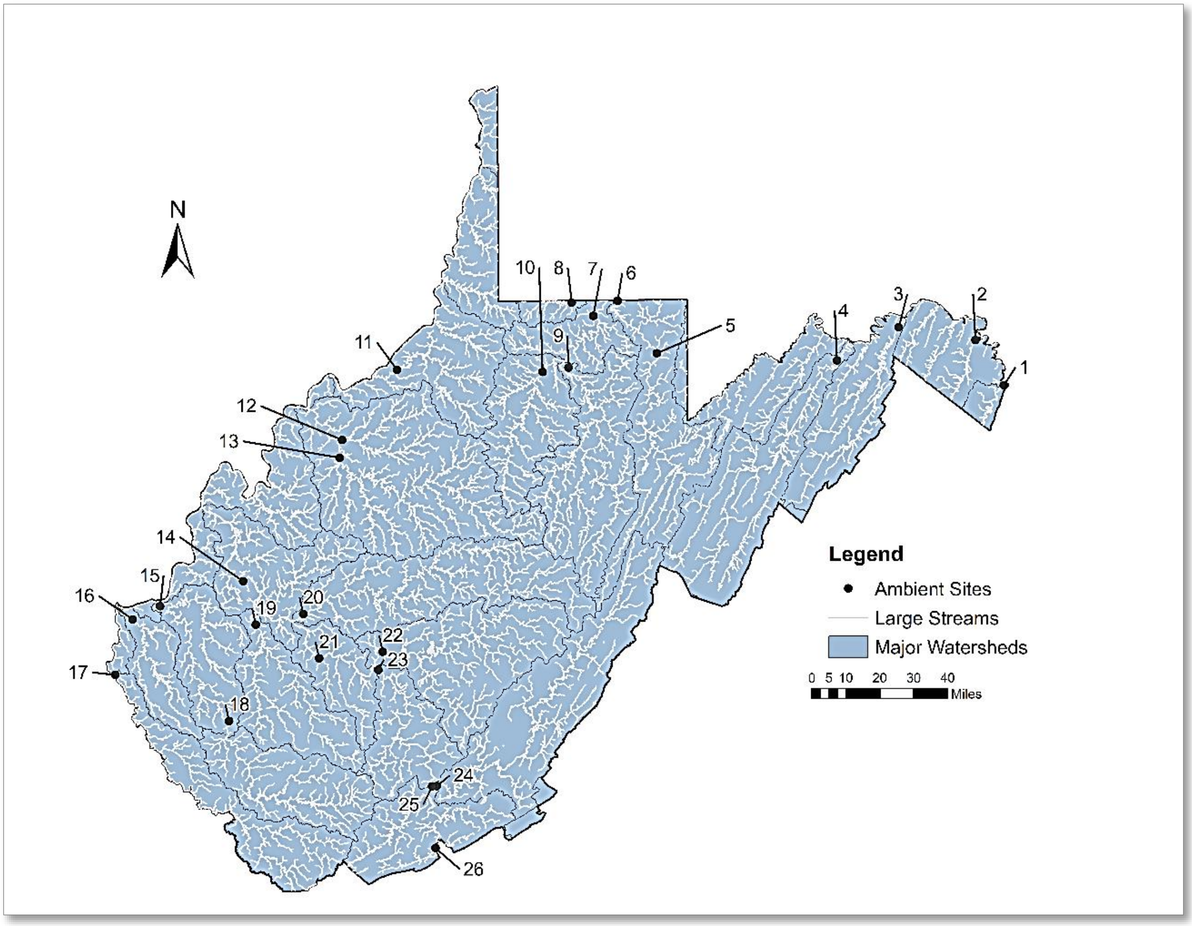
3.1 Streams and Rivers

West Virginia has a comprehensive strategy for monitoring streams and rivers. The Watershed Assessment Branch utilizes a tiered approach, collecting data from long-term monitoring stations, targeted sites within watersheds on a rotating basin schedule, randomly selected sites, and sites chosen to further define impaired stream segments in support of TMDL development. The following paragraphs further describe these programs. For full details on monitoring programs see the Watershed Assessment Branch Field Sampling Standard Operating Procedure at:

https://dep.wv.gov/WWE/watershed/Pages/WBSOPs.aspx.

Ambient Water Quality Monitoring Network

The ambient water quality monitoring network concept was established in the mid-1940s. The network currently consists of 26 fixed stations that are sampled monthly or in the Monongahela River basin, bi-monthly. Sampling stations are generally located near the mouths of the state's larger rivers and are co-located with USGS stream gages. Biological monitoring using benthic macroinvertebrate communities is conducted once annually at or near 20 of these stations. The data provides information for trend analyses, general water quality assessments and pollutant loading calculations, and allows water resources managers to quickly gauge the health of the state's major waterways. Ambient water quality monitoring resulted in 881 samples being collected between 2016 and 2020. The stations are displayed on Figure 3-2 and listed below.



1. Shenandoah River at Harpers Ferry
2. Opequon Creek east of Bedington
3. Cacapon River near Great Cacapon
4. SB Potomac River near Springfield
5. Cheat River at Albright
6. Cheat River below Cheat Lake
7. Monongahela River in Star City
8. Dunkard Creek east of Pentress
9. Tygart Valley River at Colfax
10. West Fork River at Enterprise
11. Middle Island Creek at Arvilla
12. Hughes River west of Freeport
13. Little Kanawha River at Elizabeth
14. Kanawha River at Winfield
15. Guyandotte River at Huntington
16. Twelvepole Creek south of Ceredo
17. Tug Fork at Fort Gay
18. Guyandotte River at Pecks Mill
19. Coal River at Tornado
20. Elk River at Coonskin Park
21. Kanawha River at Chelyan
22. Gauley River at Beech Glen
23. New River above Gauley Bridge
24. Greenbrier River at Hinton
25. New River at Hinton
26. New River at Virginia State line

Figure 3-2: West Virginia Ambient Monitoring Sites

Probabilistic (Random) Sampling

In 1997, the Watershed Assessment Branch began sampling sites selected through the USEPA's random stratified procedure to better assess the ecological health of watersheds and ecoregions within the state. The data generated from this random stratified (also known as probabilistic) sampling effort allows the WVDEP and the USEPA to make statistically valid assessments of aquatic integrity on a statewide basis as well as make comparisons between watersheds and ecoregions. The data also assists in monitoring long-term trends in watershed and ecoregion health. The WVDEP has completed four rounds of probabilistic monitoring. WVDEP started a fifth round of probabilistic sampling in 2019. A full round of monitoring is normally conducted over a five-year period in order to characterize conditions in wadeable streams over a range of baseflow regimes and weather conditions. Probabilistic monitoring resulted in 299 samples being collected from 278 streams within 32 major watersheds from 2016-2020. Further details are provided in the section titled Probabilistic Data Summary.

Pre-Total Maximum Daily Load (TMDL) Development Monitoring

The primary objective of this major effort is to collect sufficient data for Total Maximum Daily Load (TMDL) modelers to develop stream restoration plans. Pre-TMDL monitoring has traditionally followed the 5-year framework cycle, (i.e., impaired streams from watersheds in Hydrologic Group A were sampled in the same year as sampling by other stakeholder agencies participating in the watershed management framework). The 303(d) list is the basis for initial site selection and additional sites are added to comprehensively assess tributary waters and to allow identification of the suspected sources of impairment. More recently, to address impairments that have been listed for several years, watersheds were selected for TMDL development outside of the schedule established by the framework cycle.

Pre-TMDL development monitoring was completed for the Upper Guyandotte River Watershed in 2016; for select streams in the Lower Ohio River, Big Sandy River, and Twelvepole Creek Watersheds in 2017; and for the Lower Guyandotte Watershed in 2018. WVDEP monitoring for the Tug River watershed was completed in 2019 for most streams. The exception was in the Tug River mainstem. These sites were monitored for an extended period of time to coincide with a monitoring project in the seven largest tributaries draining from Kentucky into the Tug River. Pre-TMDL monitoring began in the Little Kanawha River watershed (except Hughes River) in 2019. Due to travel restrictions resulting from the COVID-19 pandemic, sampling in most streams was extended to December 2020. To conform to a revised assessment procedure for CNA-biological, additional benthic macroinvertebrate monitoring occurred in these watersheds beyond the scheduled pre-TMDL program timelines to obtain second samples where needed.

Pre-TMDL monitoring for the Cacapon River watershed commenced in June 2021 and should be completed in 2022. These data were not considered in this assessment cycle, except for instances to verify listing/delisting decisions based on third party monitoring data.

Pre-TMDL monitoring is intensive, consisting of monthly sampling for parameters of concern, which captures data under a variety of weather conditions and flow regimes. Pre-TMDL monitoring also includes an effort to locate the specific sources of impairment, with particular attention paid to identifying pollutant sources and land use stressors. For more information, see the TMDL Development Process section.

Targeted Monitoring

Targeted monitoring has been a component of West Virginia's assessment strategy since the Watershed Assessment Program's inception in late 1995. Streams are sampled on a five-year rotating basin approach. Sites are selected from the watersheds targeted for sampling each year. Each site is subjected to a one-time evaluation of riparian and instream habitat, basic water quality parameters, and benthic macroinvertebrate communities.

Sites are selected to meet a variety of informational needs in the following areas:

- Impaired streams
- Reference streams (minimally impacted)
- Spatial trends (multiple sites on streams exceeding 15 miles in length)
- Areas of concern as identified by the public and stakeholders
- Previously unassessed streams

Targeted Sampling was completed at 388 sites on 309 streams in 25 watersheds representing all five Hydrologic Groups (A-E) from 2016 through 2020.

Long Term Monitoring Sites (LTMS)

Data from LTMS are used to monitor water quality and habitat trends over time at targeted wadeable streams throughout the state. The stations represent a wide array of impairments commonly identified in WV (acid mine drainage, acid deposition, sediment, nutrient enrichment, etc.). Importantly, the network also includes streams that represent reference or best-attainable conditions.

Sampling frequency is variable. Most sites are sampled annually, while others are sampled every two to three years. Critical elements include habitat evaluations, benthic macroinvertebrate assemblages, on-site measurements, and water quality sampling (Refer to Table 2 for details). The sampling events take place between March and October, inclusive. Most sites are sampled once per year; however, a subset of the LTMS sites is sampled twice per year to document seasonal differences.

During the 2016-2020 sampling seasons, 318 LTMS sites were sampled representing all five Hydrologic Groups.

Continuous Monitoring

Deployable sondes are used for a variety of applications to provide more detailed information on a stream. These devices can capture conditions that may not be captured with grab samples, such as diurnal changes and episodic events. These devices are used to support existing studies, such as TMDL development and trout stream determinations. As these units are frequently moved to meet the agency's needs, the number of sites is variable.

Typically, the sondes are programmed to record parameters hourly. However, if frequent fluctuations in water quality are suspected, parameters may be recorded at 30-minute or 15-minute intervals. Deployed sondes are visited a minimum of once per month to download data, perform maintenance, and to retrieve or replace the sonde. A critical element is conducting discrete checks, wherein a second recently calibrated multi-probe meter is used to record field readings (temperature, pH, dissolved oxygen, and/or conductivity) immediately adjacent to the deployed unit. The discrete check provides a fresh baseline and aids in compensating for drift in the deployed unit's recordings.

Data recorded by deployable sondes were not included in this assessment effort, as processes to assure quality are still being finalized before developing an assessment methodology. Discreet samples collected during deployment and during monthly maintenance are included in assessments for the Integrated Report. More than one is collected at each site during a maintenance visit to allow for deployable data quality control. Only one representative sample for the site visit was assessed. To ensure no impairment was overlooked both the highest and lowest pH sample were examined to select a representative sample, while the lowest dissolved oxygen data was considered.

Water quality meters were deployed at 133 locations on 106 streams during the 2016-2020 term. Parameters measured include pH, temperature, conductivity, and dissolved oxygen.

3.2 Lakes and Reservoirs

In 2006, WVDEP resumed a lake monitoring component that focuses on physicochemical water quality parameters. WVDEP added the collection of aquatic macroinvertebrates to the lake monitoring program in 2011.

The objectives of lake monitoring are to identify areas of impairment and to document recovery where abatement plans have been implemented. Sites are selected to update existing data or to address sites with little or no information. Lakes are sampled in accordance with the five-year hydrologic grouping watershed cycle. Seven lakes from Group A, 7 lakes from Group B, 9 lakes from Group C, and 7 lakes from Group D were sampled at one or more monitoring locations four times during the May - October assessment seasons in 2016, 2017, 2018, and 2019, respectively. A full round of lake monitoring was not conducted in 2020 due to COVID travel restrictions.

The number of sites per lake is proportional to the size and shape of the impoundment. One site is established at the deepest part of the impoundment and additional sites may be added to evaluate different arms of the lake or to provide longitudinal information. Each lake is sampled four times during the summer months (June - September or May - August), coinciding with the primary growing season in WV. Critical elements are vertical chemistry profiles for temperature, pH, dissolved oxygen, and conductivity (on-site measurements); nutrients, fecal coliform bacteria, and chlorophyll-a sampling; and Secchi depth.

Many of West Virginia's largest reservoirs are controlled by the U.S. Army Corps of Engineers. Although the Corps' primary mission is to manage structures to provide navigation and flood control, the agency is also committed to water quality management. Data generated by the Corps has been used for assessment purposes.

Additional lake information is available from the West Virginia Division of Natural Resources (DNR). The DNR, one of the signatory agencies in the Partnership for Statewide Watershed Management, conducts fish community surveys on many of the state's reservoirs.

3.3 Wetlands

WVDEP contributes to the management of the State's wetlands. Wetlands are areas where the land is covered by shallow water, or the soil is saturated to the surface for at least two weeks during the growing season. Wetlands are wet enough to affect the types of soils and plants that can occur, but they may also be dry at certain times of the year. Some common names for different types of wetlands are swamp, marsh, and bog. According to the National Wetlands Inventory for WV in 2021, the current total acreage of wetlands within the state is approximately 111,000 acres and comprises less than one percent of the State's total acreage; yet wetlands are critical to the overall health of our state's aquatic resources by reducing the impacts of floods, providing baseflow to streams, reducing bank erosion, removing pollutants, processing excess nutrients, capturing sediment, and providing habitat to a high diversity of plants and animals. Management efforts are currently geared toward protection of wetlands by regulatory proceedings or acquisition. Permitting authority for activities impacting wetlands lies with the U. S. Army Corps of Engineers (Clean Water Act, Section 404). WVDEP supports protection through the Clean Water Act, Section 401 certification program.

WVDEP's Watershed Assessment Branch has developed functional and condition assessments for West Virginia's wetlands. The indices developed for the assessment are being used throughout the state to better describe the functions that different wetlands can provide and their overall health or condition. The West Virginia Wetland Rapid Assessment Method (WVWRAM) includes desktop GIS Wetland Assessment Tool (level 1), and a rapid field assessment method (level 2). These two assessments enable calculation of debits and credits for wetland impacts and mitigation sites, as well as help to prioritize sites for land acquisition, restoration, and preservation. In 2022-2023, WVWRAM is expected to be incorporated into the WV Stream and Wetland Valuation Metric (SWVM), which is used by the U.S. Army Corp of Engineers (USACE) and the WV Inter-agency Review Team to assess impacts in West Virginia.

Statewide desktop GIS assessment of wetland function was completed in 2019 for all wetlands mapped in the National Wetlands Inventory (43,124 wetland complexes). These are preliminary scores which must be field-verified for any wetlands entering the regulatory process. GIS-based wetland function scores are publicly available on the WVDEP GIS viewer at: https://tagis.dep.wv.gov/wvdep_gis_viewer/

Targeted monitoring has been a component of West Virginia's wetland assessment strategy since WVWRAM sampling began in 2017. Sites are selected to meet a variety of informational needs. The following sites were sampled using WVWRAM (level 1 & 2) in 2017-2021:

45 reference wetlands (minimally impacted)
64 restored wetlands (pre-construction and/or post-construction data)
28 wetlands facing impacts (pre-impact data)
21 training sites

In 2020, the Watershed Assessment Branch began sampling wetland sites selected through the USEPA's random stratified (probabilistic) procedure. The data generated from this sampling effort allows the WVDEP and the USEPA to make statistically valid assessments of wetland conditions on a statewide basis as well as make comparisons between watersheds and ecoregions. The data also assists in monitoring long-term trends in wetland health. WVDEP has completed 107 probabilistic WVWRAM assessments during the first two years of its first 5-year-round of stratified random wetland monitoring.

3.4 Other Monitoring

When the need arises, WVDEP responds to specific conditions or pollutants of concern in any waterbody. The Watershed Assessment Branch may partner with other agencies to collect data to better understand threats to water quality standards and designated uses.

Harmful Algal Blooms

The focus of West Virginia's Harmful Algal Bloom Response Plan is on public recreational waters, although these principles and practices can apply to any body of water. A coordinated effort is crucial to successfully respond to harmful algal blooms (HABs) in West Virginia. Agencies primarily responsible for HAB response in West Virginia include West Virginia's Bureau for Public Health, WVDEP, Division of Natural Resources (DNR) and local health departments. The following are the responsibilities of WVDEP in the development of this response plan:

- Conduct sampling when blooms are sighted
- Report potential HAB to West Virginia's HAB mailbox at HAB@wv.gov
- Train others in sampling protocols
- Conduct aerial surveillance to monitor HABs
- Maintain database of all reported HAB data
- Maintain website, reporting app and interactive map of HAB advisories
- Provide outreach to the public about HABs
- Coordinate with the USACE on all USACE lakes

Sampling will be conducted on a case-by-case basis depending on water conditions as algae starts to appear, especially during the peak recreational season. Samples should be collected and if it is determined that the algal bloom is dominated by potentially toxigenic genera of cyanobacteria, the algal bloom will be classified as a HAB and cyanotoxin analysis would be conducted. Initial testing is conducted in house via an mBio/LightDeck analysis unit to quantitatively determine concentrations of Microcystin and Cylindrospermopsin. If the toxins are detected at levels of concern, or if the algae present are capable of producing additional toxins beyond microcystin and cylindrospermopsin, the sample would be submitted to a lab for quantitative testing. The HAB location should be monitored closely and if cyanotoxin concentrations are above the Public Health Watch Advisory threshold, the area would be sampled at least weekly. Sampling should continue until two consecutive results collected one week apart indicate that cyanotoxin concentrations are below the watch advisory threshold. However, monitoring may continue based on environmental conditions and relative health risk.

In the summer of 2019, the WVDEP Watershed Assessment Branch implemented a Harmful Algal Bloom Long-Term Trend Sampling program. In total, 15 sites were selected with an approximate statewide distribution, focusing on larger waterbodies including rivers, large streams, and impoundments (lakes). In 2021, three additional sites were established, and additional sites may be established as needed in the future. Sites were selected either due to a history of harmful algal blooms, a history of elevated nutrient concentrations, or neither HAB history nor history of elevated nutrients. These locations will be sampled multiple times per year, for several years to attempt to determine trends in the occurrence of HABs in West Virginia. Sampling efforts consist of a visual survey for algae (including benthic/bottom substrate, water column, and water surface), collection and identification of algae present with emphasis on cyanobacteria, algal toxin testing via semi-quantitative methods (Abraxis field test strips) for microcystin and cylindrospermopsin, and water column nutrient concentration analysis. Nutrient samples were collected in accordance with Watershed Assessment Branch SOP methods.

Filamentous Algae

Filamentous algae are connected algae cells that grow and form long threads or filaments. When growth is excessive, large mats can form that stretch from the river bottom to the surface and cover significant portions of a river reach. The term “Filamentous Algae” refers to any number of species that can be found in rivers and streams. There are numerous species of algae that are native to West Virginia and that can be found at any one location. WVDEP is monitoring numerous rivers in the state for filamentous algae blooms, including the Greenbrier River, Tygart River, South Branch Potomac River and the Cacapon River. Monitoring generally occurs in late summer to early fall when flows lower and temperatures begin to rise in the rivers.

Fish tissue

In recent years, fish tissue analysis has been conducted annually, collecting fish from targeted sites on a 5-year rotation. Monitoring from 2016-2020 resulted in the analysis of 407 samples for PCBs and mercury, and 174 for selenium. These samples were collected from 27 HUC-8 watersheds representing 55 different waterbodies, including 11 lakes. All five Hydrologic Groups (A-E) were represented. In 2016 and 2017, WVDEP conducted a rigorous fish tissue evaluation of the Kanawha and Monongahela rivers with samples analyzed for mercury and PCBs, as well as dioxin at most Kanawha River sites.

4.0 THIRD PARTY MONITORING AND DATA

In addition to data collected by the WAB, the agency considered data from external sources for assessment. The agency sought water quality information from various state and federal agencies, including other DEP programs. Specific requests for data were made to state and federal agencies known by WVDEP to generate water quality information. Additionally, news releases and public notices requesting data submissions were published in state newspapers and on WVDEP Water and Waste Management's website. Multiple requests for data were advertised to collect available data for each of the 2018, 2020, and 2022 reporting cycles.

WVDEP has developed guidance for those wishing to submit data to be assessed for 303(d) list development. The guidance includes a list of requirements for data assembly and submission, along with helpful internet links and a checklist for data submitters. The guidance is available at:

https://dep.wv.gov/WWE/watershed/IR/Documents/3rdPartyQAGuidelines_2021.pdf

Beyond requesting data from partners, WVDEP also obtained data from the USEPA Water Quality Portal for use in assessments. Data collected from July 1, 2015 through December 30, 2020 were downloaded from the Water Quality Portal. Data were examined to identify those for which water quality criteria exist. Stations data were plotted geospatially to associate the data with appropriate assessment units. Entities that provided information in response to the agency's request for data for the 2016 Section 303(d) list, or agencies whose data were obtained only from the Water Quality Portal (i.e., having a WQX prefix) are shown in Table 4.

Table 3: Data contributors for the 2016 303(d) List and Integrated Report

ORSANCO	US Forest Service
USACE	WV Department of Agriculture
West Virginia Conservation Agency	National Park Service
US Geological Survey	USEPA- Wheeling
Friends of Deckers Creek	Trout Unlimited
Blue Ridge Watershed Coalition	Davis Creek Watershed Association
Friends of Cheat	WQX-WIB: Friends of Blackwater
WQX-The Conservation Fund Freshwater Institute	WQX-WIB: Friends of Hughes River
WQX- Chesapeake Bay Program	WQX-Division of Surface water (Ohio)
WQX-Virginia Department of Environmental Quality	WQX-Chesapeake Bay Program
WQX-PA Department of Environmental Protection	WQX-Izaak Walton League of America

All readily available data were considered during the evaluation process. WVDEP's staff reviewed data from external sources to ensure that collection methods, analytical methods, detection levels, quality assurance and quality control were consistent with approved procedures. In select instances when contributors reported pH results collected using litmus paper opposed to a calibrated probe, pH data were excluded.

5.0 USE ASSESSMENT PROCEDURES

The primary focus of this report is to assess water quality data to determine if waters are supporting their designated uses. The first step in assessing whether a waterbody is supporting its uses is to determine if monitored parameters are meeting water quality criteria. If any parameter measured in a waterbody is not meeting criteria protective of a designated use, then that waterbody will be categorized as impaired or "not supporting" its use. See Section 2.0 Water Quality Standards for more details on water quality standards.

Waters are placed in one of the five Integrated Report Categories based on their level of designated use support. Table 4 provides details of each Integrated Report Category.

Table 4: Integrated Report Categories for West Virginia Waters

Category		Description
Category 1		Waters fully supporting all designated uses
Category 2		Waters fully supporting some designated uses, but no or insufficient information exists to assess the other designated uses
Category 3		Waters where insufficient or no information exists to determine if any of the uses are being met
Category 4		Waters that are impaired or threatened but do not need a total maximum daily load (TMDL)
	4a	Waters that already have an approved TMDL but are still not meeting standards
	4b	Waters that have other control mechanisms in place which are reasonably expected to return the water to meeting designated uses
	4c	Waters that have been determined to be impaired, but not by a pollutant (ex. low flow alteration)
Category 5		Waters that have been assessed as impaired and are expected to need a TMDL

5.1 Assigning Integrated Report Categories

Integrated Report Category 1, 2, or 3

The guidelines used by WVDEP to demonstrate use support for streams (and subsequent classification into Categories 1, 2 or 3) vary for each of the designated uses. It is important to note that it is infeasible to regularly monitor many water quality standards in every location. When developing monitoring plans, WVDEP considers which pollutants are likely to occur in a waterbody and analyzes water quality for those pollutants. "Supporting" assessments for individual uses are made if certain mandatory (requisite) parameters have been monitored and those results demonstrate compliance with criteria. To demonstrate support, aquatic life uses (Warm Water Fisheries or Trout Waters) in wadeable streams require benthic macroinvertebrate monitoring and results showing a WVSCI score greater than or equal to 72. Public Water Supply and Water Contact Recreation uses require compliant fecal coliform monitoring and all other uses require compliant pH and dissolved oxygen monitoring. If monitoring results are available for "non-mandatory" (ancillary) parameters, they also must indicate compliance with any criteria prescribed for the use.

Stream segments where mandatory parameters indicate support of all designated uses are placed in Category 1. Stream segments without sufficient data to determine use support or impairment may be placed in either Category 2 or 3. Category 2 houses waters with some uses determined to be supported but lacking sufficient information to assess other uses. Waters are placed in Category 3 if insufficient or no information exists to determine if any of the uses are being met. An "insufficient data" designation may result where some water quality data are available, but not enough to conclude that the use is supported or impaired, or where water quality data for mandatory (requisite) parameters is absent.

A new subcategory, Water Contact Recreation: Fish Consumption, has been added to ATTAINS to accommodate the design of How's My Waterway. The subcategory has been assigned to all assessment units, even when the waterbody may not support fish populations because of size, stream flow, topography, etc. In most waterbodies, no fish tissue data are available for assessment, so fish consumption is "unassessed"; thus, any waterbody that is otherwise fully supporting other uses is placed in Category 2. For future Integrated Reports, WVDEP will determine an appropriate methodology to assign the subcategory for fish consumption to waterbodies. For example, fish consumption may not apply to intermittent streams in future reports.

Integrated Report Category 4 or 5

In order for a stream to be placed in Categories 1, 2, or 3, there can be no impairments. When any parameter is not meeting criteria, then the waterbody is not supporting a designated use. The entire assessment unit is considered impaired and placed in Integrated Report Category 5 (needs a TMDL) or Category 4 (does not need a TMDL). Prior to TMDL development, waters impaired by a pollutant are placed on the Section 303(d) List and in Category 5. After TMDLs are developed and approved, those waters are placed in Category 4a. Other impaired streams for which TMDLs need not be developed are placed in Categories 4b or 4c. Category 4b includes waters impaired by a pollutant for which other control mechanisms are in place that will reasonably result in the water meeting designated uses. Waters impaired by something other than a pollutant, for which no TMDL can be developed, are categorized as 4c (ex. low flow alterations).

5.2 Data for Assessment

When assessing, WVDEP generally considers water quality data with sample dates up to five years prior to the cycle end date. For instance, for the 2018 cycle, data from July 2012 through the end date of June 2017 was considered for assessment. This intentionally limits the use of data more than five years old. However, in the absence of newer information, previous assessments are carried forward even if the data becomes older than five years. Additionally, if a water quality criteria change is approved which affects an older assessment, the new assessment is based upon the current criteria. December 2020 was the 2022 cycle end date. Data collected after December 2020 will be assessed in the next reporting cycle. However, in specific instances, more recent data were considered to validate an assessment call. As described earlier, a 2018, 2020, or 2022 cycle year designation for newly identified impairment assessment units was accomplished by examining the monitoring sample date range for each assessment unit.

Waters are not deemed impaired based upon water quality data collected when stream flow conditions were less than 7Q10 flow (the seven-consecutive-day average low flow that recurs at a 10-year interval) or within regulatory mixing zones. Further, waters are not deemed impaired based upon "not-detected" analytical results from methodologies that have detection limits that are not sensitive enough to confirm criteria compliance. For example, a dissolved aluminum result of "not detected" using a method with a detection limit of 0.1 mg/l would not prompt a dissolved aluminum listing for trout waters with a criterion of 0.087 mg/l.

Additionally, WVDEP does not interpret the impacts of a single pollution event (such as a spill) as representative of current conditions if it is believed that the problem has been addressed. Similarly, WVDEP does not intend to interpret the results of clustered monitoring of a single event as being representative of water quality conditions for longer time periods. Datasets are screened for excessive clustering of monitoring, in space or time, to avoid misinterpretation. No data were excluded based on a single pollution event or clustered monitoring of a single event for this Combined Integrated Report assessment cycle.

The decision criteria do not provide for 303(d) listing of waters with severely limited data sets and exceedance (e.g., one sample in a five-year period exceeding water quality standards). Such waters would be classified as having insufficient data available for use assessment. WVDEP will target these "one-hit" waters for additional monitoring by incorporating them into the pre-TMDL monitoring plans at the next opportunity for TMDL development in their watershed. Where the intensified pre-TMDL monitoring (monthly sampling for one year) indicates impairment, TMDL development will be initiated, even though the water may not be included in Category 5 of the current Integrated Report.

With the creation of relatively static assessment units, water quality data collected from individual monitoring stations in the assessment unit were assessed separately to determine attainment. If water quality at any monitoring station within the assessment unit was considered impaired, the entire assessment unit was considered impaired. The only exception to this general rule was relative to data collected by ORSANCO along the Ohio and Kanawha Rivers at the dams. Data collected at the dam was applied to assessment units both upstream and downstream of the monitoring location.

5.3 Numeric Water Quality Criteria

The assessment methodology for numeric water quality criteria used in preparation of the combined 2018/2020/2022 Integrated Report is consistent with those used in previous reporting cycles, with one exception, the application of a duration for human health criteria. Previously, 47CSR2 listed criteria to be protective of human health. The criteria frequency was stated "not to be exceeded", but no duration was provided. The WV State Legislature and the USEPA have since approved a clarification to the human health criteria to include the duration of an annual geometric mean. See Fecal Coliform Numeric Criteria for Contact Recreation and Drinking Water below for more information.

One additional and significant change was made to the WV Water Quality Standard during the assessment period. This change was to the water quality criteria for selenium. The WV State Legislature and USEPA approved a change to add measurements of selenium concentrations in fish tissue (i.e., whole body, muscle, egg/ovary), in addition to the previously established water column concentration criteria. Water column concentrations were the only data considered for this Integrated Report cycle. In the future, once an assessment protocol is developed and data are available, concentration of selenium in fish tissue may result in listings or delistings of selenium impairment.

Chronic Criteria Protective of Aquatic Life

Typically, in cases where exceedances of chronic aquatic life protection criteria occur more than 10 percent of the time, the water is impaired. If the rate of exceedance demonstrated is less than or equal to 10 percent, then the water is supporting the designated use under evaluation.

Table 5 presents guidelines for sample counts to determine whether a parameter is meeting criteria or causing impairment for chronic criteria protective of aquatic life. Importantly, in order to assess parameters and capture the critical conditions for designated uses, a dataset should represent variations expected in water quality due to seasons, weather conditions, and flow regimes. Regardless of the sample count, if results do not represent critical conditions, data will not be used to delist known impaired waterbodies.

If the data being evaluated is generated as part of a comprehensive network being monitored for a specific purpose, the data may be assigned a higher level of assessment quality, and the "10-percent rule" may be applied with confidence to smaller data sets. The primary example of an intensified monitoring program that generates higher assessment quality data is the pre-TMDL monitoring program. The pre-TMDL monitoring format includes flow measurement and monthly water quality monitoring for one year at multiple locations throughout a watershed. Information is generated over a range of stream flow conditions and in all seasons. Habitat assessment and biological monitoring are performed in conjunction with water quality monitoring. The information generated under this format is among the most comprehensive available for assessing water quality. Upon conclusion of monitoring, it is then necessary for agency personnel to make a definitive judgment relative to impairment. In most instances, application of the "10-percent rule" to the pre-TMDL monitoring data sets result in the classification of waters as impaired if two or more exceedances of a criterion are demonstrated.

Table 5: Guidance to determine status when assessing parameters for chronic criteria protective of aquatic life.

Sample Count	Exceedance Count	Parameter Status	Additional Consideration
≥20	>10%	Causing impairment	Assess data collected within 3 years. If longer than 3 years, determine frequency of exceedances/year.
<20	2 or more	Causing impairment	Assess data collected within 3 years. If longer than 3 years, determine frequency of exceedances/year.
>20	≤10%	Meeting Criteria	Do not list new impairment. To delist a known impairment, samples must be evaluated to determine if monitoring captured low and/or high flow critical condition in waterbody. Ideally delisting decisions would be based on at least 20 samples. Data from multiple years may be assessed to consider at least 20 samples.
5-19	One or less	Meeting Criteria	To delist a known impairment, samples must be evaluated to determine if monitoring captured low and/or high flow critical condition in waterbody. Frequency and quality of

Sample Count	Exceedance Count	Parameter Status	Additional Consideration
			samples will also be considered when making delisting decisions. Ideally delisting decisions would be based on at least 20 samples. Data from multiple years may be assessed to consider as many samples as possible. In instances where fewer than 20 samples are available, best professional judgement will be applied to determine if enough information is available to change a listing status.
<5	One or less	Insufficient Information	No listing decision will be made.
<5	2 or more	Causing Impairment	Assessed data collected within 3 years. If longer than 3 years determine frequency of exceedances/year

Acute Criteria Protective of Aquatic Life

Under West Virginia Water Quality Standards, acute aquatic life protection criteria have associated exposure durations of one hour and may be exceeded once every three years. The normal practice of "grab-sampling" ambient waters is generally consistent with the one-hour exposure duration specified in the standards. Therefore, a direct application of the allowable exceedance frequency provided in the standards is made when assessing impairment relative to acute aquatic life protection criteria. If two or more exceedances of acute criteria are observed in any three-year period, the water is considered impaired. This rule is applied to acute criteria and to excursions of the water quality criteria for pH and dissolved oxygen.

Nutrient Criteria for Lakes to Protect Aquatic Life and Contact Recreation

Following 47CSR2 Section 8.3, WVDEP's lake assessment of chlorophyll-a and total phosphorus results were based on the average of a minimum of four samples collected within the May 1 through October 31 sampling season. Lake assessments are based on data collected within a meter of the surface.

Fecal Coliform Numeric Criteria for Contact Recreation and Drinking Water

Fecal coliform assessments were based on the previously described decision criteria for numeric water quality criteria. Numeric fecal coliform water quality criteria are applicable to the Water Contact Recreation and Public Water Supply designated uses. Section 8.13 of Appendix E of the West Virginia Water Quality Standards states:

> *8.13 Maximum allowable level of fecal coliform content for Water Contact Recreation (either MPN or MF) shall not exceed 200/100ml as a monthly geometric mean based on not less than five samples per month; nor to exceed 400/100ml in more than 10 percent of all samples taken during the month.*
>
> *8.13.1 Ohio River mainstem (zone I) - During the non- recreational season (November through April only) the maximum allowable level of fecal coliform for the Ohio River (either MPN or MF)*

shall not exceed 2000/100 ml as a monthly geometric mean based on not less than 5 samples per month.

Given the complexity of fecal coliform criteria, most assessments are performed by comparing observations to the "maximum daily" criterion value of 400 counts/100ml. Evaluation of the monthly geometric mean fecal coliform criterion (200 counts/100ml) occurs only where five or more individual sample results are available within a calendar month.

In general, the most frequent and regular fecal coliform water quality monitoring conducted by the Watershed Assessment Section is once per month. That monitoring frequency precludes assessment of the monthly geometric mean criterion and hinders accurate assessment of the maximum daily criterion per month. In some instances, more frequent fecal coliform monitoring can be accomplished on limited numbers of streams and/or stations where water quality assessments are performed.

WVDEP uses the following protocols when making assessments relative to fecal coliform numeric criteria:

1. No assessments are based upon the monthly geometric mean criterion (200 counts/100ml) unless an available data set includes monitoring at five per month or greater frequency. When data sets are available, the listing decision criteria for numeric water quality criteria are applied, considering each monthly geometric mean as an available monitoring result.

2. The listing decision criteria are applied to the maximum daily criterion (400 counts/100ml) and available individual monitoring results, but without the monthly prejudice. For example, if twice per month monitoring is conducted for a year and two results in two separate months are greater than 400, the stream would be assessed as fully supporting (2/24 – 8.3 percent rate of exceedance) rather than basing assessments on two months out of 12 in noncompliance (2/12 – 16.7 percent rate of exceedance). If five samples per month monitoring is conducted for one year and four daily results greater than 400 are measured in four different months, the stream would be assessed as fully supporting (4/60 – 6.7 percent rate of exceedance) rather than noncompliance (4/12 – 33.3 percent rate of exceedance), provided that the monthly geometric means were below the 200 counts/100 ml criteria.

Continuous Monitoring Data

The WVDEP uses deployable sondes to collect data on a continuous basis on selected streams. The sampling methodology uses submerged datalogging sondes that collect data continuously (most often hourly or twice hourly) for a deployment period ranging from several days to several months. Sondes or continuous monitoring instruments are especially effective for evaluating the specific requirements of water quality criteria for parameters such as pH and dissolved oxygen. For example, the pH criterion states that water quality values should remain between 6.0 and 9.0 standard units at all times (exception for waters with high photosynthetic activity). The use of continuous monitors allows WVDEP to better assess if streams are meeting water quality criteria. WVDEP is currently developing a method to assure quality of the data and to assess the vast amount of data collected by continuous monitoring instruments. The methodology must address both the magnitude and frequency of violation stipulated in current water quality criteria.

While maintaining deployable sondes, WVDEP collects discrete water quality data for pH, dissolved oxygen, and temperature. These data are used to correct the data collected directly by the deployable sondes. The discreet data were evaluated and assessed for this cycle period. Even though more than one reading was collected during the maintenance activities at each site, only one reading was chosen to represent the waterbody condition for each visit.

Ohio River – Total Iron Aquatic Life Standards

Prior to 2012, ORSANCO assessed water quality data along sections of the Ohio River bordering West Virginia based on the state's total iron numeric water quality standard. In 2012, ORSANCO's governing commission began using a weight of evidence approach when assessing all aquatic life standards for its biennial 305(b) report. However, the EPA's Region III office has stated for 303(d) listing purposes, it will only accept assessments based on a philosophy of independent applicability. Therefore, West Virginia's 303(d) assessments for aquatic life will recognize violations based on either water quality or biological survey data. A review of the ORSANCO total iron water quality data revealed violation rates greater than 10 percent for several segments of the Ohio River and, as such, the segments have been listed as impaired on West Virginia's 303(d) list.

5.4 Narrative Water Quality Criteria – Biological Impairment Data

The narrative water quality criterion of 47 CSR 2 §3.2.i prohibits the presence of wastes in State waters that cause or contribute to significant adverse impact to the chemical, physical, hydrologic, or biological components of aquatic ecosystems. Historically, WVDEP based assessment of biological integrity on a rating of the stream's benthic macroinvertebrate community using the West Virginia Stream Condition Index (WVSCI). The WVSCI is a benthic macroinvertebrate multi-metric index for use in wadeable streams. It is composed of six metrics that were selected to maximize discrimination between streams with known impairments and reference streams. Streams were listed if the data was comparable (e.g., collected utilizing the same methods used to develop the WVSCI, adequate flow in riffle/run habitat, and within the index period).

WVSCI-based "biological impairments" were included on West Virginia's Section 303(d) lists from 2002 through 2010. In 2012, legislative action (codified in §22-11-7b) directed the agency to develop and secure legislative approval of new rules to interpret the narrative criterion for biological impairment found in 47 CSR 2-3.2.i.

In its preparation of the Draft West Virginia 2012 Section 303(d) list, the WVDEP did not add new biological impairments. Previously listed biological impairments were proposed to be retained. In finalizing the 2012 list, the EPA added biological listings to those proposed by the WVDEP. The EPA considered available benthic macroinvertebrate data and added impairments to the list for biological scores less than 68 under the WVSCI methodology. The EPA determined that the uncertainty zone historically used by the WVDEP was not scientifically supported and therefore used an impairment threshold equal to the 5th percentile of reference scores as originally calculated.

For 2014, the WVDEP included biological impairment listings based upon the methodology used by the EPA in their 2012 oversight actions. The EPA partially disapproved the WVDEP's 2014 submission, eventually finalizing the list by adding 28 streams based on a genus level index known as GLIMPSS which had never been used by the WVDEP for 303(d) listing purposes.

For the 2016 listing cycle, the WVDEP determined biological impairments based on WVSCI. The WVDEP maintained that, considering the legislative mandate of SB 562, it would be inappropriate to utilize the GLIMPSS while a new assessment methodology is being developed. That said, the WVDEP updated the WVSCI scoring thresholds, based on a much larger set of reference site samples available. The WVSCI thresholds were recalculated and are still based on the 5th percentile of reference site index scores. The recalculated impairment threshold used for the 2016 303(d) list is 72. The EPA approved the 2016 303(d) list based on WVSCI in light of concerns from WVDEP about the robustness of the GLIMPSS reference dataset.

WVDEP prepared a procedural rule to address the requirements of §22-11-7b but did not finalize the rule. Rather, the process described in the procedural rule was utilized as our assessment methodology in the preparation of this combined 2018/2020/2022 list. The methodology generally requires two benthic macroinvertebrate samples to be analyzed to make an assessment decision. However, a single sample can be used to designate assessment units as impaired if the WVSCI score is below 50 and as attaining if the WVSCI score is greater than 72. Sites with initial WVSCI scores between 50 and 72 may require a second sample to be collected and assessed. The process for determining impairment of biological integrity is described in more detail in Appendix A.

If not already accomplished for listing purposes, each assessment unit will be assessed during TMDL development to determine the causative stressor(s) of impairment. The contributing sources of pollution will be identified.

Biological impairments identified in the previous 303(d) List are proposed to be delisted under the following scenarios:

- Where previous listings were determined to have been made in error.
- Where more recent biological monitoring results demonstrated WVSCI scores greater than 72.
- Where approved TMDLs have been developed pursuant to numeric water quality criteria and the Stressor Identification performed in the TMDL process demonstrated that their implementation would resolve the stress to the benthic macroinvertebrate community that caused the original listing.

5.5 Narrative Water Quality Criteria - Fish Tissue and Consumption Advisories

The narrative water quality criterion of 47CSR2 – 3.2.e prohibits the presence of materials in concentrations that are harmful, hazardous or toxic to man, animal or aquatic life in state waters. Fish consumption advisories are used to inform the public about potential health risks associated with eating fish from West Virginia's streams. WVDEP, the Division of Natural Resources, and the Bureau for Public Health have worked together on fish contamination issues since the 1980s. An executive order from the governor and subsequent Interagency Agreement signed in 2000 formalized the collaborative process for developing and issuing fish consumption advisories.

Risk-based principles are used to determine whether fish consumption advisories are necessary. These advisories are used as a public education tool to help citizens make informed decisions about eating fish caught in state waterbodies. The risk-based approach estimates the probability of adverse health effects and provides a statement on the health risk facing the angler and high-risk groups including women of childbearing age and children. West Virginia's fish consumption advisories include guidelines on the number of meals to eat and information on proper fish preparation to further minimize risk.

Waterbody-specific fish consumption advisories exist for six state streams, as well as backwaters of the major rivers, and four lakes, for a variety of fish species and contaminants. Additionally, there is a general statewide advisory that recommends limiting the consumption of certain fish from all West Virginia waters due to low-level mercury and/or polychlorinated biphenyl (PCB) contamination. The statewide advisory provides species-specific recommendations ranging from one meal per week to one meal per month. The following webpage contains the most recently issued West Virginia fish consumption advisories:

http://www.wvdhhr.org/fish/

The presence of contaminants in fish tissue from commonly consumed species in amounts leading to a two meal per month or more stringent advisory is considered sufficient evidence of impairment. In addition, methylmercury has a specific body- burden water quality criterion for protection of public water supply and water contact recreation designated uses. The criterion states "The total organism body burden of any aquatic species shall not exceed 0.5 µg/g as methylmercury." Therefore, the WVDEP applies the criterion to all aquatic species rather than just the commonly consumed fish species.

For the mainstem Ohio River, the applicable ORSANCO body-burden criterion is 0.3 µg/g. As with previous 303(d) lists, WVDEP has deferred to ORSANCO's assessment results for mercury listing purposes. ORSANCO's assessment methodology is included in their Biennial Assessment of Ohio River Water Quality Conditions. ORSANCO's assessment methodology can be found at

http://www.orsanco.org/publications/biennial-assessment-305b-report/

5.6 Narrative Water Quality Criteria – Filamentous Algae

The narrative water quality criterion of 47CSR2 – 3.2.g prohibits algae blooms which may impair or interfere with the designated uses of the affected waters. WVDEP lists streams for filamentous algae impairment because the algae blooms are impairing or interfering with the Water Contact Recreation use and/or the Public Water Supply use of a stream. The methodology (303(d) Listing Methodology for Algae Blooms) was finalized by DEP in June 2013 and is available at

http://www.dep.wv.gov/WWE/Programs/wqs/Documents/Greenbrier%20Algae/AlgaeListingMethodology2014.pdf

To develop the listing methodology for impairment of the Water Contact Recreation designated use, WVDEP utilized the results of a scientific survey of people who use West Virginia rivers that determined how much filamentous algae cover would adversely impact various recreational activities. The report *West Virginia Residents' Opinions on And Tolerance Levels of Algae In West Virginia Waters* is available at

http://www.dep.wv.gov/WWE/Programs/wqs/Documents/WVAlgaeSurveReport_ResMgmt_WVDEP_2012.pdf .

In general, WVDEP considers the Water Contact Recreation use of a stream segment to be impaired if filamentous algae cover is greater than 20% and extends for a longitudinal distance greater than three times the average stream width OR if filamentous algae cover of greater than 40% is measured, regardless of the longitudinal extent of the bloom.

WVDEP considers stream's use as a Public Water Supply to be impaired if algae blooms cause taste or odor in the drinking water that requires a level of treatment beyond "conventional treatment". Additionally, WVDEP considers available taste or odor complaints about finished drinking water when assessing the Public Water Supply designated use and may classify the use as impaired even though additional treatment is not implemented.

The listing methodology did not describe conditions that would qualify a stream for delisting. WVDEP will revise the listing methodology for filamentous algae impacted streams to include criteria for removing a stream when the impairment no longer exists. A stream may be delisted if any of the following apply:

- WVDEP has evaluated the stream for impairments of Water Contact Recreation for a period of five consecutive years and found no blooms which would have caused the stream to be listed as impaired for recreational use.
- Specific measures to control algae growth have been implemented, and WVDEP has evaluated the stream for a period of three consecutive years finding no algae blooms causing use impairment.
- For algae impairments related to the Public Water Supply use, when taste and odor complaints associated with algae blooms are alleviated and no treatment beyond "conventional treatment" is required at the drinking water treatment facility for three consecutive years.

6.0 ASSESSMENT RESULTS

The following section describes the results of the assessments completed for stream and lake assessment units. The results of assessments have been loaded to ATTAINS. The counts of water bodies, figures, and tables are those reported directly from ATTAINS. Data results are organized at three levels, IR Category, Designated Use, and Parameter. Each level provides scenarios of attainment, impairment, and insufficient information. Assessment results have also been included in the Integrated Report StoryMap.

Individual assessment unit results are also provided in Google Sheets workbooks. The first is titled *Combined Cycle 303(d)List* and provides the 303(d) listings for the 2018, 2020, and 2022 assessment cycles in a combined list. An introductory tab provides a description of the data included in the workbook's individual sheets or "tabs". For example, one tab is called "303d List-Category 5". This is where the user can find the combined 2018/2020/2022 303d listed streams.

A second workbook is titled *IR Category Designated Use*. This workbook provides the overall IR Category for each assessment unit, as well as details on whether an assessment unit supports each of its designated uses.

Both of these workbooks can be downloaded from:
https://dep.wv.gov/wwe/watershed/ir/pages/303d_305b.aspx.

6.1 IR Category Results

Streams

Table 6 shows a summary of the classification of West Virginia streams by the five IR Categories (see Table 4). Table 6 also includes the percentage of counts and miles for each IR Category. As described earlier, because assessment units have been created using a 1:24,000 scale NHD streamline product, 85.3% of stream assessment units are unassessed and placed in IR Category 3. This percentage is based on the count of assessment units. In contrast, only 58.9% of streams miles are unassessed. The streams with limited or no data are typically small unnamed tributaries, which usually contribute to the larger waterbodies which have been assessed. All major rivers in the state have been assessed and placed into categories. Figure 6-1 provides a pie chart to visualize the assignment of IR Categories for streams.

Table 6: 2016 Category Summary for West Virginia Stream Assessment Units (AUs)

Overall Category	# of Stream AUs	% Stream AUs	Miles	% Miles
1	0		0	
2	1,740	3.7	5,232	9.7
3	40,116	85.3	31,666	58.9
4a	3,739	7.9	11,660	21.7
4c	91	0.2	81	0.2
5	1,382	2.9	5,106	9.5
TOTALS	47,068		53,746	

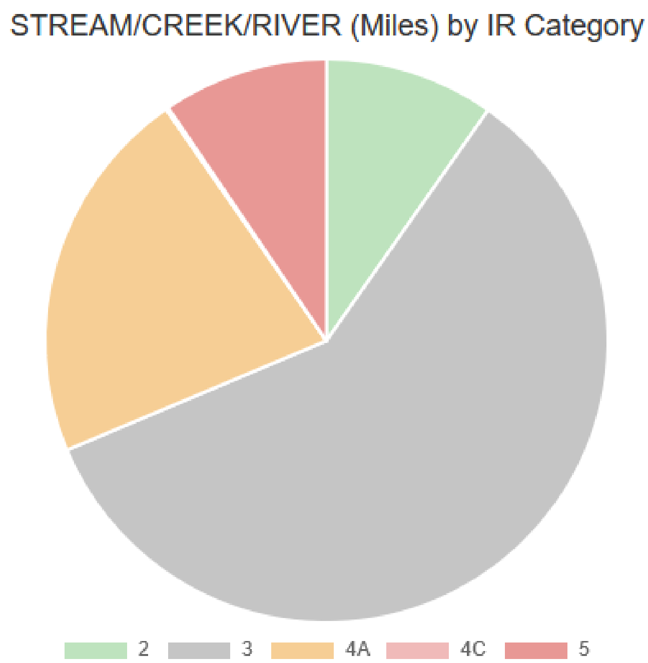


Figure 6-1: Stream miles broken out into overall IR Categories.

Category 5 includes 1,382 impaired stream assessment units, covering approximately 5,106 stream miles that are impaired and need TMDLs developed. The number and length of impaired streams varies from one list year to the next due, in part, to the TMDL development timeline. TMDLs are always in various stages of development, and with the additional sampling data generated, streams and stream segments may move from Categories 1, 2 or 3 to Category 5. Additionally, TMDLs that have not yet been approved by the EPA remain listed in Category 5. Once these TMDLs are approved for all impaired parameters, those assessment units will move to Category 4a. See the TMDL Section for more information.

Lakes

As with streams, many lake assessment units have not been monitored or assessed based on the newly delineated assessment units. When delineating the assessment units, lakes that had not been previously assessed were identified and added for possible assessment in the future. When considering the count of lakes, 77.7% of lake assessment units have not been assessed. Also, like streams, the state's largest lakes have been assessed, resulting in only 25.1% of the total lake acreage categorized as unassessed. Lakes with more than one major tributary forming "arms" of the lake were separated into smaller assessments units. If an entire lake was listed previously in the 303d list as impaired, that impairment status was applied to all of the newly delineated assessment units of the lake. See Table 7 for details on the counts and acreage placed in each IR Category. Figure 6-2 provides a pie chart to visualize the assignment of IR Categories for lakes.

Table 7: 2016 Category Summary for West Virginia Lake Assessment Units (AUs)

Overall Category	# of Lakes AUs	% Lakes AUs	Acres	% Acres
1	0	0	0	0
2	53	12.2	6920	27.8
3	337	77.7	6227	25.1
4A	5	1.2	95	0.4
5	39	8.9	11,621	46.7
TOTALS	434	100	24863	100

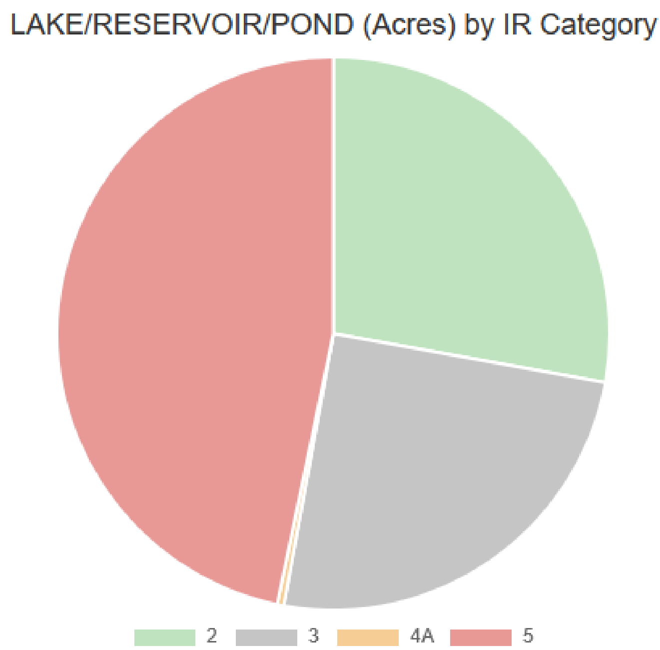


Figure 6-2: Lake areas broken out into overall IR Categories.

6.2 Use Support Results

The IR Category placement provides an overall status of attainment or impairment of a waterbody. The overall status is derived from the collective attainment statuses for each designated use. If any use is not supported, the entire waterbody will be placed in IR Category 4 or IR Category 5. Table 8 summarizes the counts of assessment units (both lakes and streams) that are not supporting each designated use, fully supporting each designated use, or have insufficient data or no data to assess. Tables 9 and 10 summarize the stream miles and lake acreage by use. WVDEP has prepared a Google Sheets workbook called *IR Category Designated Use* to provide a the overall all IR category for every assessment unit, as well as use attainment status for every designated use. The workbook can be assessed at this site:

https://dep.wv.gov/wwe/watershed/ir/pages/303d_305b.aspx

Table 8: Designated use support summary for all West Virginia assessment units by count.

Uses	Not Supporting	Insufficient Information	Not Assessed	Fully Supporting	Total
Public Water Supply	3,554	2,252	39,909	1,785	47,500
Warm Water Fishery	4,070	1,536	39,640	1,184	46,430
Trout Waters	331	197	191	351	1,070
Water Contact Recreation: Recreation	3,478	1,384	40,602	2,036	47,500
Water Contact Recreation: Fish Consumption	84	9	47,331	0	47,424*
Agriculture and Wildlife	652	873	40,673	5,302	47,500
Water Supply Industrial, Water Transport, Cooling and Power	652	873	40,673	5,302	47,500

**Buried streams have not been assigned the fish consumption subcategory.*

Table 9: Designated use support summary for West Virginia streams.

Designated Use	Not Supporting	Insufficient Information	Not Assessed	Fully Supporting	Total
	miles	miles	miles	miles	miles
A-Public Water Supply	12,682.78	4,514.66	30,907.91	5,636.96	53,742.31
B1- Warm Water Fishery	12,149.33	3,152.78	30,271.73	4,012.54	49,586.38
B2- Trout Waters	1,524.87	678.37	434.1	1,518.60	4,155.94
C-Water Contact Recreation: Recreation	12,567.07	2,544.11	32,210.38	6,420.76	53,742.32
C-Water Contact Recreation: Fish Consumption	530.21	79.18	53,066.54	0	53,675.93*
D-Agriculture and Wildlife	1,890.77	1,631.36	32,405.02	17,815.16	53,742.31
E- Water Supply Industrial, Water Transport, Cooling and Power	1,890.78	1,631.36	32,405.02	17,815.16	53,742.32

**Buried streams have not been assigned the fish consumption subcategory.*

Table 10: Designated use support summary for West Virginia lakes.

Designated Use	Not Supporting	Insufficient Information	Not Assessed	Fully Supporting	Total
	acres	acres	acres	acres	acres
A-Public Water Supply	9,555.37	2,077.1	6,288.17	6,943.2	24,863.84
B1- Warm Water Fishery	2,511.45	10,340.95	10,766.56	0	23,618.96
B2- Trout Waters	31.02	1,047.96	165.9	0	1,244.88
C-Water Contact Recreation: Recreation	2,542.47	2,984.58	10,932.46	8,404.33	24,863.84
C-Water Contact Recreation: Fish Consumption	9,936.42	0	14,927.42	0	24,863.84
D-Agriculture and Wildlife	2.38	819.55	5,407.78	18,634.13	24,863.84
E- Water Supply Industrial, Water Transport, Cooling and Power	2.38	819.55	5,407.78	18,634.13	24,863.84

6.3 Causes for Impairment

The information in Table 11 and Table 12 provides an overview of the impairment status of West Virginia waters. Some waters are impaired for multiple water quality criteria.

ATTAINS provides an opportunity to report on both impairment and *attainment* of water quality criteria for specific parameters. However, the Tables below underreport the miles and acreages that are meeting criteria for specific parameters. This is a result of established data capture and reporting methods that focused primarily on impairments. In the future WVDEP will alter the data capture methods to also include parameter attainment. See Section 7 Probabilistic Data Summary for a more appropriate representation of the overall water quality of state waterbodies.

Figures 6-3 and 6-4 provide the distribution of stream miles and lake acreage that are impaired or attaining water quality standards for the listed parameters. Impairment is identified in the graph as "cause", meaning the parameter is a cause for impairment.

Table 11: Summary of impairment causes for West Virginia streams shown in miles.

Parameter	Impairment Cause (miles)	Meeting Criteria (miles)	Insufficient Information (miles)	Total (miles)
Iron	11,856.73	519.23	294.59	1,2670.55
Fecal Coliform	11,312.28	940.71	132.05	1,2385.04
Benthic Macroinvertebrate Bioassessments	6,973.03	4,287.86	391.96	1,1652.85
pH	1,302.99	1,614.02	316.89	3233.9
Aluminum, Dissolved	1,166.33	490.74	167.44	1,824.51
Dissolved Oxygen	164.85	821.18	413.42	1,399.45
Selenium	512.97	608.04	52.94	1,173.95
Filamentous Algae	74.74	417.88	0	492.62
PCBs in Fish Tissue	440.81	0	0	440.81
2,3,7,8-tetrachlorodibenzo-P-Dioxin	359.89	70.03	0	429.92
Dioxin In Fish Tissue	66.49	60.79	0	127.28
Manganese	37.23	174.84	0	212.07
Lead	0	160.7	0	160.7
Zinc	0	138.63	0	138.63
Chloride	55.95	33.67	1.92	91.54
Methylmercury in Fish Tissue	83.99	0	0	83.99
Aluminum, Total	64.1	0	0	64.1
Flow Regime Modification-Low Flow	62	0	0	62
Buried Stream	54.33	0	0	54.33
Beryllium	23.23	6.58	0	29.81
Ammonia	0	8.61	0	8.61
Temperature	7.11	0	0	7.11

Table 12: Summary of impairment causes for West Virginia lakes shown in acres.

Parameter	Impairment Cause (acres)	Meeting Criteria (acres)	Insufficient Information (acres)	Total (acres)
Methylmercury in Fish Tissue	9,393.25	0		9,393.25
Chlorophyll-a	692.1	5,826.4		6518.5
Phosphorus	1,883.02	3,970.46		5,853.48
Polychlorinated Biphenyls (PCBs)	543.17	0		543.17
Sedimentation/Siltation	162.12	0		162.12
Trophic State Index (TSI)	81.45	0		81.45
Iron	60.37	0		60.37
Dissolved Oxygen	2.38	0		2.38

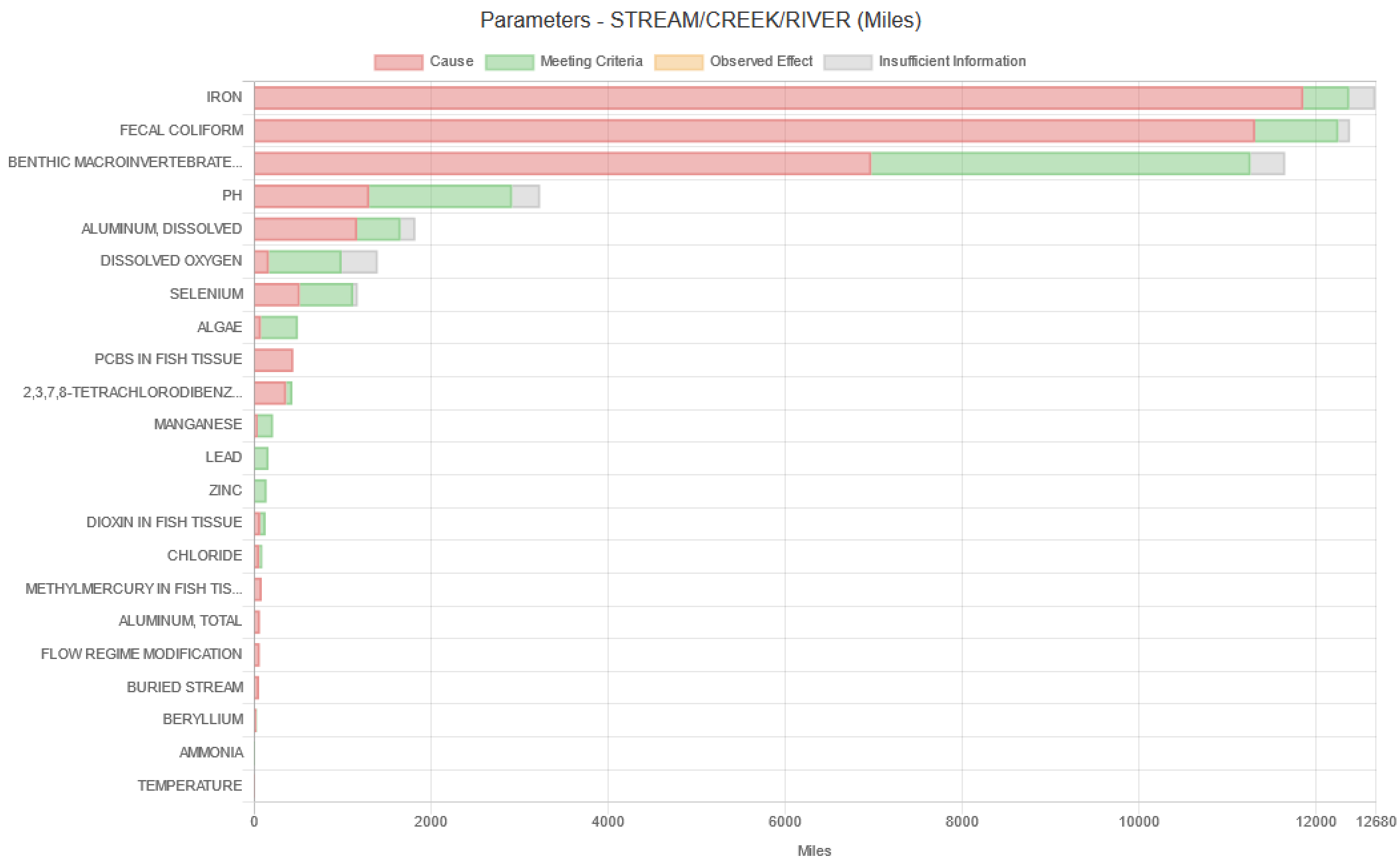


Figure 6-3: Chart showing a breakdown of stream miles with parameter attainment or impairment.

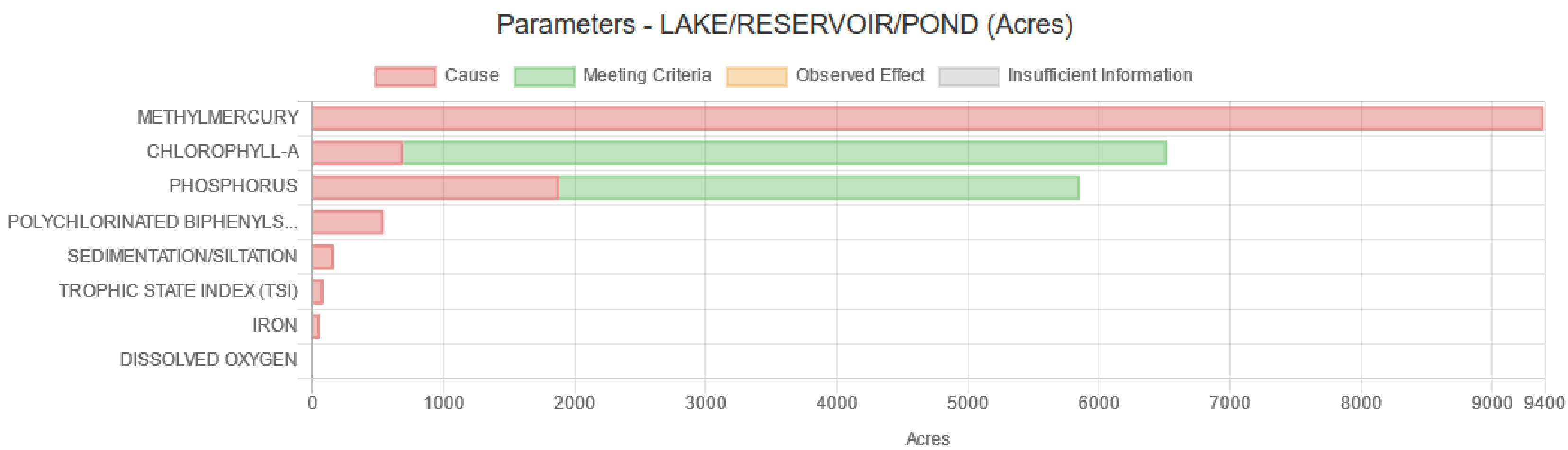


Figure 6-4: Chart showing a breakdown of lake acres with parameter attainment or impairment.

6.4 Filamentous Algae Resulting in Delisting

Advanced nutrient removal technology was installed on several wastewater treatment plants discharging to the South Branch of the Potomac River and the Greenbrier River after these streams were first listed for filamentous algae impairment in 2010. Following the upgrades, reductions in filamentous algae biomass occurred quickly and were commensurate with reductions in phosphorous loading from the treatment plants. WVDEP has monitored instream water quality and levels of filamentous algae growth for several years after the installation of the nutrient removal units.

The following graph (Figure 6-5) compares the percent of the Greenbrier River covered by filamentous algae, before and after plant upgrades, during peak growing season in years with a similar flow rate in the river. Treatment plant effluent phosphorous loadings were reduced by more than 80%, and this resulted in an 85% reduction in the surface acres of the river covered by filamentous algae.

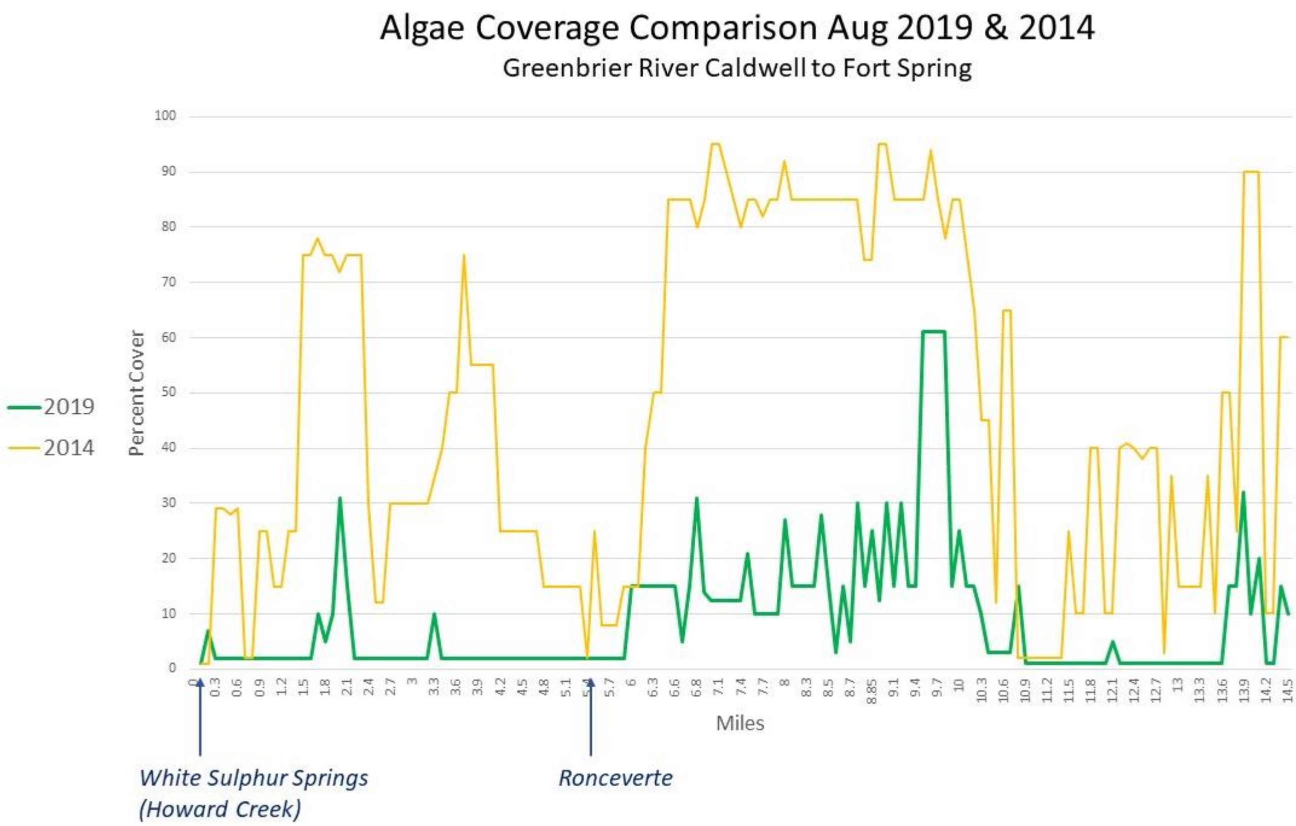


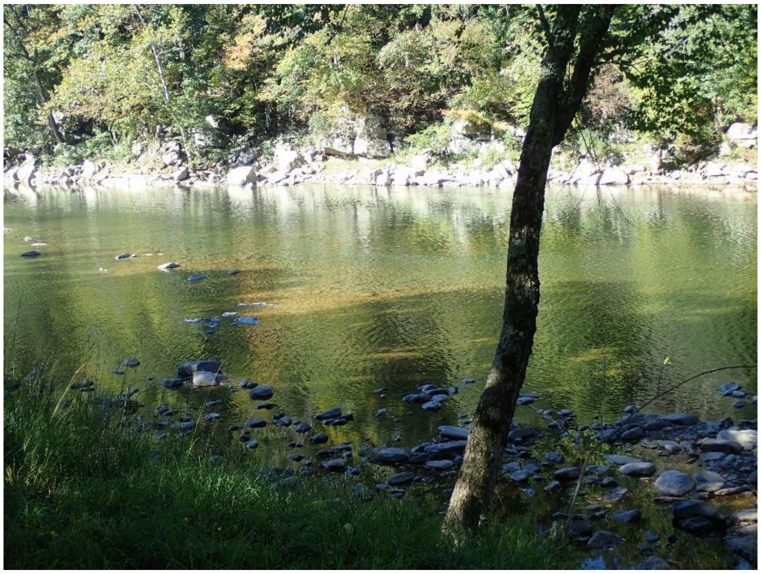
Figure 6-5: Observed filamentous algae coverage in the Greenbrier River.

WVDEP's observation and measurement of filamentous algae growth, and its monitoring of taste and odor complaints in drinking water, have resulted in the removal of the South Branch of the Potomac River and portions of the Greenbrier River from the 303(d) list. See the photos comparing the filamentous algae coverage in the South Branch and Greenbrier Rivers below.

South Branch of Potomac at public access for the famed "Trough" section (2009).

South Branch of Potomac at the "Trough" public access after the Moorefield Regional WWTP installation (2019).

Greenbrier River at Fort Spring (2008).



Greenbrier River at Fort Spring following WWTP upgrades at White Sulphur Springs and Ronceverte (2019).

Wastewater treatment plants equipped with nutrient removal technology have been installed on the South Branch of the Potomac River and the Greenbrier River and operational for several years, significantly reducing blooms of filamentous algae. WVDEP's observation and measurement of filamentous algae growth, and its monitoring of taste and odor complaints in drinking water, have resulted in removing the South Branch of the Potomac River and portions of the Greenbrier River from the 303(d) list.

All previously impacted portions of the Greenbrier River are improved significantly since the river's wastewater treatment plants, but a three-mile section of river below one of the wastewater treatment plants exhibited algal growth above the listing threshold during the summer of 2021. Because this three-mile segment of river overlaps portions of two larger Assessment Units, the Greenbrier River remains listed from RM 35.6 to RM 49.7. WVDEP will continue monitoring this treatment plant and the river below it to determine if the 2021 bloom was the result of an operational problem, aging equipment, or the extremely low river flow in the summer of 2021.

The application of the assessment methodology to observations from the 2017-2021 growing seasons resulted in the following impairments on the 2018-2022 Draft West Virginia 303(d) List:

- Greenbrier River – RM 35.6 (Davis Spring) to RM 49.7 (Howards Creek) – refinement of 2016 listing
- Cacapon River – RM 39.0 (North River) to RM 76 (Route 259 Bridge near Wardensville)
- Tygart River – RM 73.2 (Grassy Run) to RM 90.1 (Dodson Run)

7.0 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 7-1), basin scale (Figure 7-2), 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 296 sites that were sampled at baseflow conditions during the late spring/early summers of 2016 – 2020.

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 below. In each of the graphs, the Statewide results are listed first, followed by the ecoregions, and then then basins.

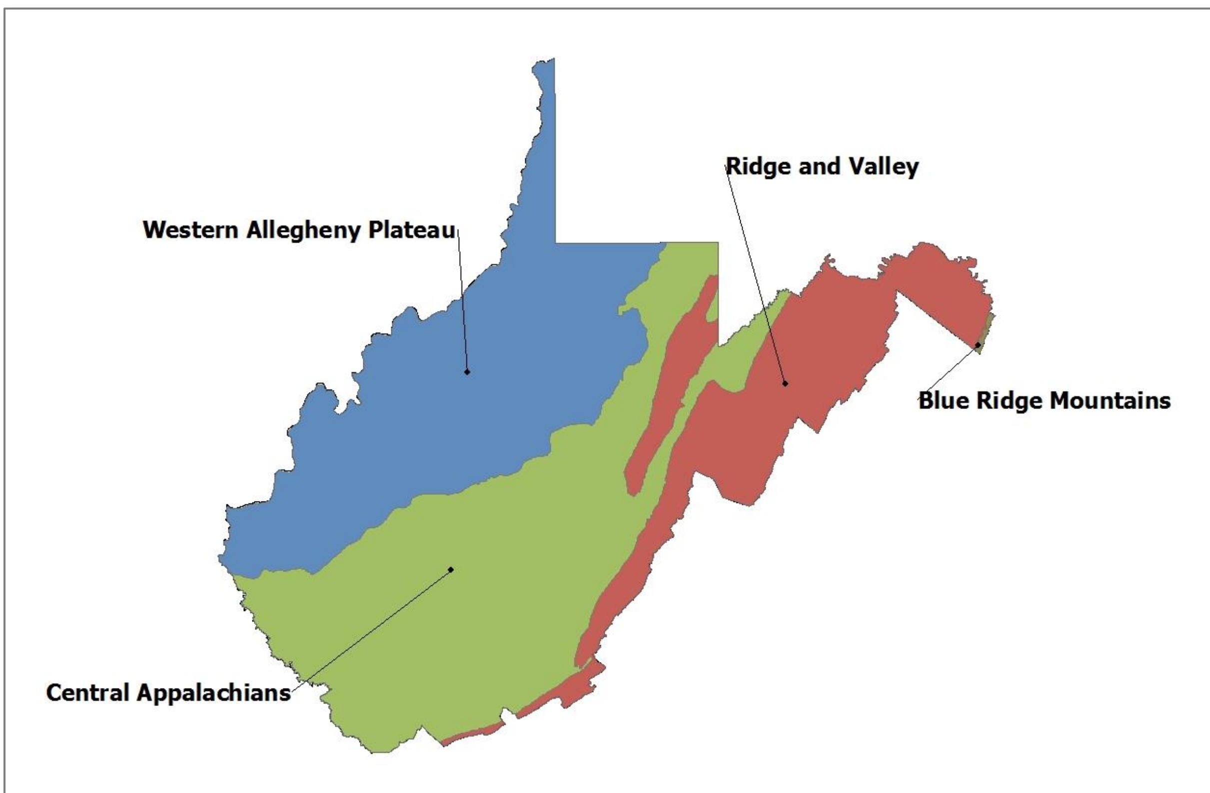


Figure 7-1: West Virginia Ecoregions

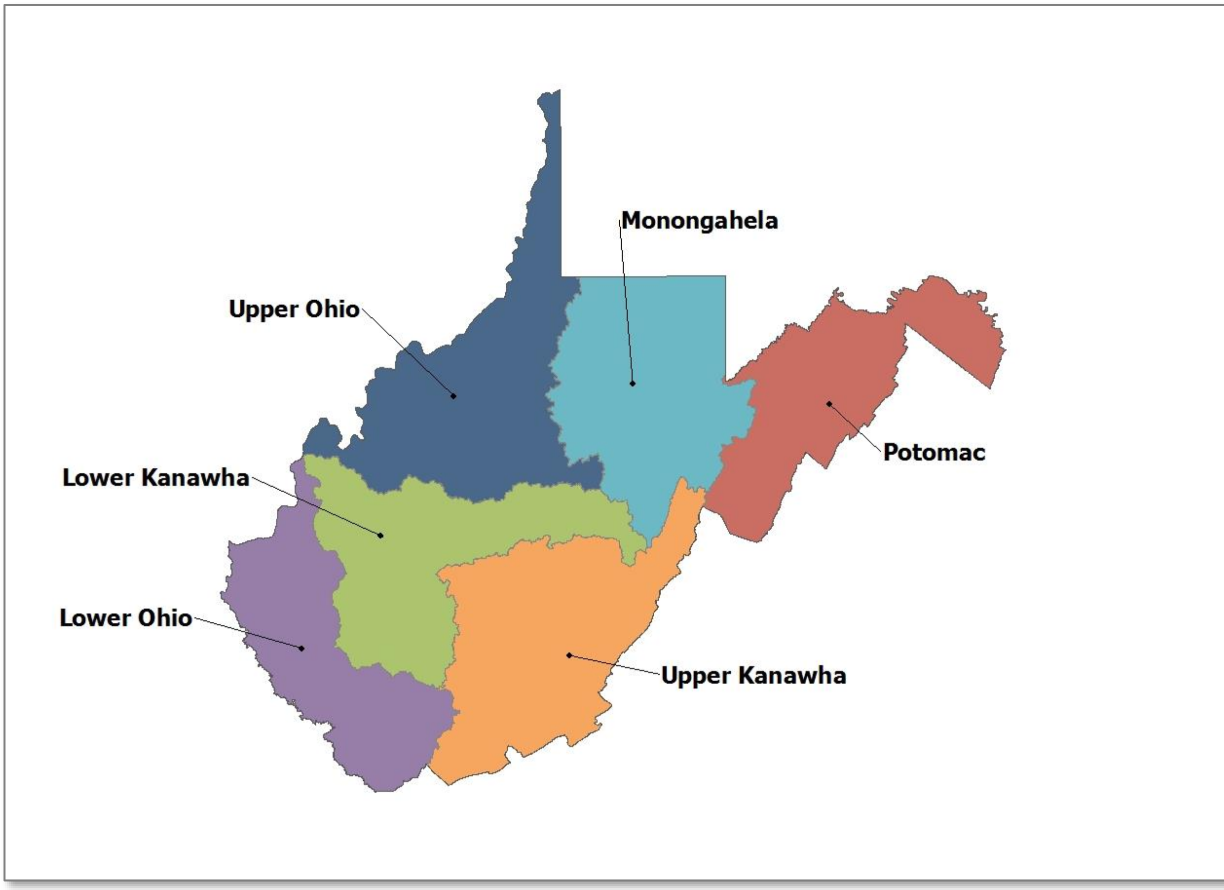


Figure 7-2: West Virginia Basins

7.1 Indicators of Stream Condition

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. Further, 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 intention of eventually developing a new biotic index. Development of a genus level index is now complete. The new tool, known as GLIMPSS (Genus Level Index of Most Probable Stream Status), which is stratified by season and ecoregion, 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), 49.2 percent of wadeable stream miles have scores equal to or above the low-end reference condition threshold (i.e., are generally in good biological condition) statewide with the remaining 50.8 percent scoring less than this threshold (Figure 7-3). Breaking this down by ecoregion, the Ridge and Valley has the highest percentage of streams with healthy aquatic ecosystems, with 69.5 percent scoring above the 5th percentile threshold. The Western Allegheny Plateau ecoregion scores lowest with an estimated 40.0 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 48.0. Among basins, the Potomac had the highest percent of streams miles (63.0) above the reference threshold, while the Lower Ohio had the fewest (40.6).

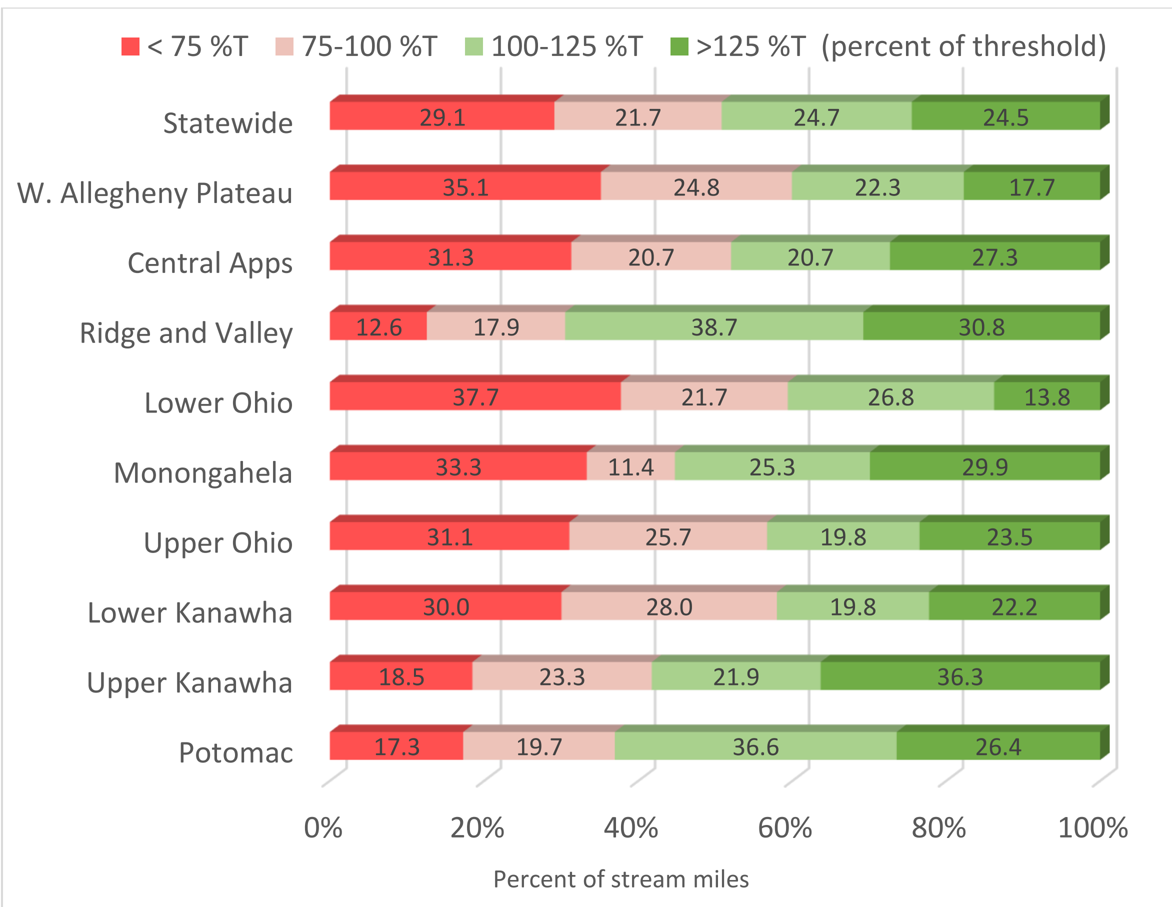


Figure 7-3: Biological Health – Benthic Macroinvertebrate Community IBI Scores for GLIMPSS at Genus Level (except Chironomidae)

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, including:

- Conductivity – various levels
- Sulfate > 50mg/L
- Acidity: pH < 5.0 and <6.0
- Bacterial Contamination: fecal coliform bacteria > 400 colonies/100mL
- Dissolved Organic Carbon - various concentrations
- Hardness – various concentrations

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 82.4% of wadeable stream miles statewide having late spring /early summer levels below 300 µS/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 µS/cm (Figures 7-4 and 7-5). The Upper Ohio Basin and the closely aligned Western Allegheny Plateau ecoregion have fewer low conductivity (<100 µS/cm) streams, and also includes some areas (northern panhandle) with the high conductance streams associated with coal mining. The Monongahela Basin includes some of the 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. Figure 7-4 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 are attributable to the limestone geology of the area.

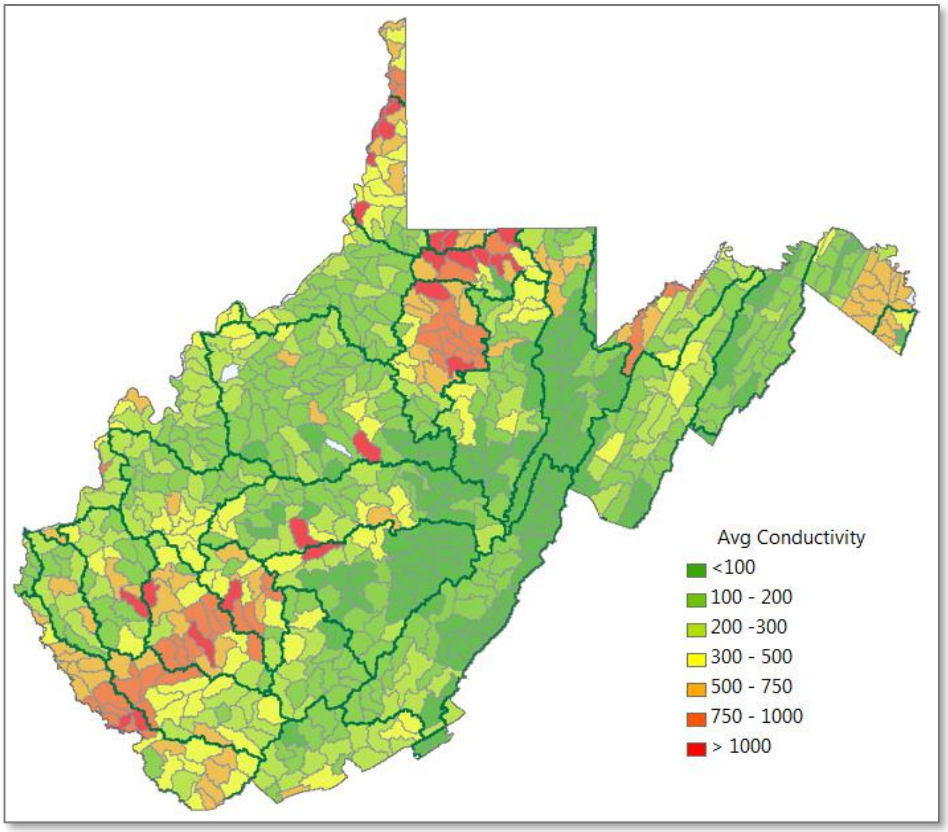


Figure 7-4: Average Specific Conductance at 12-digit-HUC Scale Watersheds in West Virginia

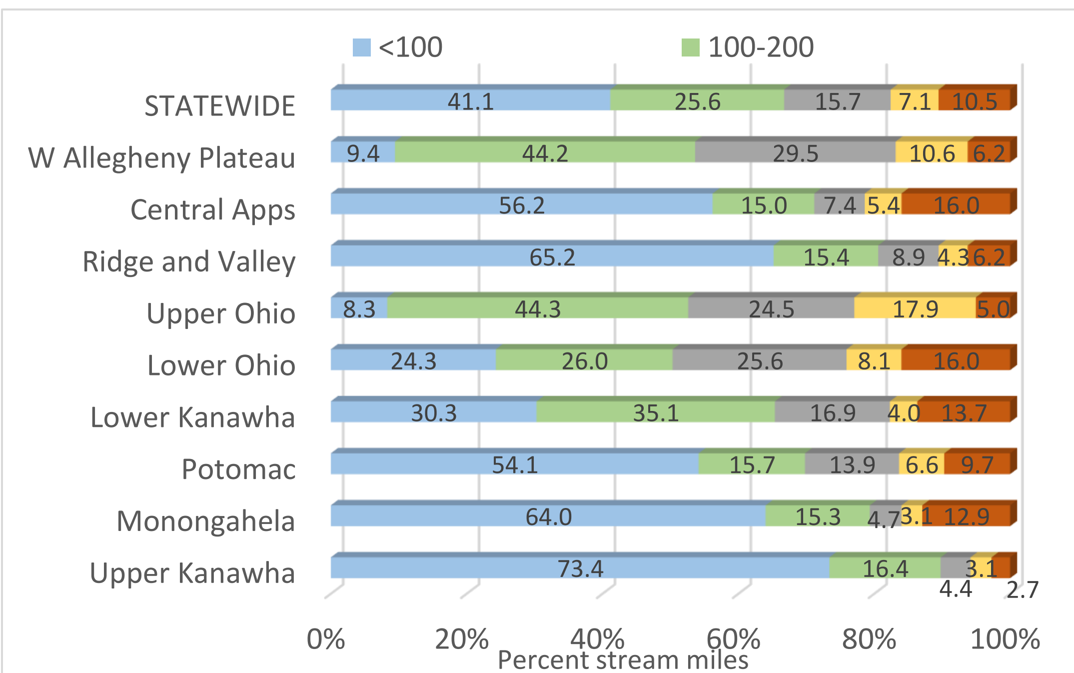


Figure 7-5: Specific Conductance in West Virginia Streams

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 14 % of the stream miles statewide are influenced by mine drainage (Figure 7-6). Observed on an ecoregional basis, mine drainage influences a greater proportion of stream miles in the coal rich Central Appalachians (24.4%) than in the Ridge and Valley (2.2%) or Western Allegheny Plateau (8.0%). Among basins, the Lower Ohio (26.3%) and Lower Kanawha (16.9%) had the highest percent of streams miles exceeding the 50 mg/L threshold of sulfate.

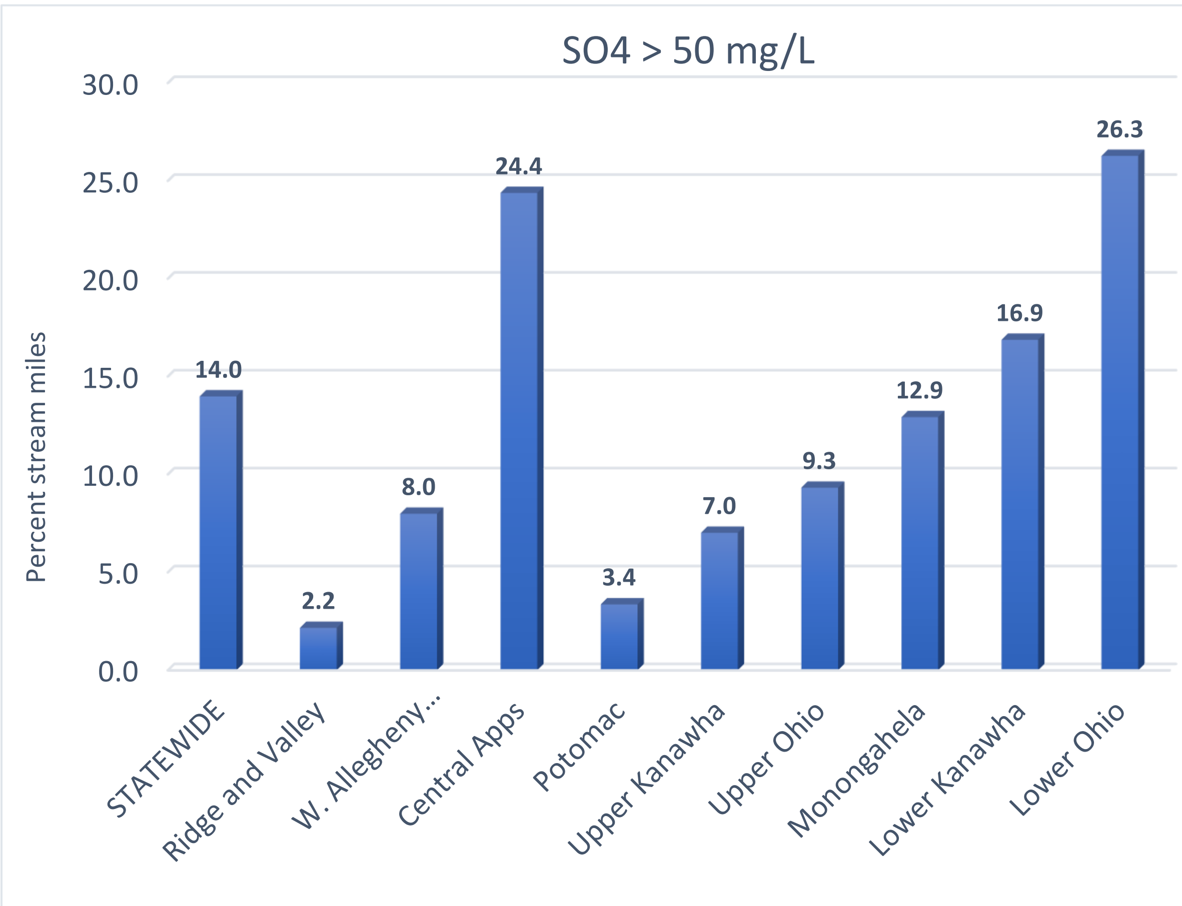


Figure 7-6: Sulfate in West Virginia Streams

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, 20.0% of stream miles in the state have fecal coliform bacteria levels that exceed the criterion of 400 colonies/100mL (Figure 7-7). 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 36.0 % of stream miles exceeding the criterion. The proportions of stream miles exceeding the criterion were considerably lower in the Central Appalachians at 13.5% and Ridge and Valley Ecoregions at 4.8%. 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 42.1% and 26.1%, respectively.

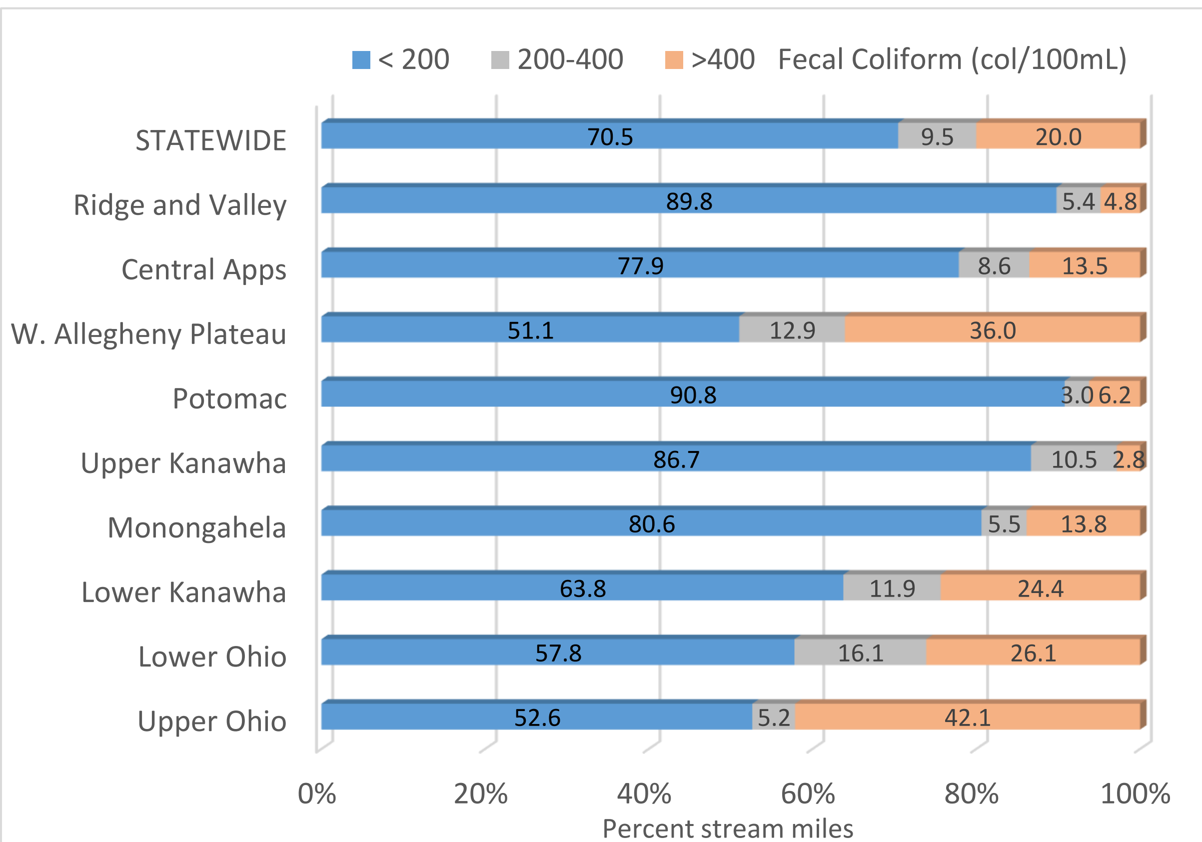


Figure 7-7: Fecal Coliform Bacteria in West Virginia Streams

Acidity

Aquatic life communities in the headwater sections of many West Virginia streams continue to be impacted by low pH (acidic) water. 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 5.7% of the stream miles in the state have pH values below 6.0 (Figure 7-8). Most of the stream miles identified as impacted by acidic waters are in the Central Appalachians Ecoregion, representing 10.2% 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 3.7% of the stream miles in the Ridge and Valley Ecoregion are impacted by acidic conditions. Although present, the extent of stream miles impacted by acidic waters within the Western Allegheny Plateau Ecoregion is very low, just 1.3%. Again, this ecoregion has well buffered soils that limit the impacts of acid precipitation. Furthermore, where they do exist in the western Allegheny Plateau 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 11.5% of stream miles estimated to be acidic. The Monongahela Basin likely has significant contributions from both acid deposition and acid mine drainage.

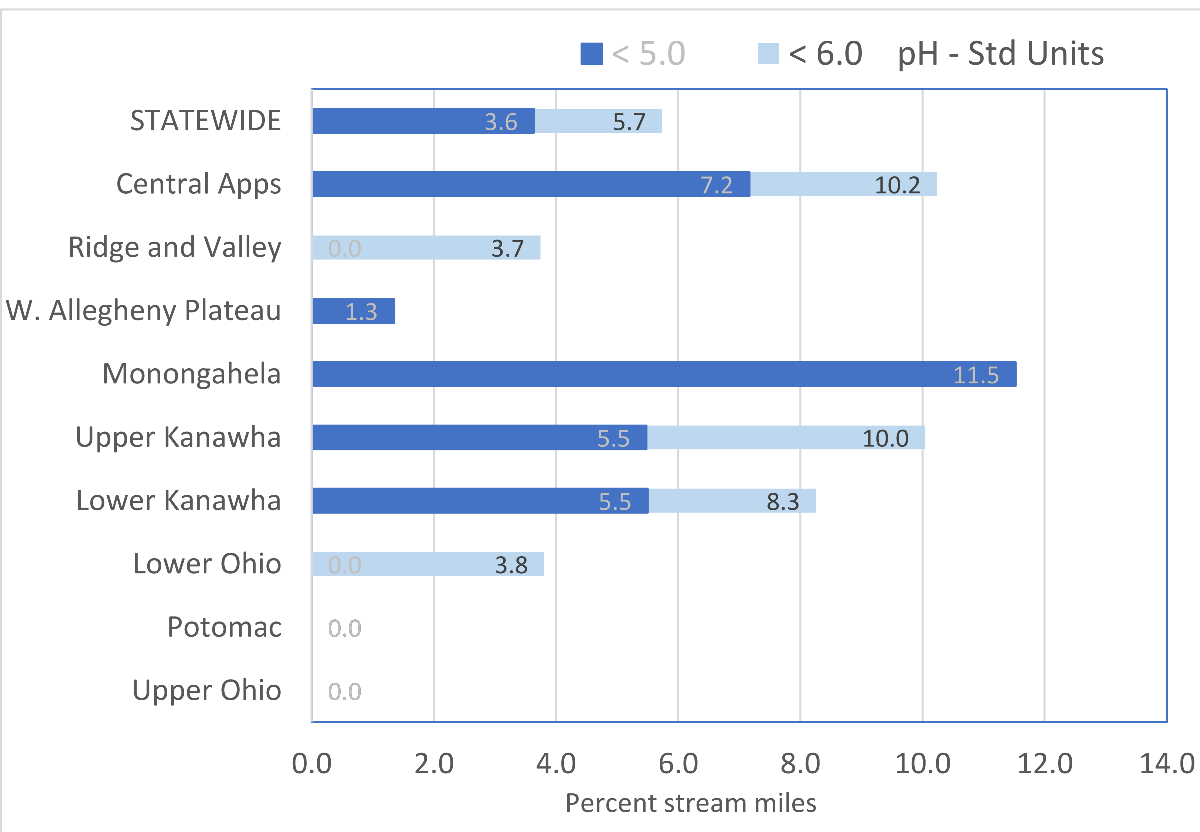


Figure 7-8: Acidic Streams in West Virginia as Indicated by pH

Dissolved Organic Carbon (DOC)

WVDEP added DOC to the list of parameters analyzed at probabilistic sites in 2019. USEPA put out new aluminum criteria in 2018 that is dependent on the conditions of the water, specifically pH, hardness, and DOC. Hardness analyses have been included since the beginning of the probabilistic monitoring program in 1997. To better understand the potential implications of EPA's aluminum criteria, estimates of DOC (Figure 7-9) and hardness levels (Figure 7-10) have been added to this summary of the program's results.

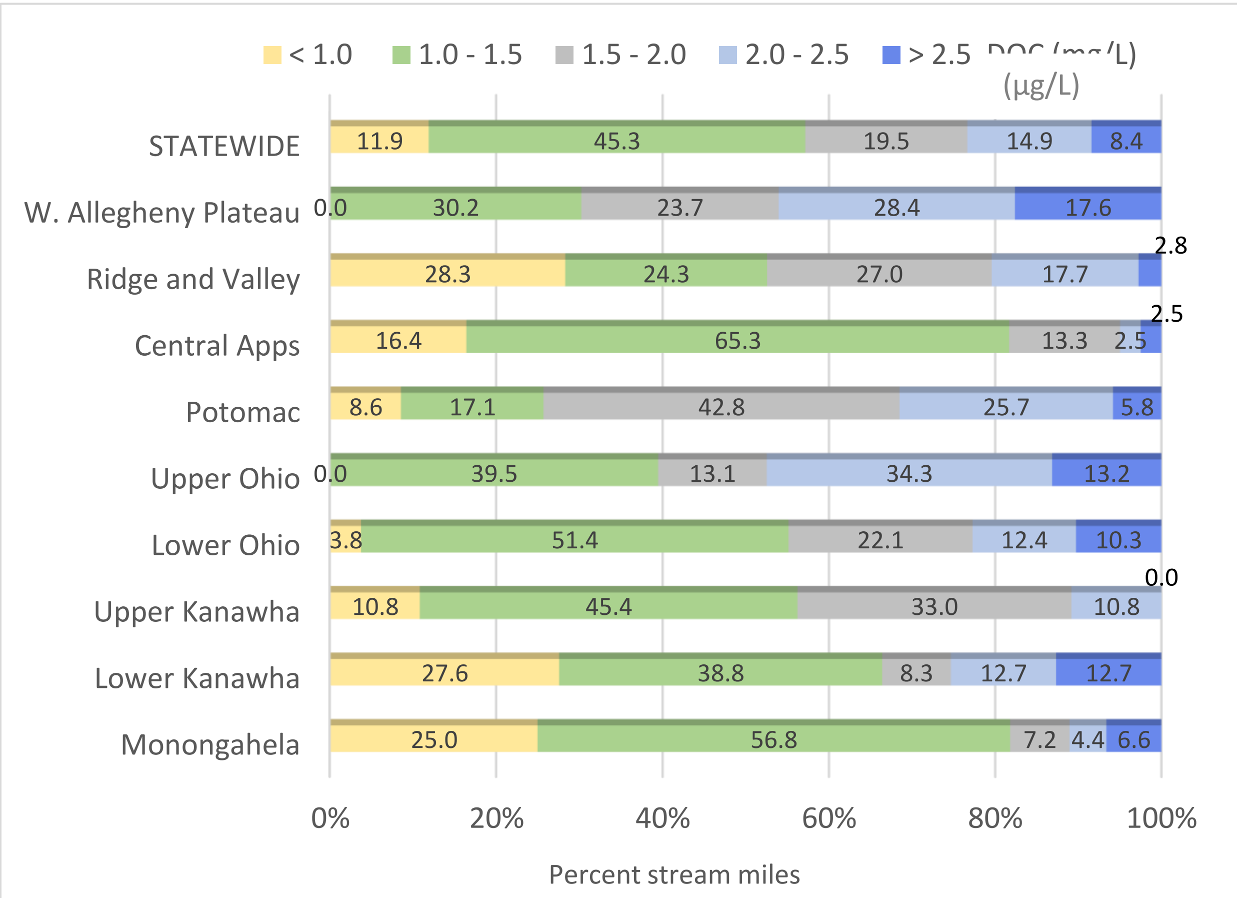


Figure 7-9: Dissolved Organic Carbon (mg/L) in West Virginia Streams

Hardness

Hardness in West Virginia varies from very low in some of the mountain streams to very high in certain streams impacted by mining and other industry. Statewide, 25.8 percent of stream miles had hardness of 25 mg/L or less; and 10.9 percent of stream miles had hardness > 200 mg/L. Figure 7-10 shows the probabilistic results and Figure 7-11 provides a better representation of how variable hardness is across the state than the ecoregion and basin summaries. For example, the Monongahela Basin includes streams with some of the lowest as well as some of the highest values.

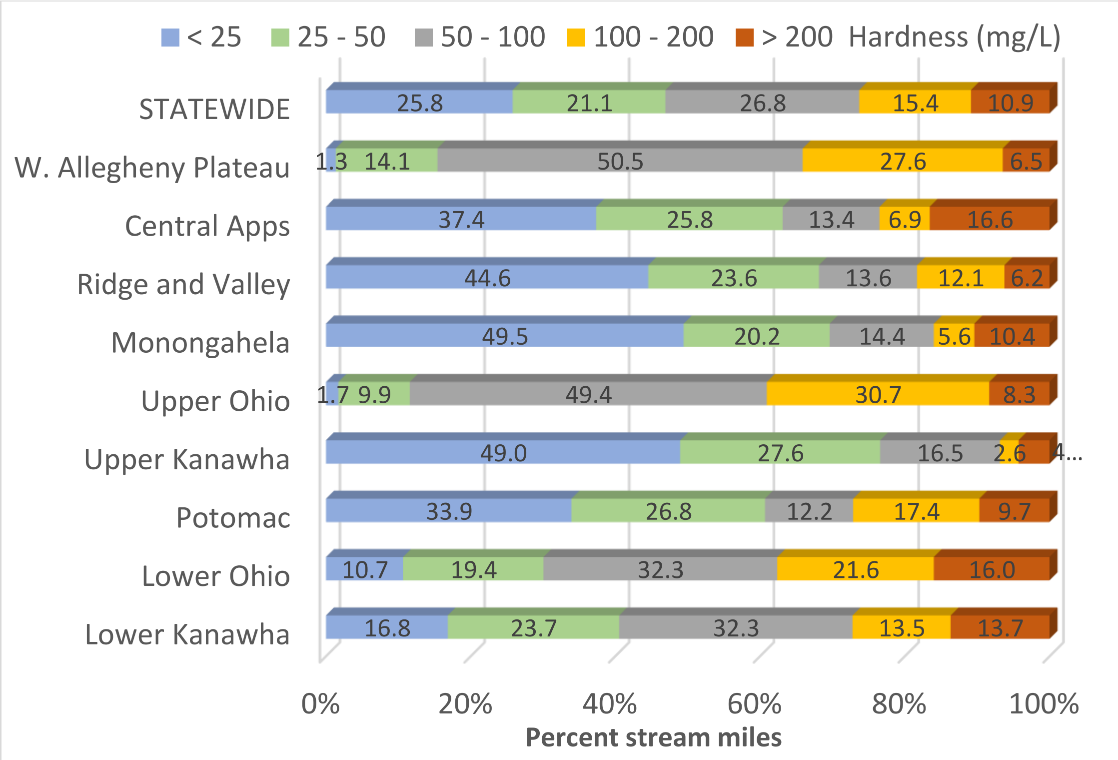


Figure 7-10: Hardness (mg/L) in West Virginia Streams

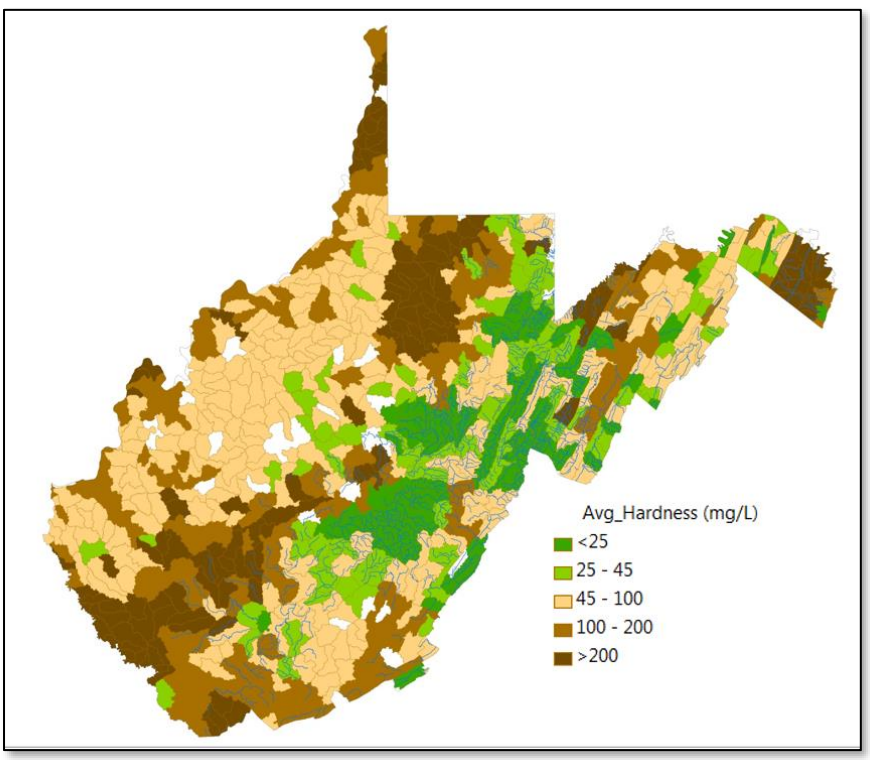


Figure 7-11: Hardness (mg/L) in West Virginia HUC 12 Watersheds

Habitat Indicators of Aquatic Integrity

Overall Stream Habitat Condition

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 7-12). Based on probabilistic data, just 14.0% of stream miles statewide have good habitat quality (total RBP score of 160 or greater), 71.5% of stream miles have moderate habitat quality (110–159), and 14.5% 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 24.6%. Additionally, this ecoregion had the least number of stream miles rated as poor for overall habitat quality at only 8.0%.

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 zero percent of its stream miles being rated as good in overall habitat quality. Additionally, the percentage of stream miles with poor habitat quality (25.4%) is substantially higher in this ecoregion.

The Upper Kanawha basin stands out as having the highest percentage of stream miles (29.3%) with good overall habitat. This basin includes large portions of the Monongahela National Forest and several undisturbed wilderness areas. The Upper Ohio basin had almost no miles in good condition and almost 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. Although the DEP may gain insight into overall habitat conditions by combining the individual measures, it is useful to examine specific habitat characteristics.

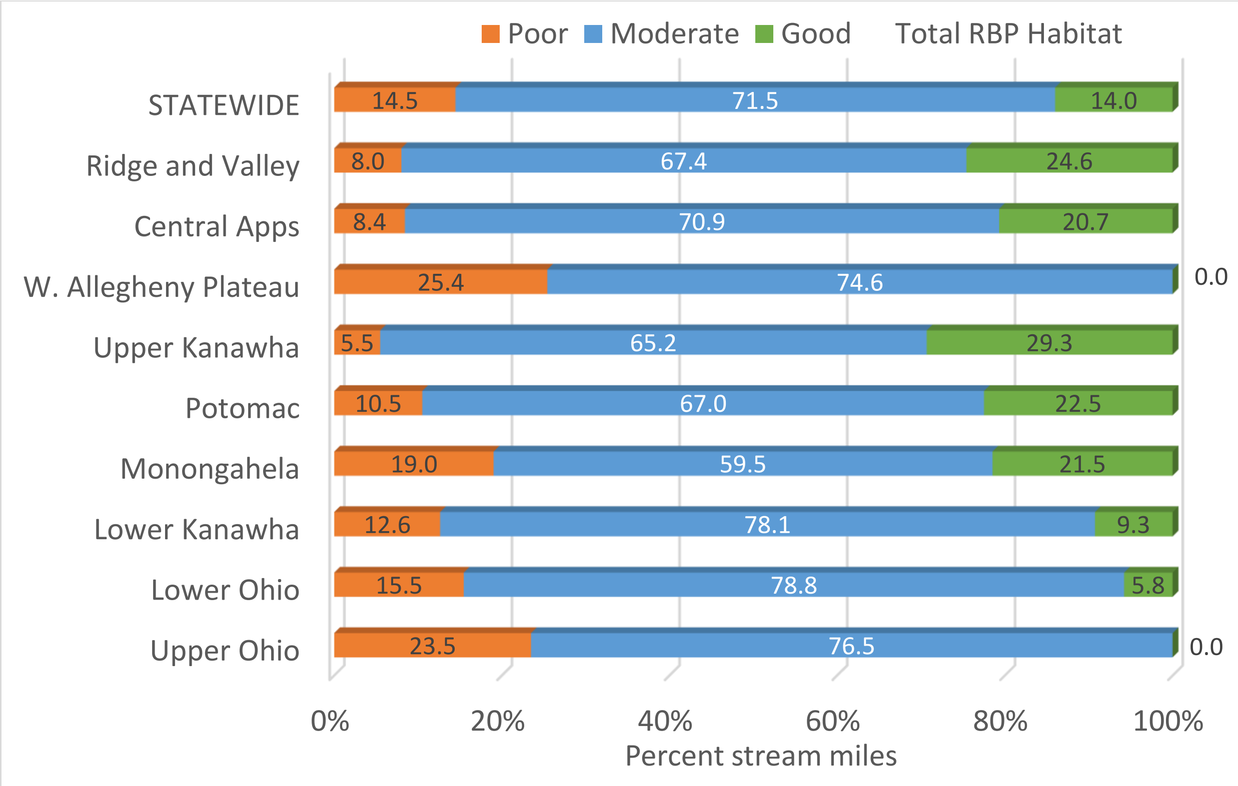


Figure 7-12: Overall Stream Habitat (RBP Total Score) in West Virginia Streams

Relative Presence of Embeddedness

Sedimentation, and the resulting embeddedness, is one of the most important problems facing West Virginia streams. Figure 7-13 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 (34.2%) 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 25.0% and 12.2% combined poor and very poor ratings, respectively. The Lower Ohio and Monongahela basins had the highest percent of stream miles in the poor or very poor category with 40.6% and 29.0%, respectively.

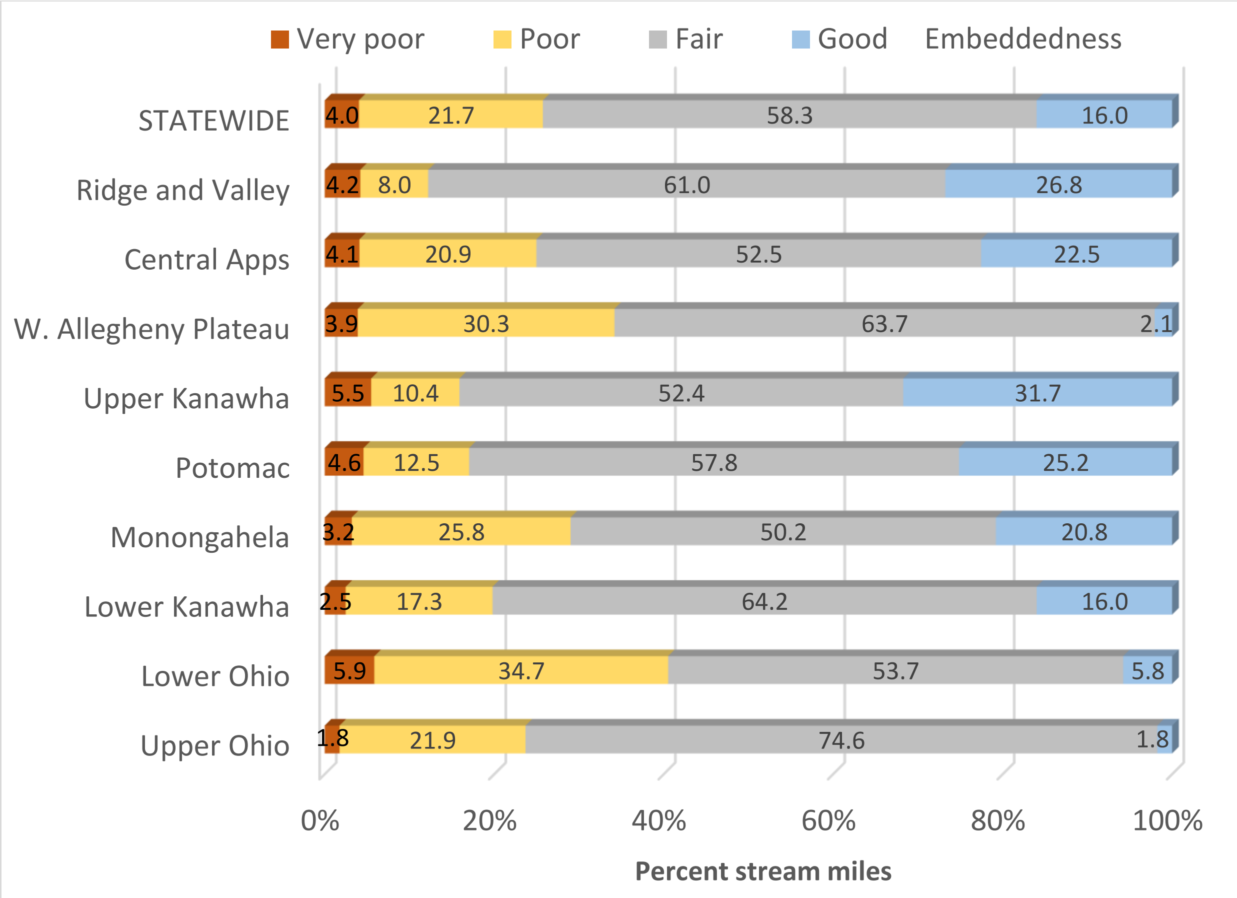


Figure 7-13: Embeddedness Scores in West Virginia Streams

Condition of Riparian Vegetation Zones

The Western Allegheny Plateau ecoregion had the lowest percentage of wide, undisturbed riparian zones at just 8.2 % (Figure 7-14). The Central Appalachians and Ridge and Valley ecoregions were much better, with 51.9% and 51.3% of stream miles in good condition for this indicator. 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. Among basins, the Potomac was better than the others for riparian zone intactness with an estimate of 52.9% of its stream miles in the good category.

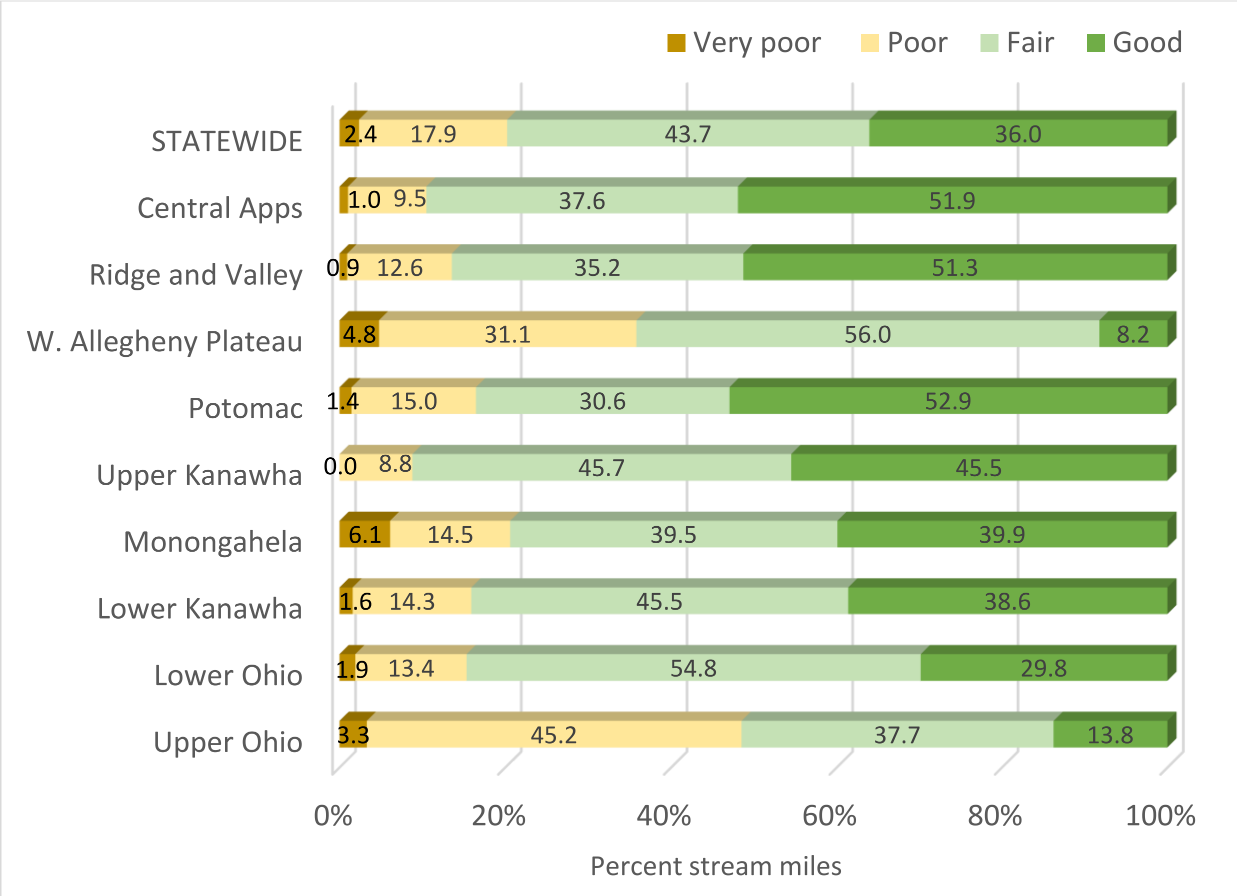


Figure 7-14: Riparian Zone Vegetation Scores in West Virginia Streams

Range of Human-Refuse Intensity Values - 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) (Figure 7-15). The Central Appalachian and the Ridge and Valley ecoregions had the highest percentage of "clean" stream miles with over 60 percent of stream miles in that category.

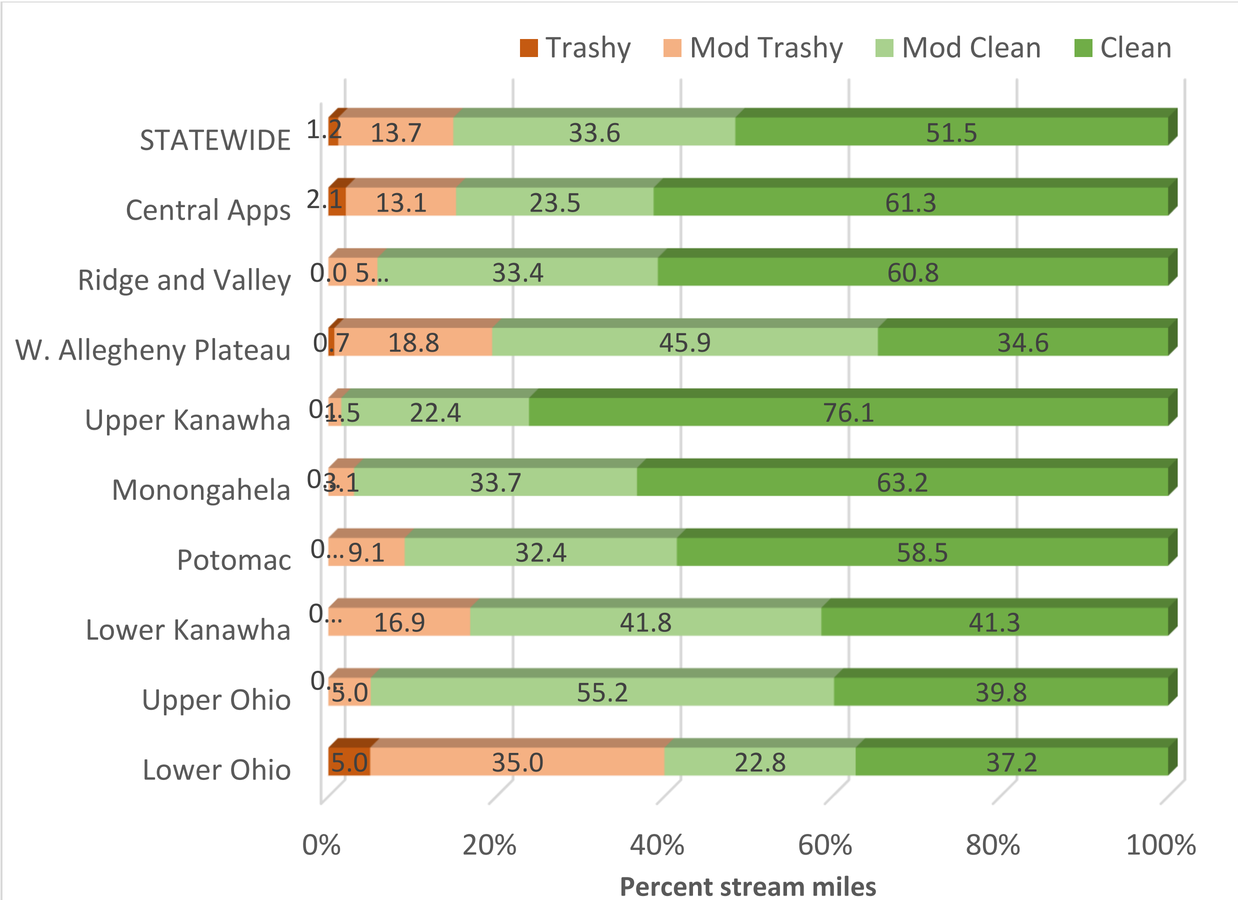


Figure 7-15: Trash/Aesthetic Scores in West Virginia Streams

8.0 TOTAL MAXIMUM DAILY LOAD (TMDL) DEVELOPMENT PROCESS

From 1997 until 2003, EPA Region III developed West Virginia TMDLs under the settlement of a 1995 lawsuit, Ohio Valley Environmental Coalition, Inc., West Virginia Highlands Conservancy, et. al. v. Browner, et. al. The lawsuit resulted in a consent decree between the plaintiffs and the EPA that specified TMDL development requirements and compliance dates. While the EPA was working on developing TMDLs, WVDEP concentrated on building its own TMDL program. With the help of the TMDL stakeholder committee, the agency secured funding from the state legislature and created the TMDL section within the Division of Water and Waste Management.

The TMDL Section is committed to implementing a TMDL process that reflects the requirements of TMDL regulations, provides for the achievement of water quality standards, and ensures that ample stakeholder participation is achieved in the development and implementation of TMDLs. The DWWM's approach to TMDL development allows 48 months to develop a TMDL from start to finish. This approach enables the agency to carry out an extensive data generation and gathering effort to produce scientifically defensible TMDLs; and allows ample time for modeling, report drafting and frequent public participation opportunities.

WVDEP's TMDLs are generally developed according to the Watershed Management Framework cycle. The framework divides the state into 32 major watersheds and operates on a five year, five-step process. The TMDL process begins in the first year of the cycle with pre-TMDL sampling and public meetings in the affected watersheds. The data is compiled and TMDL development begins in year two of the cycle. In the third year, TMDL development continues and the TMDL is drafted. The TMDL is finalized in the fourth year. In the fifth year of the cycle, TMDL implementation is initiated through the NPDES permitting process and efforts toward limiting nonpoint source loading. Throughout the TMDL development process, there are numerous opportunities for public participation and input.

For ongoing TMDL projects, the 303(d) list identifies and prioritizes the waters and impairments for which future TMDLs will be developed by specifying the year in the "Projected TMDL Year" column. For other waters and impairments, where the timing of TMDL development is less certain, a high priority has been placed on TMDL development in this Combined Integrated Report. WVDEP will develop a methodology for prioritizing TMDLs in the future to refine the priority listings. Pre-TMDL sampling has traditionally followed the framework cycle, i.e., impaired streams from watersheds in Hydrologic Group A were sampled in the same year as the targeted sampling. More recently, in order to address impairments that have been listed for several years, some watersheds are being selected for TMDL development outside of the framework cycle schedule.

WVDEP personnel are typically working on some aspect of TMDL development in each of the five Hydrologic Groups (A-E). Each set of TMDLs moves through several stages of development prior to finalization and the EPA's approval. Table 12 shows the state's TMDL development progress. The number after the Hydrologic Group letter indicates the number of TMDL cycles have occurred in each group. For examples, Cacapon River represents the fourth TMDL cycle in Hydrologic Group A. While Tug Fork River represents the fifth TMDL cycle for Hydrologic Group C. Tug Fork River was prioritized because WVDEP's programmatic goal to revisit watersheds where TMDLs were developed under the consent decree.

Table 13: DEP TMDL Development in 2016-2020

Hydrologic Group	Watersheds	Progress
A4	Cacapon River	Pre-TMDL monitoring planned (Monitoring delayed due to COVID-19 pandemic travel restrictions)
B3	Tygart Valley	EPA Approved
C3	Gauley (Meadow River) Potomac Direct Drains (Rockymarsh Run and Warm Springs Run)	EPA Approved
C4	Lower Guyandotte	EPA Approved

C5	Tug Fork River	Pre-TMDL sampling complete TMDL development ongoing
D3	Monongahela main-stem Little Kanawha (Hughes River)	EPA Approved
D4	Little Kanawha (other than Hughes River)	Pre-TMDL sampling complete TMDL development ongoing
E3	Upper Guyandotte	EPA Approved
E4	Big Sandy Lower Ohio Twelvepole Creek	EPA Approved

WVDEP believes the TMDL development process, which links extensive water quality monitoring and source tracking efforts with pollutant sources through computer modeling, provides the best assessment of criterion attainment and the most accurate identification of the watershed sources for which pollutant reductions are necessary. TMDL modeling predicts water quality over a wide range of climatic and stream flow conditions, incorporates the specific exposure duration and exceedance frequency terms of water quality criteria and prescribes pollutant/s allocations that will result in attainment of criteria in all stream segments.

WVDEP's website contains all approved TMDL documents and the draft TMDL documents currently out for public comment. These documents can be found at:

http://www.dep.wv.gov/WWE/watershed/TMDL/Pages/default.aspx

9.0 INTERSTATE WATER COORDINATION

9.1 Virginia DEQ on Bluestone River PCB monitoring and TMDL development

DEP has been working with the Virginia Department of Environmental Quality (VADEQ) to assess Polychlorinated Biphenyls (PCBs) impairment along the Virginia section of the Bluestone River. The product of this cooperative effort will be a TMDL for the Bluestone River and tributaries with loadings and allocated reductions for sources in both Virginia and West Virginia. The West Virginia DEP, Virginia DEQ and EPA Region III have been cooperating in an effort to locate and reduce sources of PCBs to the Bluestone River. As part of this effort, remediation of the now defunct Lyn Electric Site in Bluefield, W.Va. has been completed. Efforts included leveling and removal of the electric motor remanufacturing buildings on the site. Also, contaminated water and debris were removed from the site and clean material used to backfill the open basement areas of the property. Within the watershed additional monitoring and source evaluation is on-going to determine what steps, if any, need to be taken in the future.

Continued monitoring has determined in part that groundwater rising into the Bluestone River watershed is contaminated by PCBs and contribute to the impairment of the river. Virginia DEQ is leading an effort to develop a TMDL in the watershed that will likely address the contaminant sources in both states.

9.2 Virginia DEQ on New River PCB TMDL development

Virginia DEQ developed a PCB TMDL for the mainstem New River and selected tributaries and impoundments. WVDEP contributed to the TMDL via the Technical Advisory Committee to ensure the final TMDL meets both state's water quality standards. The New River PCB TMDL developed for the Virginia portion of the watershed was approved in March 2019.

9.3 Ohio River Valley Water Sanitation Commission – ORSANCO

As with previous reports, WVDEP Combined Integrated Report includes assessments based on data provided by ORSANCO. Throughout the development of ORSANCO's Biennial Assessments, WVDEP has been involved with ORSANCO's efforts to standardize assessments among the compact states. WVDEP's personnel continue to participate in several standing committees, along with representatives from other compact states, charged with helping direct ORSANCO's water quality and biological monitoring efforts.

9.4 Chesapeake Bay

The Chesapeake Bay is impaired by nutrients and sediment from multiple sources originating locally and in upstream states. This biologically diverse waterbody is an important economic and recreational resource. The need to restore this waterbody is a high priority for many agencies, organizations and the public in general. Approximately ten percent of West Virginia's stream miles drain into the Potomac River and on into the Bay. In addition, portions of the James River Watershed in West Virginia contribute flow to the Bay.

In June 2002, Governor Bob Wise signed the Chesapeake Bay Program Water Quality Initiative Memorandum of Understanding, committing West Virginia to nutrient and sediment load reductions. In November 2005, West Virginia proposed pollutant reduction plans in the West Virginia Potomac Tributary Strategy. In December 2010, EPA finalized TMDLs for the Chesapeake Bay and other impaired tidal waters in Virginia and Maryland. In response to the TMDLs, West Virginia and the other Bay jurisdictions developed Watershed Implementation Plans (WIPs). The West Virginia WIP identifies actions and controls that the State will pursue to implement the TMDLs, and West Virginia will accomplish its TMDL responsibilities if the WIP is successfully executed. Progress in meeting the TMDL responsibilities is measured and reported regularly. The WIP has been revised to ensure TMDL 2025 implementation goals are met. Many DEP programs are actively participating in this effort. The West Virginia WIP and supporting documents may be viewed at:

http://www.wvchesapeakebay.us/WIP/WIP3.cfm

9.5 Interstate Commission on Potomac River Basin

The Commission is a non-regulatory agency of basin states (Maryland, Pennsylvania, Virginia and West Virginia), Washington, D.C. and the federal government. The Commission promotes watershed-wide solutions to the pollution and water resources challenges facing the basin and its more than 6.11 million residents. Examples of current commission efforts include the Chesapeake Bay Program involvement, stream biological assessments, support of selected stream gages, the Potomac Groundwater Assessment, Potomac Basin Drinking Water Source Protection Partnership coordination and Potomac Watershed Toxic Spill Model support. In addition, the Commission's public outreach program supports and helps coordinate an annual watershed-wide clean-up effort and produces and distributes the newsletter Potomac Basin Reporter to 20,000 subscribers. The commissioners are appointed by their respective jurisdictions and provide policy guidance and oversight for a skilled staff of scientists and educators.

10.0 WATER POLLUTION CONTROL PROGRAMS

10.1 Division of Water and Waste Management

The Division of Water and Waste Management's mission is to preserve, protect, and enhance West Virginia's watersheds for the benefit and safety of all its citizens through implementation of programs controlling hazardous waste, solid waste and surface and groundwater pollution, from any source.

The DWWM strives to meet its mission through implementation of programs controlling surface and groundwater pollution caused by industrial and municipal discharges, and through the oversight of construction, operation, and closure of hazardous waste, solid waste, and underground storage tank sites. In addition, the division works to protect, restore, and enhance the state's watersheds through comprehensive watershed assessments, groundwater monitoring, wetlands preservation, inspection and enforcement of hazardous and solid waste disposal, and proper operation of underground storage tanks.

Environmental Enforcement (EE) is a branch of the Division of Water and Waste Management charged with assuring compliance with many of the state pollution control regulations. EE promotes compliance with the Solid Waste Management Act, Water Pollution Control Act, Groundwater Protection Act, Hazardous Waste Management Act, Underground Storage Tank Act, and Dam Safety Act by providing assistance, inspecting regulated sites, and enforcing conditions required by these acts.

10.2 National Pollution Discharge Elimination System (NPDES) Program

The DWWM's primary mechanism for controlling point sources is the West Virginia NPDES permitting program. This program, administered by the Permitting Branch, regulates activities and facilities involved in the installation, construction, modification, and operation and maintenance of industrial and wastewater treatment systems as well as their discharges. Individual and general permits are used to implement the program. Most permits include effluent limits, requirements for facility operation and maintenance, discharge monitoring, and reporting. Other permits require the installation and implementation of best management practices in lieu of effluent limitations and discharge monitoring requirements. In addition to the NPDES program, the Permitting Branch administers a *pretreatment* program, which outlines procedures for regulating proposed industrial wastewater connections to publicly owned treatment works (POTW). The program imposes discharge limitations for these indirect discharges and requires the installation of pretreatment facilities where necessary to ensure that the pollutants contributed by industrial users do not pass through the POTW and violate water quality standards, and also to prevent interference with POTW operations and sludge disposal practices. The National Combined Sewer Overflow (CSO) Policy is implemented as a component of the NPDES Permits for POTWs with CSOs. WVDEP has issued three Concentrated Animal Feeding Operation (CAFO) permits with no further permits currently under consideration. Activities administered by the Permitting Branch include the regulation of industrial solid waste landfills, the land application of sewage sludge, and developing wasteload allocations for new or expanding sewage treatment facilities. Below is a list of permit applications processed during the time period beginning in July 2015 and ending in December 2020.

Table14: WVDEP-DWWM-Permit Branch NPDES Permit Action Summary

	New Permits	Permit Modifications	Permit Reissues	Permit Transfers
Industrial	539	377	1335	126
Sewage Treatment	1322	1407	2530	324
Construction Stormwater	3079	814	427	69
Total	4940	2598	4292	519

In addition to permitting, compliance assessment and enforcement activities are coordinated between Permitting and Environmental Enforcement. Noncompliance is initially addressed by administrative actions to compel compliance. These may include warning letters, notices to comply, enforcement orders, or referrals for civil action.

10.3 Nonpoint Source Control Program

The Nonpoint Source Program in WVDEP's Watershed Improvement Branch focuses on restoration and protection of streams from nonpoint source pollution. The program assesses nonpoint source impacts, then develops and implements watershed-based plans and projects designed to reduce pollutant loads from agricultural, silviculture, resource extraction, urban runoff, construction activities, and failing septic systems. Program initiatives are based upon education, technical assistance, financial incentives, demonstration projects, and enforcement, as necessary. The Nonpoint Source Program supports overall administration and coordination of the nonpoint source activities through these participating state agencies: the West Virginia Conservation Agency, the Office of Oil and Gas, and the Division of Health and Human Resources. Each year, specific activities are funded under the Nonpoint Source Program.

Many of the streams being listed on the state's list of impaired waters are affected by nonpoint sources. The majority of the Total Maximum Daily Loads being developed involve nonpoint source water quality impacts. To more effectively respond to TMDL implementation needs, the Nonpoint Source Management Plan was updated in 2000 to incorporate watershed management principles, including integration of

TMDL and Watershed Management Framework scheduling. In addition to several plans currently under development, the Nonpoint Source Program has a total of 44 watershed-based plans, 32 of which have recently had or currently have active projects. These watershed-based plans address a variety of nonpoint sources of pollution and are in various stages of implementation. These plans are developed in cooperation with the stakeholders, including federal, state, and local government agencies, within the watershed. As a result of these plans, numerous nonpoint source remediation projects for acid mine drainage, agriculture, streambank erosion, and dirt roads have been undertaken. The goal of the watershed- based plans is to restore the impaired streams to meet water quality standards. The successes to date emphasize the need to focus more resources on voluntary installation of best management practices in identified priority watersheds where local stakeholders are interested in making a difference.

10.4 Groundwater Program

Under the Groundwater Protection Act, West Virginia Code Chapter 22, Article 12, Section 6.a.3, DEP's Groundwater Program is responsible for compiling and editing information for a biennial report to the Legislature on the status of the state's groundwater and groundwater management program. WVDEP, the West Virginia Department of Agriculture, and the West Virginia Department of Health and Human Resources all have groundwater regulatory responsibility and contribute to the report. Along with these three state agencies, six standing committees currently share the responsibility of developing and implementing rules, policies, and procedures for the Ground Water Protection Act (1991): the Environmental Quality Board, the Groundwater Coordinating Committee, the Groundwater Protection Act Committee, the Groundwater Monitoring Well Drillers Advisory Board, the Well Head Protection Committee, and the Nonpoint Source Coordinating Committee. The biennial report provides a concise, thorough overview of those programs that are charged with the responsibility of protecting and ensuring the continued viability of groundwater resources in West Virginia. The current biennial report to the Legislature covers the period from July 1, 2015 through June 30, 2017. Copies of the report "Groundwater Programs and Activities: Biennial Report to the West Virginia 2018 Legislature" may be obtained by contacting the Groundwater Program at the Division of Water and Waste Management, 601 57th St., S.E., Charleston, WV 25304 or by calling (304) 926-0495. The report also may be reviewed at:

https://dep.wv.gov/WWE/Programs/gw/Documents/2018-04-09.%20Groundwater%20Biennial%20Report%20(002).pdf

The Ambient Groundwater Quality Monitoring Network was established by the DWWM in cooperation with the USGS in 1992 and is an ongoing project. The network provides critical data needed for proper management of West Virginia's groundwater resources. The major objective of this USGS study is to assess the ambient groundwater quality of major systems (geologic units) within West Virginia and to characterize those individual systems. Characterization of the quality of water from the major systems helps to:

- Determine which water quality constituents are problems within the state.
- Determine which systems have potential water quality problems.
- Assess the severity of water quality problems in respective systems.
- Prioritize these concerns.

The USGS has worked with WVDEP on several groundwater monitoring efforts. These include monitoring of a set of sentinel wells and wide variety of topical studies. All associated groundwater quality data for each well sampled and summaries of groundwater quality from the topical studies are published in the USGS Water Resources Data for West Virginia annual report.

10.5 Division of Mining and Reclamation

The mission of the Division of Mining and Reclamation (DMR) is to regulate the mining industry in accordance with federal and state law. Activities include issuing both NPDES and Surface Mining Control and Reclamation Act (SMCRA) permits for mineral extraction sites and related facilities, inspecting facilities for compliance, monitoring water quality, tracking ownership and control, and issuing and assessing violations. The DMR is responsible for the computer databases that track their regulatory activities - Environmental Resources Information System (ERIS) and Applicant Violator System (AVS, the federal OSM database). The Permitting unit is responsible for reviewing permit applications for surface and underground coal mines, preparation plants, coal loading facilities, haulage ways, and coal-related dams. This unit also reviews permit applications for non-coal quarry operations (sand, gravel, limestone, etc.). Permit review teams staffed with geologists, hydrologists, engineers, and others are located in each regional office throughout the state and in the headquarters office.

The DMR’s Inspection and Enforcement unit is responsible for inspecting all coal mining and quarry operations in the state. It enforces compliance through regular inspections and Notices of Violation; and it ensures site reclamation through final release of the operation. This unit is also responsible for civil penalty assessments, show cause proceedings, bond forfeiture and collection. The DMR’s Program Development unit is responsible for implementing a proactive approach to policy issues, legislation, and training. This unit is designed to keep the Division staff current with technological advances and to provide clear direction through development of cogent policy and guidance to meet legal and regulatory requirements. This unit provides regulatory interpretation and support to field offices, develops and updates handbooks and forms, drafts legislation, and initiates regulation changes. Other responsibilities of this unit include the Small Operators Assistance Program, public relations, special projects, employee training, and research of laws, regulations, and policy.

11.0 COST BENEFIT ANALYSIS

A true cost/benefit analysis on the economic and social costs and benefits of water pollution control is a difficult and time-consuming task. Particularly, the evaluation of industrial facilities would be a monumental task considering the various types of industry (mining, chemical, power generation, etc.), each having a very different process of pollution control. However, the information contained in the following paragraphs provides an idea of the amount of money currently expended to construct and upgrade both the municipal facilities within the state as well as programs available to homeowners wanting to correct failing onsite sewage systems.

WVDEP is responsible for administering a combination of state and federal funds expended for projects to improve water quality in state streams. The following narrative provides an overview of the programs within WVDEP's Division of Water and Waste Management that provide funding for water quality improvements and a summary of the funds dispersed between July 2015 and December 2020 to improve water quality. These sections will be updated with funding totals soon.

11.1 Clean Water State Revolving Fund Program

The Clean Water State Revolving Fund (CWSRF) program is a funding program administered by the State Revolving Fund Branch to address water quality problems through wastewater facility construction, upgrades, or expansions. The branch is charged with general oversight, fiscal management and technical and administrative compliance review of local governmental entities that receive funds and provides information and guidance on what administrative actions are needed to process a loan through the program. When a community has been recommended by the West Virginia Infrastructure and Jobs Development Council to seek CWSRF program funding for financial assistance, the community is contacted by a financial manager and project engineer. A meeting may be scheduled to advise the community leaders about the overall program requirements and specifically what they should do next to obtain a CWSRF loan. There are federal, state, and program requirements that must be met prior to scheduling a loan closing. The CWSRF currently has three financial assistance programs available. These three programs are described below.

Low Interest Loan Program

A low interest loan program for construction of municipal wastewater treatment works is available for municipalities and public service districts to build, upgrade, or expand treatment facilities and collection systems. Conventional loans with a repayment period of 20 years are available with an interest rate and annual administrative fee not exceeding 2% for certain communities. Loans with repayment periods from 21 to 40 years are available for disadvantaged communities where financial affordability is an issue. The interest rate and annual administration fee on these loans do not exceed 1/2%. This section will be updated with funding totals soon.

Agriculture Water Quality Loan Program

The Agriculture Water Quality Loan Program is a partnership with the West Virginia Conservation Agency developed to address pollution from nonpoint sources using Best Management Practices approved by the U.S. Environmental Protection Agency. CWSRF money is loaned to participating banks so they can offer below market rate low interest loans to qualifying applicants. For more information, contact your local Conservation District office, http://www.wvca.us/map.cfm. This section will be updated with funding totals soon.

Onsite Systems Loan Program

In cooperation with the West Virginia Housing Development Fund and Safe Housing and Economic Development office (Welch, WV) a low interest loan program has been established to address onsite sewage disposal problems. Called the "Onsite Systems Loan Program," loans are available to replace malfunctioning septic systems and to install new onsite sewage systems for homes that have direct sewage discharges to ditches and streams. Centralized treatment for these homes will not be available in the next five years. This section will be updated with funding totals soon.

11.2 Cost Benefit Analysis Conclusion

In conclusion, although it may be difficult or even impossible to completely and accurately quantify the costs and benefits of water pollution control measures, WVDEP recognizes that multiple millions of dollars are expended annually by businesses, municipalities, private and public entities (including state and federal agencies) to improve and maintain water quality in West Virginia. These expenditures address pollutants from various media including solid and hazardous waste, air, and water.

12.0 Public Participation And Responsiveness Summary

In order to allow public participation in the 303d listing process, public comments are being accepted through June 1, 2022.

Comments may be submitted by e-mail to depwab@wv.gov or mailed to:

West Virginia Department of Environmental Protection
Division of Water and Waste Management
303(d) List – Attn: Mindy S. Neil
601 57th Street, S.E.
Charleston, WV 25304.

Appendix A

Aquatic Life Use Assessment and Biological Stressor Identification Procedures **August 2021**

Introduction

The federal Clean Water Act contains requirements to report on the quality of a state's waters. Section 305(b) requires a comprehensive biennial report and Section 303(d) requires, from time to time, a list of waters for which effluent limitations or other controls are not sufficient to meet water quality standards (impaired waters). West Virginia code §22-11-7b also requires a biennial report of the quality of the state's waters. Water quality standards, both numeric and narrative are protective of designated uses. Thus, if water quality standards are not met in a waterbody, the waterbody cannot support its designated uses.

Legislative rules on Water Quality Standards (§47-CSR-2) describes in section 6.3, one of the designated uses, Category B – Propagation and maintenance of fish and other aquatic life, including both B1 (warmwater fishery) and B2 (Trout waters) waters. §47-CSR-2 – Section 3.2.i. prohibits the presence of wastes in state waters that cause or contribute to significant adverse impact to the chemical, physical, hydrologic, and biological components of aquatic ecosystems and is commonly referred to as the narrative water quality criterion for aquatic life use.

WVDEP has modified its procedures for assessing attainment of the narrative criteria for Aquatic Life Use (AQL) in response to legislative action amending WV Code §22-11-7b, requiring WVDEP to develop new assessment methodologies. This document provides a general assessment procedure, identifies attainment thresholds, and provides the specific processes and tools used in determining attainment of the narrative criteria for the Aquatic Life Use. This document also includes the stressor identification component that is utilized to determine when additional monitoring is required.

Procedures for assessing AQL in non-wadeable streams and rivers and lakes have not yet been developed. This document will be updated when those methods are developed.

Part I. Aquatic Life Use Attainment Procedures

This assessment methodology is based on benthic macroinvertebrate community data that has been determined to be the most effective and efficient way to assess wadeable streams with riffle / run habitats – by far the most common aquatic resource across West Virginia.

> Biological assessments and criteria address the cumulative impacts of all stressors, especially habitat degradation, and chemical contamination, which result in a loss of biological diversity. Biological information can help provide an ecologically based assessment of the status of a waterbody and as such can be used to decide which waterbodies need TMDLs (USEPA 1997c) and aid in the ranking process by targeting waters for TMDL development with a more accurate link between bioassessment and ecological integrity. (Barbour 1999).

> Rapid bioassessment using the benthic macroinvertebrate assemblage has been the most popular set of protocols among the state water resource agencies since 1989 (Southerland and Stribling 1995).

Regarding efficiency, benthic macroinvertebrate data can be collected by one person with minimal equipment and in a relatively short period of time. WVDEP has collected over 10,000 samples since the Watershed Assessment Branch began collecting these samples in 1996. The Watershed Assessment Section's Standard Operating Procedures Manual provides an in-depth description of benthic data collection that must be followed to meet quality assurance and quality controls and comparability before data are considered reliable for assessment.

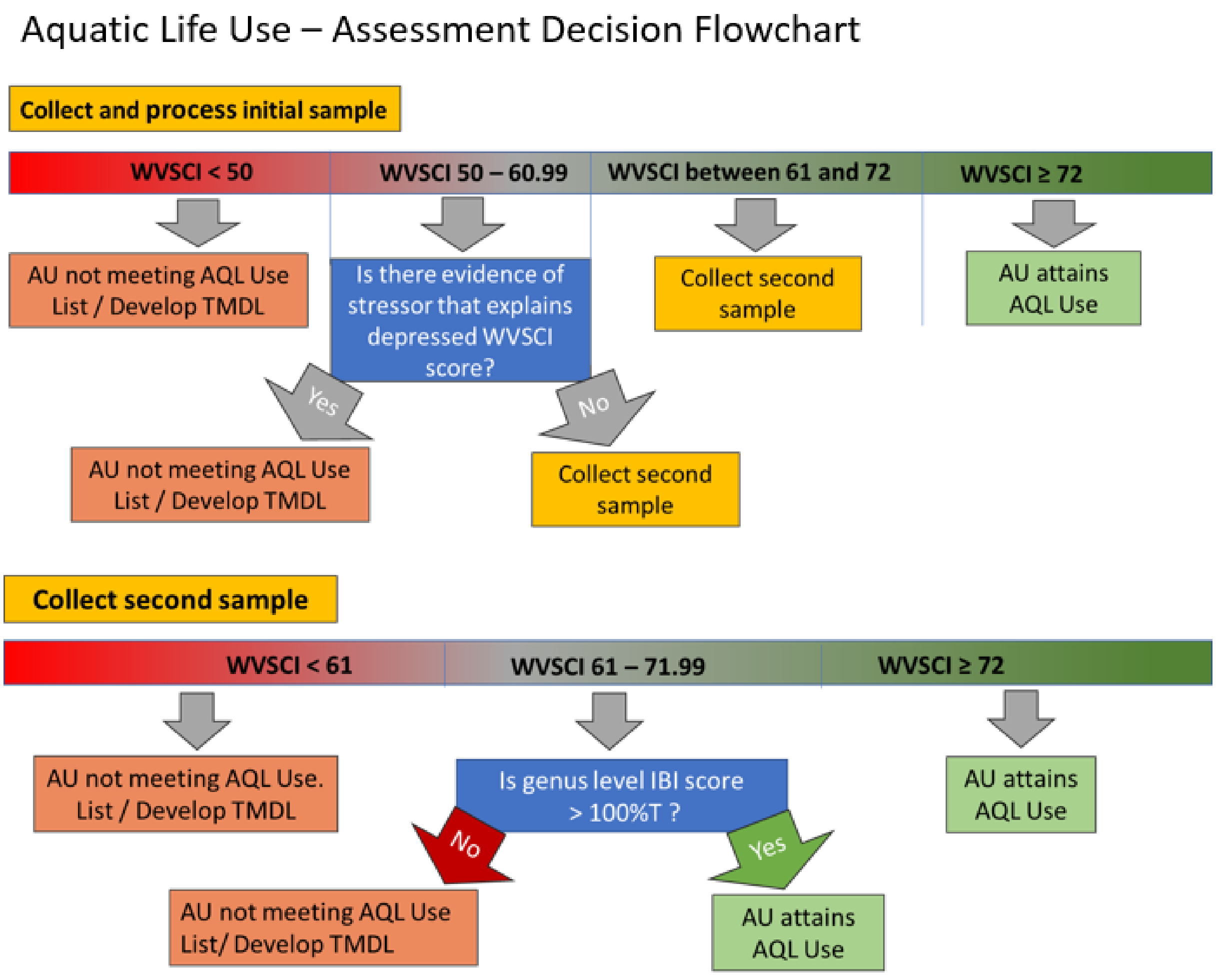
Benthic IBI:
Based on general rapid bioassessment protocols designed to efficiently determine the health of wadeable streams, WVDEP developed a state specific Benthic Index of Biotic Integrity (Benthic IBI), referred to as the West Virginia Stream Condition Index (WVSCI), using family level benthic macroinvertebrate data collected from 1996 to 1999. Information on the development of WVSCI, the use of biological data, and the metrics on which a WVSCI score is derived are available at: https://dep.wv.gov/WWE/watershed/bio_fish/Pages/Bio_Fish.aspx. This site also describes minor updates made to WVSCI scoring that were made possible by the large volume of data acquired since 1999. WVDEP has based AQL assessments for 303(d) listing on this IBI since 2002.

Assessment Specifics:
When reporting on water quality and impairment, the WVDEP applies attainment decisions to assessment units of a waterbody. Depending upon the size of the waterbody and factors such as anthropogenic influences and historic data; a stream may be assessed as one unit or divided into multiple segments. Results from one monitoring station may be applied to an entire assessment unit.

If conflicting results emerge from multiple monitoring stations within the same assessment unit, assessments decisions will be based on the preponderance of the data from recent samples. Data from the collection efforts will be re-examined to ensure sample comparability. The proximity of the stations to pollution sources will be considered. If an obvious reason for data disagreement amongst sample stations exists, the stream segment may be divided into smaller assessment units.

The attainment threshold is a WVSCI score equal to 72, which is based on the 5th percentile of reference sample scores. The remainder of this document describes the procedures WVDEP will follow in determining attainment status. This includes descriptions of when additional benthic macroinvertebrate samples are required, a Stressor Identification determination based on water chemistry and habitat (see Part II), and/or the use of genus level taxonomy.

When a single recent benthic macroinvertebrate sample from an assessment unit is available, an attainment decision can be made if the WVSCI score is < 50 or if it is $\geq$ the attainment threshold of 72. Streams with WVSCI score <50 will be considered impaired – or not attaining the narrative criteria for AQL, and streams with WVSCI score ≥ 72 will be considered attaining.



For stream segments with an initial WVSCI score ≥ 50 and < 61, an evaluation of all available water quality and habitat data will be made based on the Stressor Identification section (Part II) of this document. The stream segment will be classified as impaired for the biological integrity criterion when water quality or physical habitat conditions clearly explain the depressed WVSCI score. If no clear causative stressor is identified, an additional benthic macroinvertebrate sample must be collected before an attainment decision can be made.

For stream segments with initial WVSCI scores ≥ 61 and < 72, and for streams with WVSCI scores ≥ 50 and < 61 with no identified causative stressor, at least one additional benthic macroinvertebrate sample is required to determine compliance with the biological integrity criterion.

For cases where a second benthic macroinvertebrate sample is required, the Department will determine biological integrity criterion compliance based on the most recent sample. Stream segments for which the most recent WVSCI score is < 61 will be considered impaired – or not attaining AQL. Stream segments for which the most recent score is ≥ 72 will be considered attaining for AQL.

For streams or stream segments whose most recent sample has a WVSCI score ≥ 61 and < 72, WVDEP will base decisions on genus level IBI scores. As with WVSCI, the attainment thresholds for this genus level IBI, which has been developed for two regions (Mountains and Plateau) and two seasons (spring and summer) will be based on the 5th percentile of region and season specific reference sample scores. These scores have been adjusted so that the 5th percentile score is equal to 100. These adjusted scores are referred to as %T (percent of threshold) Genus IBI scores. When this genus level IBI was being developed, there was concern regarding the difficulty involved with processing and identifying the small larvae of the chironomidae family which often require individual specimens be mounted on microscope slides for accurate identification to genus level. For this reason, an IBI was developed and tested that used genus level identifications for most families but kept chironomids at the family level. This version performed well and will be used in this step of the assessment process. Streams or stream segments with %T Genus IBI CF (chironomidae at family level) scores ≥ 100 will be considered attaining AQL Use and those with scores below this threshold will be considered impaired. Information on the development of the genus level IBI can be found at: https://dep.wv.gov/WWE/watershed/bio_fish/Pages/Bio_Fish.aspx

Fish Community Assessments**:**
In 2012, state legislators voted to change state code: §22-11-7b. Water quality standards; implementation of antidegradation procedures; procedure to determine compliance with the biologic component of the narrative water quality standard. Subsection (f) was updated, stating: "The secretary shall propose rules measuring compliance with the aquatic life component of West Virginia's narrative water quality standard requires evaluation of the holistic health of the aquatic ecosystem and a determination that the stream: (i) Supports a balanced aquatic community that is diverse in species composition; (ii) contains appropriate trophic levels of fish, in streams that have flows sufficient to support fish populations; and (iii) the aquatic community is composed of benthic invertebrate assemblages sufficient to perform the biological functions necessary to support fish communities within the assessed reach, or, if the assessed reach has insufficient flows to support a fish community, in those downstream reaches where fish are present."

WVDEP worked with WVU faculty and graduate students to assemble all available fish community data and develop a means of assessing this data for use in determining compliance with the aquatic life component of WV's narrative criteria. A group of fish biologists and regulators worked for several years on the development of metrics capable of accurately describing fish community health. It was determined that fish community data could not be used for small headwater streams that have too few species to allow development of useful metrics. There was also insufficient data available for larger streams and rivers. Therefore, efforts were focused on wadeable streams, defined for this project as watersheds with drainage areas of between 7 and 250 km^2. It was determined that regional differences in fish communities required unique metrics be developed for 5 distinct regions of the state and also that there was insufficient data available to develop measures for coldwater streams.

After several years of working to develop regional fish IBI's for warmwater wadeable streams it was determined that there was not enough data and other problems to provide for development of useful assessment tools for regulatory purposes.

- There were too few reference and stressed sites that are needed to assess the performance of metrics in several regions.
- For regions with adequate numbers of reference and stressed sites, no IBI could be developed that could consistently distinguish between pre-determined high quality and stressed sites.
- Higher IBI scores were correlated with known stressors (e.g. lower percent forest and human development)

Fish community data continues to be collected across the state, with a focus on areas most in need of additional data. The use of fish data for assessment of AQL Use will be revisited in the future.

Southerland, M.T. and J.B. Stribling. 1995. Status of biological criteria development and implementation. Pages 81-96 *in* W.S. Davis and T.P. Simon (editors). *Biological assessment and criteria: Tools for water resource planning and decision making.* Lewis Publishers, Boca Raton, Florida.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Part II.

Stressor Identification Overview

The Biological Stressor Identification (SI) process used to identify the cause of stream impairment is based on an analysis of existing quantitative and qualitative water quality, physical habitat, and biological data. This process was originally developed as part of the TMDL development for streams deemed to be biologically impaired.

Biological assessments are useful in detecting impairment, but they do not necessarily identify the cause (or causes) of impairment. USEPA developed *Stressor Identification: Technical Guidance Document* to assist water resource managers in identifying stressors or combinations of stressors that cause biological impact (Cormier et al., 2000). Elements of the SI process are used to evaluate and identify the primary stressors on the aquatic life of biologically impacted streams. SI is a formal and rigorous method that identifies stressors and provides a structure for organizing the scientific evidence supporting the conclusions.

Technical Approach

Biological communities respond to any number of environmental stressors, including physical impacts and changes in water and sediment chemistry. The primary sources of data used in the SI process are water quality, biological, habitat, and other information stored in the WVDEP Watershed Assessment Branch (WAB) database. Importantly, this database includes information on pollutant source tracking, narrative descriptions of potential stressors and their sources, and sample location photography. SI also includes the examination of pertinent Geographic Information Systems (GIS) data including, but not limited to, National Pollutant Discharge

Elimination System (NPDES) point source data, WVDEP mining permits and activities coverages, and aerial imagery.

WVDEP interprets water quality and biological information collected primarily by the agency's Watershed Assessment Section via several monitoring programs. Most of these programs are based on collecting data from the state's 32 major watersheds (HUC 8 level) on a five-year rotation. Pre-TMDL monitoring is conducted to collect sufficient data for the development and calibration of hydrology and water quality models. This monitoring is intensive, consisting of monthly sampling for parameters of concern, which captures data under a variety of weather conditions and flow regimes in one year. A comprehensive habitat assessment and biological monitoring are performed in conjunction with water quality monitoring. Sediment related habitat evaluations are performed during all monthly visits. Pre-TMDL monitoring also includes an effort to locate the specific sources of impairment, with attention paid to identifying non-point source land use stressors as well as any permitted facilities that may not be meeting their permit requirements

Development of the Conceptual Model

The first step in the SI process is to develop a list of candidate causes, or stressors. Potential causes are evaluated based on an assessment of watershed characteristics and the likely causes and sources of biological impairment. The relationship between candidate causes of impairment and potential biological effects are based on initial data analyses, knowledge of these watersheds, and experience in defining impairment causes in similar watersheds. Sources, impairment causes, and the resulting effects on the biological community depend on the stream or watershed in question. In some cases, biological impairment can be linked to a single stressor; in other situations, multiple stressors might be responsible for the impact.

Data Analysis

The second step in the SI process is to evaluate the information related to each of the candidate causes. Water quality parameters, habitat data, source tracking data, and all other quantitative and qualitative data are grouped under each respective candidate cause for analysis. In some cases, a variety of information is used to evaluate a candidate cause (e.g., sedimentation). The evidence presented is used to determine support or non-support of the listed candidate cause. At the conclusion of this process, one or more stressors (pollutants) may be identified.

SI analysis involves comparing the water quality data, habitat information, and other non-biological data from an impaired station to established water quality standards and threshold values that have been developed on the basis of a statistical analysis of stressor-response patterns using reference stream data (Table 1.). Two sets of threshold values: elimination and strength of evidence are designated for most parameters. Elimination threshold values represent "not to exceed" levels for water quality and habitat variables. Sample station data are first compared with the elimination thresholds to determine whether additional analyses is necessary to evaluate a particular candidate cause (stressor). Each potential stressor is further evaluated using a strength-of-evidence approach if the elimination threshold is exceeded, related parameters or other information showed conflicting results, or there are limited data available. At least one parameter should exceed the candidate stressor threshold before a stressor can be identified.

Biological data are also used in the SI process and include diagnostic tools with statistically derived thresholds that evaluate a biological community's response to specific stressors. Currently, diagnostic tools based on an Observed/Expected (O/E) concept are used in SI process. O/E is a taxonomic completeness model that assesses biological condition using the ratio of observed taxonomic richness (O) to expected taxonomic richness (E) in the absence of disturbance. Expected (E) taxonomic richness is established using reference site populations. This basic concept was followed to develop three models capable of providing stressor specific evidence of biological impacts in WV streams. These models are the O/E Sensitive (taxa that are sensitive to a given stressor are included in the Expected group), O/E Opportunistic (taxa that are opportunistic to a given stressor are included in the Expected group), and Percent Model Affinity (similarity of a biological sample to the average taxonomic composition of each stressor population) approaches. The stressors for which models are developed include organic enrichment, sediment, ionic strength, acid deposition, and dissolved metals. The SI process includes calculating O/E model scores for each stressor using biological sample data and then comparing them to derived thresholds. These thresholds are considered with a weight of evidence approach along with water chemistry, habitat, and other pertinent sources of information.

Biological community metric and individual taxa are also reviewed for each sample station to confirm decisions resulting from other lines of evidence. Many pollutants have a direct and negative impact on macroinvertebrate presence/abundance; however, some stressors act by more complex means on the biota. For example, an increased abundance of the midge group *Cricotopus_Orthocladius* (Diptera - true flies) is typical in waters heavily enriched by nutrients; consequently, both the population's abundance and corresponding information regarding the potential stressor are closely considered. A useful benthic community metric for identifying metals toxicity is Ephemeroptera Taxa Richness (mayflies). This metric is often substantially reduced compared to reference site values in streams with elevated dissolved metals and low pH. As with other data, biological reviews of specific taxa and community metrics are used in a weight of evidence approach along with water chemistry, habitat, and other pertinent sources of information.

Table 1.

Candidate Cause	**Parameter**	**Elimination Threshold (Rule out stressors at these thresholds)**	**Strength of Evidence (Evidence for each Candidate Cause as stressor) Candidate Stressor Thresholds**
1. Metals Toxicity (Primarily Acid Mine Drainage)	Al (dissolved)	<0.09 mg/L	>0.20 mg/L – Evidence of Stressor[1,4]
	Fe (total)	Fe toxicity to benthic invertebrates is not well established.	
	Mn (total)	Mn toxicity to benthic invertebrates is not well established.	
	O/E Opportunistic Model (AMD)	na	> 2.0 – Evidence of Stressor[2]
	O/E Sensitive Model (AMD)	na	< 0.5 – Evidence of Stressor[2]
	O/E PMA Model (AMD)	na	> 0.3 – Evidence of Stressor[2]
	Benthic Taxa review	Professional judgment applied to benthic macroinvertebrate taxa and community metrics from sample station.	
	Qualitative Metals Toxicity Evaluation:	Professional judgment applied to combination of station observations including hot acidity, alkalinity, dissolved metals, specific conductance, TDS, sulfate, and other signature ions. Qualitative ratings of metals flocculation and field rating of AMD stress. Station photography, GIS imagery evaluation, and field notes and source tracking observations.	
2. Acidity (Acid Deposition)	pH	>6.3	< 6.0[3]
	O/E Opportunistic Model (Acid Precip)	na	> 2.0 – Evidence of Stressor[2]
	O/E Sensitive Model (Acid Precip)	na	< 0.5 – Evidence of Stressor[2]
	O/E PMA Model (Acid Precip)	na	> 0.3 – Evidence of Stressor[2]
	Benthic Taxa review	Professional judgment applied to benthic macroinvertebrate taxa and community metrics from sample station.	
	Qualitative Acid Deposition Evaluation:	Professional judgment applied to combination of station observations including hot acidity, alkalinity, dissolved metals, specific conductance, TDS, sulfate, and other signature ions. Station photography, GIS imagery evaluation, and field notes and source tracking observations.	
3. High pH	pH	<8.39	>9[3]
4. Ionic Strength	Specific Conductance	Consider as independent stressor in non-acidic, non-AMD streams. Maximun value at monitoring station.	
		< 300 µmhos	> 500 – Evidence of Stressor[1]
	O/E Opportunistic Model (Ionic strength)	na	> 2.0 – Evidence of Stressor[2]
	O/E Sensitive Model (Ionic strength)	na	< 0.5 – Evidence of Stressor[2]
	O/E PMA Model (Ionic strength)	na	> 0.3 – Evidence of Stressor[2]

Candidate Cause	Parameter	Elimination Threshold (Rule out stressors at these thresholds)	Strength of Evidence (Evidence for each Candidate Cause as stressor) Candidate Stressor Thresholds
4. Ionic Strength (cont.)	Benthic Taxa review	Professional judgment applied to benthic macroinvertebrate taxa and community metrics from sample station.	
	Qualitative Ionic Strength evaluation:	Professional judgment applied to combination of station observations including concentrations of constituent ions alkalinity, calcium, chloride, potassium, sodium, sulfate, magnesium. Concurrent (with bio sample) and mean specific conductance at station also considered. Station photography, GIS imagery evaluation, and field notes/source tracking observations.	
5. Sedimentation	% Fines (sand + silt + clay) - in Kicked Area	<10%	>= 25 - Evidence of Stressor[4]
	RBP: Embeddedness	16.0 - 20.0 (optimal)	< 9 - Evidence of Stressor[4]
	RBP: Sediment Deposition	16.0 - 20.0 (optimal)	< 8 - Evidence of Stressor[4]
	RBP: Bank Stability	16.0 - 20.0 (optimal)	< 12 - Evidence of Stressor[4]
	Silt Deposition Rating - in 100m Assessment Reach	Qualitative evaluation based on field rating of magnitude:	
		<2 (none or low)	> 2 (high or extreme) - Evidence of Stressor[1]
	Sand Deposition Rating - in 100m Assessment Reach	Qualitative evaluation based on field rating of magnitude:	
		<2 (none or low)	> 2 (high or extreme) - Evidence of Stressor[1]
	O/E Opportunistic Model (Sedimentation)	na	> 2.0 – Evidence of Stressor[2]
	O/E Sensitive Model (Sedimentation)	na	< 0.5 – Evidence of Stressor[2]
	O/E PMA Model (Sedimentation)	na	> 0.3 – Evidence of Stressor[2]
	Benthic Taxa review	Professional judgment applied to benthic macroinvertebrate taxa and community metrics from sample station.	
	Qualitative Sedimentation evaluation:	Professional judgment applied to combination of RBP embeddedness, sediment deposition, bank stability, bank vegetation, riparian vegetation, and total scores; supplemented with watershed erosion rating, reach substrate particle characterization, sediment layer profile, and field rating of sediment stress. Station photography, GIS imagery evaluation, and field notes/source tracking observations.	
7. Metals flocculation (habitat alteration)	Embeddedness due to metals flocculation	16.0 - 20.0 (optimal)	< 9 - Evidence of Stressor[4]
	Metal Flocculation Rating	Qualitative evaluation based on field rating of magnitude:	
		<1 (none)	> 1 (moderate to extreme) - Evidence of Stressor[1]

Candidate Cause	Parameter	Elimination Threshold (Rule out stressors at these thresholds)	Strength of Evidence (Evidence for each Candidate Cause as stressor) Candidate Stressor Thresholds
8. Organic Enrichment	Filamentous Algae	Qualitative evaluation based on field rating of abundance:	
		<2 (low or none)	> 2 (high or extreme) – Evidence of Stressor[4]
	Diatom Growth	Qualitative evaluation based on field rating of abundance:	
		<2 (low or none)	> 2 (high or extreme) – Evidence of Stressor[4]
	Dissolved Oxygen	>7.0 mg/L	< 6.0 - Evidence of Stressor[3]
	Total Phosphorus	<0.02 mg/L	> 0.05 – Evidence of Stressor[5]
	Total Nitrogen	<2.0 mg/L	> 2.0 – Evidence of Stressor[5]
	Fecal coliform	<150 counts/100 mL	> 500 - Evidence of Stressor[4]
	O/E Opportunistic Model (Organic Enrichment)	na	> 2.0 – Strong Indication of Stressor[2]
	O/E Sensitive Model (Organic Enrichment)	na	< 0.5 – Strong Indication of Stressor[2]
	O/E PMA Model (Organic Enrichment)	na	> 0.3 – Strong Indication of Stressor[2]
	Benthic Taxa review	Professional judgment applied to benthic macroinvertebrate taxa and community metrics from sample station.	
	Qualitative Organic Enrichment evaluation:	Professional judgment applied to combination of station observations such as atmospheric and water odors, presence of foam/suds, poorly treated domestic sewage, agriculture and livestock, residences, lawns, field biologist/specialist organic enrichment determination, field notes, station photography, GIS imagery evaluation, and information from sources tracking efforts.	
9. Temperature	Degrees F		Max >87 F May through November; or
			Max >73 F December through April.[3]
10. Chemical Spills	Various chemical parameters		Qualitative supplemental information (field notes and other sources listed below this table).

Notes:

-Elimination: Screening step to rule out particular stressors, based on unambiguous criteria.

-Strength of evidence: Data that provide evidence for identification of each particular candidate cause as a biological stressor.

-RBP: Rapid Bioassessment Protocol.

-Qualitative: Supplemental evidence to evaluate each candidate stressor.

-Benthic taxa review: Review taxa lists and metrics to find indicators of specific stressor.

-O/E Models: Observed over Expected models using benthic macroinvertebrate taxa; diagnose specific stressor.

Candidate Cause	Parameter	Elimination Threshold (Rule out stressors at these thresholds)	Strength of Evidence (Evidence for each Candidate Cause as stressor) Candidate Stressor Thresholds

References & Sources:

[1]WVDEP WAB Data Analysis. 2020.

[2]Tetra Tech Memo: Methods & Results of Site-Specific Biological Modeling (O/E) with Stressor Module Task (Feb. 26, 2019).

[3]West Virginia Code §47, Series 2. 2014. Requirements governing water quality standards.

[4]Gerritsen, J., L. Zheng, J. Burton, C. Boschen, S. Wilkes, J. Ludwig, and S. Cormier. 2010. Inferring Causes of Biological Impairment in the Clear Fork Watershed, West Virginia. U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, Cincinnati, OH. EPA/600/R-08/146.

[5]VDEQ. 2017. Stressor Analysis in Virginia: Data Collection and Stressor Thresholds. VDEQ Technical Bulletin WQA/2017-001.

[6]Novak, M.A. and R.W. Bode. 1992. Percent model affinity: a new measure of macroinvertebrate community composition. Journal of the North American Benthological Society 11(1): 80-85.

Actions based on Assessments and Stressor Identification

Listing on the 303d list as impaired, requires the development of TMDLs to prescribe reductions of pollutants causing impairment. Most often streams for which AQL Use is non-attaining are also impaired for associated numeric water quality criteria. For instance, because of the high iron content in West Virginia soils, streams stressed with sedimentation often also exceed the total iron water quality criterion. When a relationship is established through total suspended solids and iron correlations during TMDL development, a sediment reference watershed is used to test if reductions to pollutant sources prescribed in total iron TMDLs are as protective as those that would be prescribed through biological TMDLs for sedimentation. When those reductions are determined to be protective, total iron TMDLs are used as surrogates for biological TMDLs. In instances where total iron TMDLs are not appropriate surrogates, independent biological TMDLs are required to resolve the 303d listing.

Similar relationships can be seen between other common biological stressors and impairment of numeric criteria, such as organic enrichment and fecal coliform where there are sources of untreated human waste or influence from a pasture; acidity and low pH when there is acid precipitation; metals toxicity and dissolved aluminum when there is acid mine drainage. TMDLs that prescribe reductions to pollutant sources to attain fecal coliform, pH, and dissolved metals criteria act as surrogates to resolve stress from organic enrichment, acidity, and metals toxicity.

In the absence of a relationship between a stressor and an established numeric criterion, such as for ionic toxicity, biological TMDLs are required to prescribe reductions to ions to address the 303d listing. Prescribed reductions will meet a TMDL endpoint for specific conductivity that will be protective of aquatic life. WVDEP is aware that in some streams, biological impairment for the designated AQL Use associated with ionic toxicity may not be attainable. In those instances, a multisector variance or Use Attainability Analysis will be pursued for both an alternate biological attainment threshold and specific conductivity endpoint.