Water Resources Sustainability and Safe Yield in West Virginia

Prepared for
West Virginia Department of Environmental Protection

Prepared by
Heidi L.N. Moltz
James B. Palmer
Karin R. Bencala

Interstate Commission on the Potomac River Basin
51 Monroe Street, Suite PE-08
Rockville, MD 20850

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Abbreviations

ASCE	American Society of Civil Engineers
DRBC	Delaware River Basin Commission
GIS	Geographic Information Systems
ICPRB	Interstate Commission on the Potomac River Basin
NLCD	National Land Cover Dataset
NASS	National Agricultural Statistics Service
NWIS	National Water Information System
PA	Pennsylvania
PA DEP	Pennsylvania Department of Environmental Protection
SRBC	Susquehanna River Basin Commission
SY	Safe Yield
U.S.	United States
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WV	West Virginia
DEP	West Virginia Department of Environmental Protection
YAT	Pennsylvania Yield Analysis Tool

Units of Measurement

in/yr	Inches per year
Mgal/y	Million gallons per year

1 Introduction

Sustainably managing West Virginia's water resources is critical to ensuring the availability of dependable water supplies now and into the future. With water use rates on the rise due to factors such as population increases, the pressures to develop this finite resource will continue.

But what does sustainability mean and how can one determine the amount of water that can be used sustainably? There are numerous definitions of sustainability. For example, four definitions are listed here:

- "Sustainable water resource systems are those designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental, and hydrological integrity" (ASCE 1998).
- "Development and use of groundwater in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social consequences" (Alley et al. 1999).
- "The groundwater extraction regime, measured over a specified planning timeframe, that allows acceptable levels of stress and protects dependent economic, social, and environmental values" (Australian Department of Sustainability, Environment, Water, Population, and Communities 2004).
- "Withdrawals from the underground waters of the basin shall be limited to the maximum draft of all withdrawals from a groundwater basin, aquifer, or aquifer system that can be sustained without rendering supplies unreliable, causing long-term progressive lowering of groundwater levels, water quality degradation, permanent loss of storage capacity, or substantial impact on low flows of perennial streams" (DRBC 1999).

Water resources sustainability can be determined for a particular withdrawal or on a watershed basis. In both cases, sustainability includes consideration of 1) the amount of water available, 2) the acceptable impact to those waters, and 3) the amount of current and/or projected future withdrawals (**Eq. 1** through **Eq. 3**). The first step in determining sustainability is to calculate safe yield based on the amount of available water and the fraction of that water that can be withdrawn given the accepted level of risk. Determining the level of risk is a social decision, rather than a discrete scientific value, because the impacts often occur along a gradient of degradation with no clearly defined thresholds. Safe yield is a key component to understanding the limitations of a watershed's resources (calculated as either **Eq. 1** or **Eq. 2**).

Safe Yield – The maximum sustainable withdrawal that can be made continuously from a water source.

$$SY = A*F \qquad \textbf{(Eq. 1)}^{1}$$

Where SY = safe yield, A = measure of total available water, F = the fraction of the available water that can be withdrawn given the accepted level of risk.

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[1] This equation was modified from Smith et al. (2010).

$$SY = M_n \qquad \textbf{(Eq. 2)}$$

Where M_n = one of many possible statistical metrics calculated as a function of total available water that describes a hydrologic condition of acceptable impact (e.g. 7Q10[2] and the 1-in-25 year average annual baseflow[3]).

The safe yield is then compared to the volume of withdrawals to determine whether the water resources are being used sustainably (**Eq. 3**).

$$\text{if } SY > W, \text{ then } SU \qquad \textbf{(Eq. 3)}$$

Where SY = safe yield, W = withdrawals, SU = sustainable use of the water resources.

This approach to determining water resources sustainability can be used in both surface- and ground-water systems, an important consideration since water withdrawals in West Virginia draw upon both. The average annual reported withdrawal from groundwater was 36,517 Mgal/y across the state between 2003 and 2011. These withdrawals were made at 423 locations. In comparison, surface water withdrawals are generally larger and come from fewer locations (1,415,593 Mgal/y at 329 locations[4]).

This document details methodologies for determining sustainability using **Eq. 1** through **Eq. 3** in both surface- and ground-water systems. The most appropriate methodology for a particular evaluation depends on the available data and the acceptable level of risk.

2 Methodology

Evaluating water uses to determine sustainability utilizing **Eq. 1** through **Eq. 3** can be broken into a series of steps, numbered here by the subsection in which they are discussed:

2.1. Availability is calculated.
2.2. The acceptable impacts to water resources are determined.
2.3. Withdrawals are calculated.
2.4. The above components are compared to determine if additional sources of water or management efforts are needed.

Each of these steps is discussed in more detail in this section.

2.1 Calculate Availability

The first step to determining whether the current or proposed use of a water resource is sustainable is to calculate how much water is available. The method used to calculate the amount of available surface- and/or ground-waters depends on the nature of the system and the source of the withdrawals. Methods for calculating availability for surface- and ground- water systems are described in this section.

2.1.1 Groundwater

Two approaches to calculating groundwater availability for safe yield determinations are baseflow and recharge estimations.

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[2] 7Q10 is the seven day low flow statistically expected to occur once in every ten years.

[3] The 1-in-25 year annual baseflow is the lowest annual average baseflow estimated to occur once every 25 years.

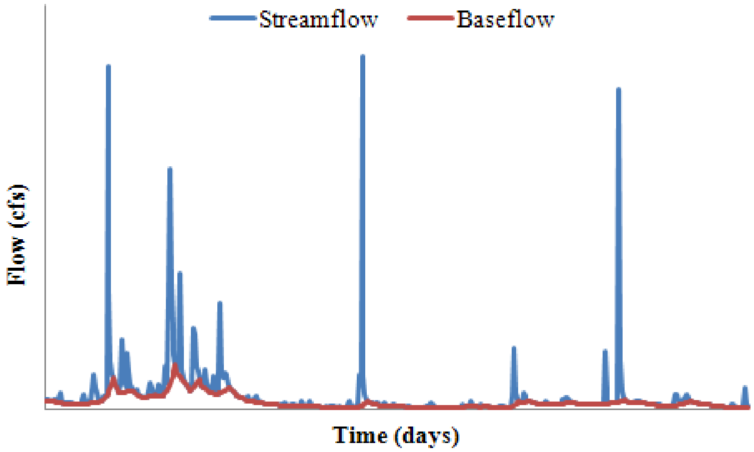
[4] This number represents the reported surface water withdrawals from the DEP large quantity user database excluding hydroelectric withdrawals.

2.1.1.1 *Baseflow Method*

Baseflow is the water that enters the surface water from the groundwater. During low-flow periods, such as droughts, natural streamflow is comprised solely of baseflow. The amount of baseflow during low-flow conditions indicates the amount of groundwater available to meet human uses when the resource is under stress.

For locations with a sufficient period of record, flow time series from United States Geological Survey (USGS) streamflow gages (**Appendix A**) can be input into freely available tools such RORA, PART, and HYSEP (Risser et al. 2005) for conducting baseflow separation techniques. These tools produce monthly, quarterly, and annual baseflow time series using streamflow values and other factors such as drainage area and physiographic province. **Figure 1** is an example baseflow separation using the PART software. Utilizing the estimated baseflows, the selected baseflow metric can be calculated (e.g. the 1-in-25 year average annual baseflow).

Figure 1. Example of baseflow separation using PART software.



Previous baseflow estimations for West Virginia were completed by Wiley (2008), Wiley and Atkins (2010), and Wiley (2012). The products of these efforts include regression equations for hydrologically based low-flow frequency values in West Virginia streams without impoundments, regression equations to estimate seasonal streamflow statistics, and comparison of estimated baseflow values with published streamflow metrics, respectively.

2.1.1.2 *Recharge Method*

A portion of the water that falls as precipitation ultimately ends up recharging the aquifer. The amount of groundwater recharge is another way to estimate how much water can be sustainably removed for human use. This approach assumes that if the system is sustainable the withdrawn water will be recharged without depleting the groundwater resources over time.

Unfortunately, recharge is difficult to measure directly. Estimation of recharge, therefore, often requires analytical methods other than direct measurement. Two approaches to estimating recharge are the use of Geographic Information Systems (GIS) and baseflow estimations.

Recharge can be estimated in a GIS utilizing geology and precipitation data (Gerhart and Lazorchick 1988). This approach uses the percentage of precipitation that will recharge for each geologic unit. In the state of West Virginia, this method is applicable in localized areas due to data availability and knowledge of the groundwater resources. River Basin Bulletins are available for the major river basins within West Virginia from the West Virginia Geological and Economic Survey Publications Catalog. The bulletins provide information on groundwater potential and characteristics.

Recharge can also be estimated using the baseflow separation techniques previously described, assuming that baseflow equals recharge on a long-term basis (e.g. Gerhart and Lazorchick 1988). This is valuable because baseflow can be more readily estimated using available streamflow data. Other methods for estimating recharge include the use of watershed and groundwater models, chloride tracers (Harlow et al. 2008), recession displacements (Kozar and Mathes 2001) (**Appendix A**), baseflow indices (Wolock 2003), lysimeters, and seepage meters to name a few[5]. Some methods have high costs, extensive data needs, and are difficult to implement. Estimating recharge for broad spatial scales across the state of West Virginia using baseflow separation from USGS streamgages or a GIS-based geospatial analysis is less costly, the data is readily available, and is relatively simple to implement.

2.1.2 Surface Water

The availability of surface water can be determined using streamflow gages. West Virginia is fortunate to have an extensive USGS gage network (**Appendix A**). Data from these sites are available for download through the USGS' National Water Information System (NWIS)[6]. Available parameters will depend on the site, but often include real-time or daily streamflows and statistics for the period of record.

Methodologies for estimating safe yield from reservoirs have been developed in Pennsylvania[7]. Their approach has been automated in Excel spreadsheets and in the state's Yield Analysis Tool (YAT). It uses factors such as usable reservoir capacity, surface area, USGS gage data, evaporation estimates, and conservation releases to calculate a 50-year safe yield for water supply reservoirs (PA DEP 1992).

2.2 Decide on Acceptable Impact to the Water Resources

Altering the streamflow regime through either surface- or ground-water withdrawals can have negative ecological consequences and reduce the amount of water available for downstream human uses. The ecological impacts often occur along a gradient of degradation, meaning that there is often no clear point of hydrologic alteration beyond which the habitat is severely impacted (U.S. Army Corps of Engineers et al. 2012). Because clear thresholds are often not apparent, the acceptable level of stress on the water resources is a societal decision that should be made with input from affected parties.

Thresholds should also be determined in consideration of the accepted risk tolerance. It may be most appropriate to develop thresholds for each watershed in the state, given that some may need more conservative measures due to the presence of endangered species or other special considerations.

The amount of water that can be removed from the system without negatively impacting humans or the ecosystem can be estimated utilizing low-flow metrics to ensure that sufficient water will be available during water stressed periods. However, typical conditions can also be used, depending on the level of risk that is acceptable. Utilizing a drought period enables conservative sustainability evaluations while estimates for normal conditions yields an understanding of whether withdrawals are sustainable in a typical meteorological year. Commonly used thresholds are described here for both drought and normal conditions.

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[5] Methods for Estimating Groundwater Recharge In Humid Regions, (http://water.usgs.gov/ogw/gwrp/methods/, accessed 2/15/2013)

[6] http://waterdata.usgs.gov/nwis, accessed 2/20/2013.

[7] http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-90079, accessed 2/15/2013.

Drought conditions:

- SRBC uses 60 percent of the average annual recharge (Ballaron et al. 2005). The average annual recharge can be calculated utilizing the methods described in the recharge section.
- DRBC considers the total amount of water available in a watershed to be equal to the 1-in-25 year average annual baseflow (DRBC 1999). The 1-in-25 year annual baseflow is the lowest annual average baseflow estimated to occur once every 25 years. This metric can be calculated utilizing readily available software such as USGS' SWSTAT (Lumb et al. 1990).
- For DRBC, the total amount of withdrawals in the watershed should be less than 50 percent of the 1-in-25 year average annual baseflow to protect first-order streams and watersheds with "baseflow-sensitive resources" such as exceptional waters or wild trout streams (DRBC 1999). This metric can be calculated utilizing readily available software such as DFLOW (Rossman 1990) and USGS' SWSTAT (Lumb et al. 1990).
- A more conservative approach, the 1-day 25-year low flow (1Q25), is used by the Chester County Water Resources Authority (2002). That is the daily low flow expected to occur once every 25 years. This is a more conservative approach than the 1-in-25 year average annual baseflow described previously. This metric can be calculated utilizing readily available software such as DFLOW (Rossman 1990) and USGS' SWSTAT (Lumb et al. 1990).
- To maintain necessary instream flows required to protect habitat and recreational quality, Tennant (1976) recommends that flows should be maintained at a minimum of 10 percent of mean annual discharge (also known as the Montana method). Flows below this amount result in severe degradation. Seasonally, fair conditions for habitat and recreational quality can be maintained above 10 percent of mean annual discharge in the winter and 30 percent in the summer. Mean annual discharge can be calculated using USGS streamflow data.
- The safe yield of surface waters can be based on the drought of record utilizing historic flow data. This is a conservative approach and protects for the lowest flow on record.
- In places where using the drought of record is too conservative, other low-flow surface water metrics such as 7Q10 or 7Q10 plus 10 percent may be considered. The 7Q10 metric can be calculated using readily available software such as DFLOW (Rossman 1990).

Normal conditions:

- Average annual baseflow is a measure of typical baseflow amounts. This metric can be calculated utilizing the methods described in the baseflow section.
- Average annual recharge is a measure of typical recharge amounts. This metric can be calculated utilizing the methods described in the recharge section.
- Median streamflow is a measure of typical streamflow conditions. This metric can be calculated utilizing the methods described in the surface water section.

Threshold selection should take into account the acceptable level of risk, with the ultimate level of desired protection in mind. For example, utilizing average annual metrics may not capture risk of seasonal low flows, resulting in safe yield estimates that are not conservative enough. Results based on the drought of record may be too conservative for surface water sustainability because it protects for the worst drought at all times. For this reason, other low-flow metrics may be more appealing.

Metric selection will determine the amount of withdrawal determined to be sustainable and is a key part of the process.

2.3 Calculate Withdrawals

Determining whether human withdrawal uses are sustainable requires a firm understanding of how much water is being, or will be, used. According to the West Virginia Water Resources Protection and Management Act, large quantity users (or "any person who withdrawals over 750,000 gallons of water in a calendar month from the state's waters and any person who bottles water for resale regardless of quantity withdrawn") are required to report their water use.

The small quantity users, those not required to report water use, may not have a significant impact individually; however, the cumulative impact for the state and to any given watershed may be substantial. For the purpose of determining water resources sustainability, therefore, estimating unregistered withdrawals is needed for small quantity self-supplied domestic, agricultural, industrial, and commercial water uses. Estimation methods are available that utilize readily available data such as the Census of Agriculture, the National Land Cover Dataset, and the U.S. Census (e.g. Stuckey 2008; Jarrett and Roudsari 2007). Examples of these estimation methods are provided below for irrigation, livestock, commercial, and self-supplied domestic water uses.

Irrigation water use can be estimated using the area of irrigated cropland and orchards and a water use rate per land area. The amount of irrigated cropland acres can be obtained in several ways. The USDA National Agricultural Statistics Service (NASS) produces a Census of Agriculture every five years for every county in the nation. This census includes the number of farms, the farmed acreage, and the irrigated acreage among other statistics (USDA 2009; USDA 2004). Other sources of irrigated lands data include the USGS 2006 National Land Cover Dataset (NLCD) and local land use parcels, typically held by local planning agencies. A water use factor can be developed to estimate the water needed by each crop type during the growing season utilizing values from available literature such as Jarrett and Roudsari (2007) or from local stakeholder knowledge.

Livestock water use is determined based on the number of head of livestock and a water use rate per head. The number of animal head is available through the Census of Agriculture. Water use factors are designed as a function of temperature because animals use more water in higher temperatures. For spatially explicit water use estimation, livestock are assumed to be located in row crop areas. Areas with row crops are readily identified in available data sets (e.g. USDA NASS).

Employment data are available from WorkForce West Virginia to estimate the water use in unregistered commercial and industrial facilities using a method described in Stuckey (2008). A water use factor of 42 gpd per employee for commercial users and 665 gpd per employee for industrial users is used.

Self-supplied domestic water use can be estimated by 1) identifying geographic areas not served by public water suppliers, 2) quantifying the population in those areas using U.S. Census data, and 3) multiplying the population by a water use factor (e.g. 80 gallons per capita per day in Stuckey [2008]).

Taken together, the reported withdrawals from the large quantity user database and estimates of small quantity users would provide a reasonable quantification of total withdrawals for the state.

2.4 Compare Safe Yield to Withdrawals to Determine Sustainability

If the total amount of current and proposed future withdrawals is greater than the safe yield of the watershed, then the water is not being sustainably used. This indicates the need to identify additional sources of water or reduce the amount of withdrawals. On the other hand, if the safe yield is greater than the amount of withdrawals, the water resources are being sustainably managed given the identified amount of acceptable risk.

3 Discussion

Additional considerations may need to be addressed when evaluating sustainable use and management of the water resources. First, there are potential water quality concerns in different parts of the state that may affect the safe yield (e.g. northern coal fields). Differing water quality considerations may require that different limits on aquifer yield be imposed. Further, safety margins should be considered in the estimation of safe yield to allow for uncertainty like potential climate variability. Another consideration is the reliability of water use estimations using existing water accounting mechanisms. A final consideration is the ongoing task of data compilation, verification, and accessibility. The certainty of the calculations from these methodologies depends on the data quality.

It should be noted that the different methods can yield different results. For example, Kozar and Mathes (2001) estimated recharge for a watershed in West Virginia at 9 in/yr using the RORA program (Rutledge 1998). The SRBC method of estimating sustainable yield takes 60 percent of the long-term recharge. Applying this to the recharge amount from Kozar and Mathes gives a sustainable yield of 5.4 in/yr. The 1-in-25 year baseflow estimate of sustainable yield is 5 in/yr. Other test calculations in other watersheds yielded widely varying degrees of agreement between these two methods. Selection of the method for determining water resources sustainability should include consideration of site or watershed specific factors, available data, and an acceptable level of risk.

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Appendix A

USGS gages in West Virginia; Recharge estimates (in/yr) at select gages[8]

Station number	Station name	Recharge (in/yr)
Potomac River Basin		--
1595300	Abram Creek At Oakmont, Wv	--
1595800	North Branch Potomac River At Barnum, Wv	--
1598500	North Branch Potomac River At Luke, Md	--
1604500	Patterson Creek Near Headsville, Wv	7.3
1605500	South Branch Potomac River At Franklin, Wv	--
1606000	N F South Branch Potomac River At Cabins, Wv	11.0
1606500	South Branch Potomac River Near Petersburg, Wv	--
1607500	S F South Branch Potomac River At Brandywine, Wv	9.0
1608000	S F South Branch Potomac River Nr Moorefield, Wv	7.3
1608500	South Branch Potomac River Near Springfield, Wv	--
1610400	Waites Run Near Wardensville, Wv	--
1611500	Cacapon River Near Great Cacapon, Wv	8.7
1613030	Warm Springs Run Near Berkeley Springs, Wv	--
1614000	Back Creek Near Jones Springs, Wv	8.5
1616400	Mill Creek At Bunker Hill, Wv	--
1616500	Opequon Creek Near Martinsburg, Wv	9.8
1617000	Tuscarora Creek Above Martinsburg, Wv	11.4
1618100	Rockymarsh Run At Scrabble, Wv	--
1636464	Bullskin Run Below Kabletown, Wv	--
1636500	Shenandoah River At Millville, Wv	--
Monongahela River Basin		
3050000	Tygart Valley River Near Dailey, Wv	--
3050500	Tygart Valley River Near Elkins, Wv	--
3051000	Tygart Valley River At Belington, Wv	15.4
3052000	Middle Fork River At Audra, Wv	24.5
3052120	Buckhannon River At Alton, Wv	--
3052450	Buckhannon R At Buckhannon, Wv	--
3052500	Sand Run Near Buckhannon, Wv	--
3053500	Buckhannon River At Hall, Wv	--
3054500	Tygart Valley River At Philippi, Wv	--
3056000	Tygart Valley R At Tygart Dam Nr Grafton, Wv	--
3056250	Three Fork Creek Nr Grafton, Wv	--
3057000	Tygart Valley River At Colfax, Wv	--
3057300	West Fork River At Walkersville, Wv	--
3058000	West Fork R Bl Stonewall Jackson Dam Nr Weston, Wv	--
3058020	West Fork River At Weston, Wv	--

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[8] Values reported in Kozar and Mathes (2001).

Station number	Station name	Recharge (in/yr)
3058500	West Fork River At Butcherville, Wv	--
3058975	West Fork River Near Mount Clare, Wv	--
3061000	West Fork River At Enterprise, Wv	--
3061500	Buffalo Creek At Barrackville, Wv	--
3062224	Monongahela R At Opekiska Lock & Dam (Upper), Wv	--
3062225	Monongahela R At Opekiska Lock & Dam (Lower), Wv	--
3062245	Monongahela R At Hildebrand Lock & Dam (Upper), Wv	--
3062250	Monongahela R At Hildebrand Lock & Dam (Lower), Wv	--
3062445	Monongahela R At Morgantown Lock & Dam (Upper), Wv	--
3062450	Monongahela R At Morgantown Lock & Dam (Lower), Wv	--
3062500	Deckers Creek At Morgantown, Wv	--
3065000	Dry Fork At Hendricks, Wv	--
3065400	Blackwater River Near Davis, Wv	--
3066000	Blackwater River At Davis, Wv	22.5
3067510	Shavers Fork Nr Cheat Bridge, Wv	--
3068800	Shavers Fork Below Bowden, Wv	--
3069500	Cheat River Near Parsons, Wv	19.9
3070260	Cheat River At Albright, Wv	--
3070500	Big Sandy Creek At Rockville, Wv	21.2
3071600	Cheat River At Lake Lynn, Pa	--
Wheeling Creek Basin And Ohio Mainstem		
3110685	Ohio R At New Cumberland Lock & Dam (Upper), Oh	--
3110690	Ohio R At New Cumberland Lock & Dam (Lower), Oh	--
3110830	Kings Creek At Weirton, Wv	--
3111515	Ohio R At Pike Island Dam Nr Wheeling (Upper), Wv	--
3111520	Ohio R At Pike Island Lock & Dam (Lower), Wv	--
3111955	Wheeling Creek Near Majorsville, Wv	--
3112000	Wheeling Creek At Elm Grove, Wv	9.6
3112500	Ohio River At Wheeling, Wv	--
3114275	Ohio River At Hannibal Lock And Dam (Upper), Oh	--
3114280	Ohio River At Hannibal Lock And Dam (Lower), Oh	--
3150700	Ohio River At Marietta, Oh	--
3151000	Ohio River At Parkersburg, Wv	--
3201500	Ohio River At Point Pleasant, Wv	--
3206000	Ohio River At Huntington, Wv	--
Little Kanawha River Basin		
3151400	Little Kanawha River Nr Wildcat, Wv	19.8
3151600	Little Kanawha River At Burnsville, Wv	--

Station number	Station name	Recharge (in/yr)
3152000	Little Kanawha River At Glenville, Wv	9.3
3153500	Little Kanawha River At Grantsville, Wv	8.8
3154000	West Fork Little Kanawha River At Rocksdale, Wv	8.7
3155000	Little Kanawha River At Palestine, Wv	--
3155220	South Fork Hughes River Below Macfarlan, Wv	--
Kanawha River Basin		
3177120	East River At Willowton, Wv	--
3177480	Indian Creek At Red Sulphur Springs, Wv	--
3179000	Bluestone River Near Pipestem, Wv	--
3180500	Greenbrier River At Durbin, Wv	21.1
3182500	Greenbrier River At Buckeye, Wv	--
3183500	Greenbrier River At Alderson, Wv	--
3184000	Greenbrier River At Hilldale, Wv	--
3184500	New River At Hinton, Wv	--
3185000	Piney Creek At Raleigh, Wv	11.9
3185400	New River At Thurmond, Wv	--
3186500	Williams River At Dyer, Wv	26.4
3187000	Gauley River At Camden On Gauley, Wv	25.2
3187500	Cranberry River Near Richwood, Wv	31.6
3188900	Laurel Creek Near Fenwick, Wv	--
3189100	Gauley River Near Craigsville, Wv	--
3189600	Gauley River Below Summersville Dam, Wv	--
3190000	Meadow River At Nallen, Wv	--
3190400	Meadow River Near Mt. Lookout, Wv	20.6
3191500	Peters Creek Near Lockwood, Wv	--
3192000	Gauley River Above Belva, Wv	--
3193000	Kanawha River At Kanawha Falls, Wv	--
3194700	Elk River Below Webster Springs, Wv	23.9
3195500	Elk River At Sutton, Wv	--
3196500	Birch River At Herold, Wv	--
3196600	Elk River Near Frametown, Wv	--
3196800	Elk River At Clay, Wv	--
3197000	Elk River At Queen Shoals, Wv	--
3197990	Kanawha R At Charleston, Wv Auxiliary (Upper)	--
3198000	Kanawha River At Charleston, Wv	--
3198350	Clear Fork At Whitesville, Wv	--
3198500	Big Coal River At Ashford, Wv	11.9
3200500	Coal River At Tornado, Wv	--
3201405	Hurricane Creek At Hurricane, Wv	--
380649081083301	New River Below Hawks Nest Dam, Wv	--

Station number	Station name	Recharge (in/yr)
Guyandotte River Basin		
3202400	Guyandotte River Near Baileysville, Wv	14.5
3202750	Clear Fork At Clear Fork, Wv	14.8
3203000	Guyandotte River At Man, Wv	--
3203600	Guyandotte River At Logan, Wv	--
3204000	Guyandotte River At Branchland, Wv	--
Twelvepole Creek Basin		
3206600	East Fork Twelvepole Creek Near Dunlow, Wv	12.4
3207020	Twelvepole Creek Below Wayne, Wv	--
Big Sandy River Basin		
3212750	Tug Fork Downstream Of Elkhorn Creek At Welch, Wv	--
3212980	Dry Fork At Beartown, Wv	--
3213500	Panther Creek Near Panther, Wv	11.1
3213700	Tug Fork At Williamson, Wv	12.5
3214500	Tug Fork At Kermit, Wv	11.2
Lakes And Reservoirs		
1599200	Linton Creek Near Laurel Dale, Wv	--
1605002	Painter Run Near Fort Ashby, Wv	--
1606900	South Mill Creek Near Mozer, Wv	--
1607300	Brushy Fork Near Sugar Grove, Wv	--
1610195	Parker Hollow Run At Needmore, Wv	--
1613020	Unnamed Trib To Warm Spr Run Nr Berkeley Spr, Wv	--
3049930	Elkwater Fork Near Spangler, Wv	--
3055500	Tygart Lake Nr Grafton, Wv	--
3057900	Stonewall Jackson Lake Near Weston, Wv	--
3061430	Whetstone Run Near Mannington, Wv	--
3071590	Cheat Lake Near Stewartstown, Wv	--
3111950	Dunkard Fork Near Majorsville, Wv	--
3151550	Saltlick Creek Near Flatwoods, Wv	--
3155405	North Fork Hughes River Near Cairo, Wv	--
3159750	Tug Fork At Statts Mills, Wv	--
3178150	Middle Fork Brush Creek At Edison, Wv	--
3182050	Marlin Run At Marlinton, Wv	--
3182888	Dry Creek At Tuckahoe, Wv	--
3197910	Unnamed Trib To Elk Twomile Cr Nr Charleston, Wv	--
3204250	Mud River At Palermo, Wv	--
Middle Island Creek Basin		
3114500	Middle Island Creek At Little, Wv	8.0