West Virginia Water Use and Consumption 2015-2019

West Virginia Department of Environmental Protection
Division of Water and Waste Management
Water Use Section

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Introduction

Water is the most important natural resource in West Virginia. It has carved our hills and hollows and quenches the thirst of all living things in the Mountain State. Humans require water for drinking, sanitation, and food production. We also use it for recreation, industry, and energy production. The understanding where our water comes from, how much we have, how we use it, and how much we use is essential if we hope to intelligently protect and manage this critical resource. Our environment, our communities, our economy, and our future depend on the sound management of West Virginia's water resources.

This report aims to better understand how we use water. Water use is a complex subject. "Use" is an umbrella term for any human-made alteration of the natural water system. Use typically involves a withdrawal, which has consumptive and non-consumptive components, depending how much water is returned to the local system. Use also includes diversions without withdrawal, such as hydropower, or even water used "in-stream" such as dedicated flows for navigation, recreation, or maintaining sport fisheries. We can even use water indirectly, such as a warm water discharge that increases the natural water temperature and leads to greater evaporation. The U.S. Geological Survey (USGS) collects comprehensive water use data across the country every five years as part of their Water Use Data and Research (WUDR) Program. This report is one piece in support of that program (Deiter et al. 2018).

Key Terms

This report will focus primarily on water use as it pertains to West Virginia Department of Environmental Protection (WVDEP) authorities under WV Code 22-26, the Water Resources Protection and Management Act. This act directs WVDEP to monitor all Large Quantity Users with an annual water use survey. These Large Quantity User surveys form the foundation of our knowledge of water use in West Virginia.

"Large-quantity user" (LQU) means anyone who withdraws over 300,000 gallons of water in any 30-day period from the state's waters, and anyone who bottles water for resale regardless of quantity withdrawn. LQU excludes farm use, including watering livestock or poultry on a farm, though farms and other exempt users may voluntarily report water withdrawals to assist with the accuracy of the annual LQU survey.

"Withdrawal" means the removal or capture of water from water resources of the state regardless of whether it is consumptive or non-consumptive; provided that water encountered during coal, oil, gas,

water well drilling and initial testing of water wells, or other mineral extraction and diverted, but not used for any purpose is not deemed a withdrawal (e.g. dewatering a mine).

"Consumption" means any withdrawal of water which returns less water to the water body than is withdrawn. Consumption is not directly measured as part of the annual LQU survey, owing to complexities explained in the Methodology section. Consumption includes processes such as manufacturing or agriculture where the water is incorporated as part of the final product and hydraulic fracturing (fracking) where water is injected deep below the water table.

Most often, the largest driver of the consumptive portion of a water withdrawal is evaporation. This can be a hard concept to communicate to stakeholders, because many intuitively feel that the water is just returning to the environment and the water cycle, and is thus non-consumptive. However, we typically lose more than half of the precipitation that falls in West Virginia to evaporation or transpiration (use in plants) (McCoy et al. 2015). Subsequent evaporation from human withdrawals and/or use of surface or groundwater prevents further beneficial use within West Virginia and removes that water from the local ecosystem. By the time those water vapor molecules will condense and fall again as rain, they are likely hundreds if not thousands of miles away from the Mountain State.

Current Water Withdrawal

In 2019, 394 Large Quantity Users reported withdrawing water from 733 individual sites in West Virginia (Table 1). After a multi-year decline in total annual water withdrawal, driven primarily by the long-term shuttering of coal-fired thermoelectric power plants (but no plants closed in 2019), reported water use is up 4% over 2018. This increase is mostly due to a jump thermoelectric water use - with thermoelectricity being by far the largest water use category in West Virginia (excluding hydroelectric) the state's overall water use patterns closely track that industry's ups and downs.

WVDEP Water Use Category	# of LQUs	2019 Total Gallons WD	% of Total WD
Agriculture/Aquaculture	14	11,366,372,753	1.75%
Chemical	13	133,655,672,743	20.55%
Industrial	22	19,958,107,366	3.07%
Mining	72	13,260,094,521	2.04%
Oil & Gas	16	4,548,804,221	0.70%
Petroleum	1	301,407,497	0.05%
Public Water Supply	206	68,377,376,711	10.51%
Recreation	27	1,170,135,868	0.18%
Thermoelectric	9	396,571,231,051	60.98%
Timber	3	1,075,306,386	0.17%
TOTAL	**394**	**650,284,509,117**	**100.00%**
Hydroelectric	11	237,066,964,475,109	

Table 1. Total 2019 water withdrawals (WD) in West Virginia reported to WVDEP Large Quantity User (LQU) database

The vast majority of water used in West Virginia comes from surface resources which include rivers, streams, and lakes. The public water supply is the single largest user of groundwater (which comprise nearly 20% of all public water supply withdrawals). Groundwater use is concentrated in the alluvium along the Ohio River, the state's southern coalfields, and karst aquifer systems of eastern WV.

WVDEP Water Use Category	Surface WD (gallons)	% of SW WD	Groundwater WD (gallons)	% of GW WD
Agriculture/Aquaculture	8,769,467,753	1.42%	2,596,905,000	7.71%
Chemical	124,775,679,099	20.24%	8,879,993,644	26.35%
Industrial	19,241,840,915	3.12%	716,266,451	2.13%
Mining	6,231,168,181	1.01%	7,028,926,340	20.86%
Oil & Gas	4,335,341,088	0.70%	213,463,133	0.63%
Petroleum	522,900	0.00%	300,884,597	0.89%
Public Water Supply	55,160,166,789	8.95%	13,217,209,922	39.22%
Recreation	836,470,279	0.14%	333,665,589	0.99%
Thermoelectric	396,163,369,131	64.25%	407,861,920	1.21%
Timber	1,066,696,474	0.17%	8,609,912	0.03%
TOTAL	**616,580,722,609**	**100.00%**	**33,703,786,508**	**100.00%**
Hydroelectric	237,066,964,475,109		0	

Table 2. Breakdown of 2019 surface water (SW) and groundwater (GW) withdrawals (WD) reported to WVDEP Large Quantity User database.

Monthly water withdrawals are generally highest in the summer and winter. Energy demands during these times of the year increase the need for thermoelectric water withdrawals. These seasons are also peak for public supply water withdrawals, likely owing to burst water supply pipes during severe winters and increased outdoor water use in the summer. The summer peak in total water use often coincides with the lowest surface water levels of the year throughout West Virginia, potentially leading to supply and demand mismatches - particularly in smaller, unregulated watersheds. This seasonal mismatch could become more problematic with the anticipated increase in both the frequency and severity of drought expected from climate change in the Mid-Atlantic region (Fernandez & Zegre 2019).

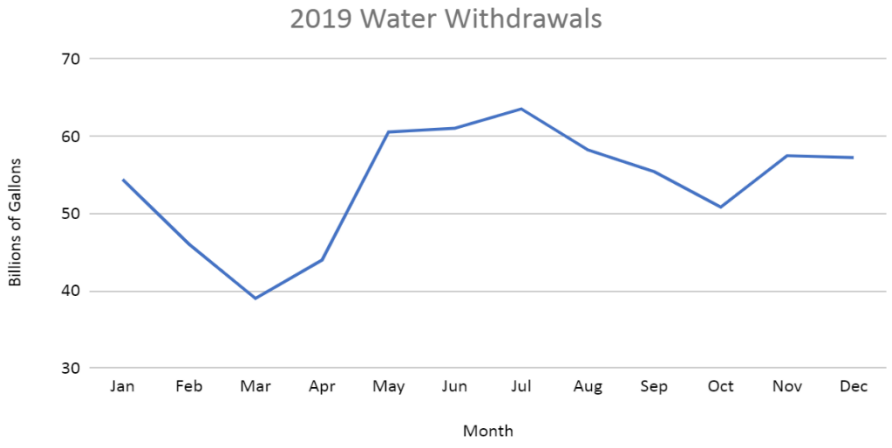

Figure 1. Total monthly withdrawal during 2019 reported to WVDEP Large Quantity User database

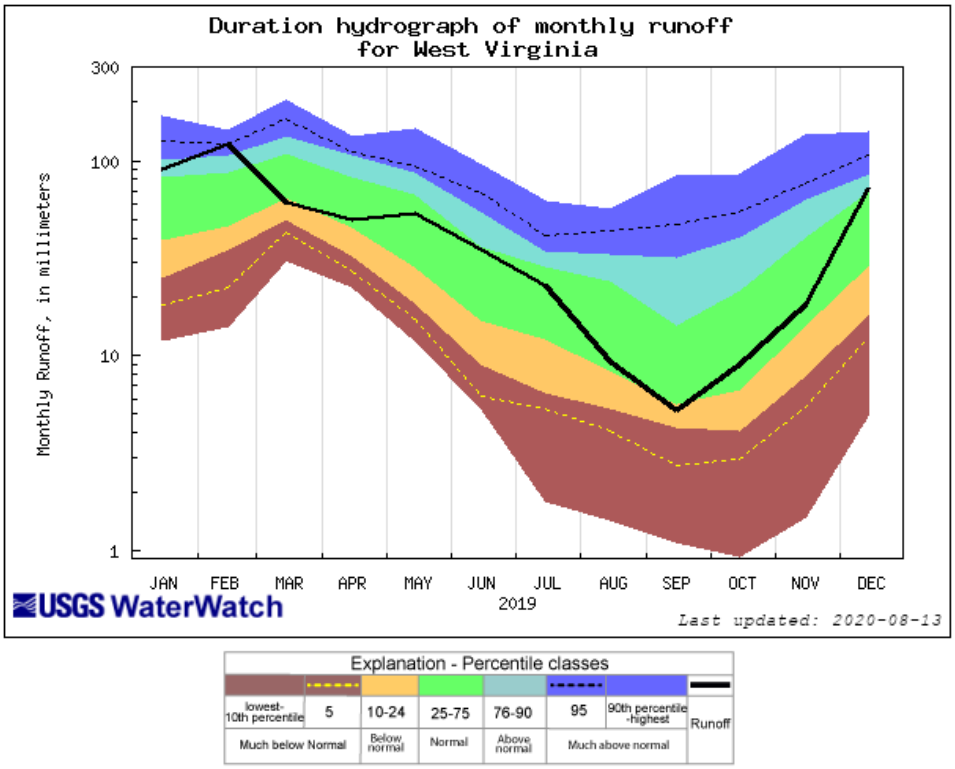

Figure 2. West Virginia's 2019 monthly hydrograph from USGS. Note logarithmic scale

Current Water Consumption

A consumption coefficient is a fraction or decimal value that represents the portion of the water use or withdrawal that does not return to the local system. A coefficient of 0 would indicate that no water is consumed (all water is returned) whereas a coefficient of 1 would indicate that all water is consumed (none returned). Current water consumption coefficients used in WVDEP calculations are derived from a USGS report on consumption coefficients for the Great Lakes and climatically similar areas, with West Virginia being one of the climatically similar states (Shaffer and Runkle 2007).

WVDEP Water Use Category	**2019 Total Gallons WD**	**Current WVDEP Cons. Coeff.**	**Est. Gallons Cons.**	**% of Total Cons.**
Agriculture/Aquaculture	11,366,372,753	0.12	1,363,964,730	2.25%
Chemical	133,655,672,743	0.2	26,731,134,549	44.07%
Industrial	19,958,107,366	0.13	2,594,553,958	4.28%
Mining	13,260,094,521	0.17	2,254,216,069	3.72%
Oil & Gas	4,548,804,221	1	4,548,804,221	7.50%
Petroleum	301,407,497	0.27	81,380,024	0.13%
Public Water Supply	68,377,376,711	0.18	12,307,927,808	20.29%
Recreation	1,170,135,868	0.5	585,067,934	0.96%
Thermoelectric	396,571,231,051	0.025	9,914,280,776	16.35%
Timber	1,075,306,386	0.25	268,826,597	0.44%
TOTAL	**650,284,509,117**		**60,650,156,665**	**9.33%**
Hydroelectric	237,066,964,475,109	0	0	0%

Table 3. Current WVDEP consumption coefficients applied to 2019 water withdrawals reported to WVDEP Large Quantity User database.

However, it is apparent from previous WVDEP reports that the current "standard" consumption coefficients, used since the 2013 publication of the State Water Resources Management Plan, were selected from between the 50th (median) and 75th percentile values from the USGS report. Current staff can find no further rationale or justification for this decision in WVDEP records, other than the suggestion of a middle road between a "low" scenario at the median value and a "high" scenario at the 75th percentile. The primary aim of this report is to update the consumption coefficients used by WVDEP into the future and provide insight into those decisions with locally relevant data, derived from our own water users.

Methodology

Each year between January and March, West Virginia's Large Quantity Users submit water withdrawal surveys to WVDEP for all qualifying water withdrawals during the previous calendar year. WVDEP staff conduct basic quality controls on the surveys, which are then stored in a database. Before any analysis the water withdrawal data is cleaned using a function in R (an open source statistical programming application) that sorts withdrawals and discharges, calculates various subtotals and metrics, assigns watershed or county information based on geo-location, and bins the LQUs by economic sector using SIC and NAICS codes. For this report, a separate R code was written to compare available withdrawal, purchased, and discharged water across economic sectors and time in order to compute consumption coefficients. Using similar methodology as Shaffer 2009, consumption coefficients are defined as ((withdrawal + purchased water) - return flow / (withdrawal + purchased water)). Since LQU reports include monthly water withdrawal, purchases, and discharge data, consumption coefficients were calculated for each LQU facility for each month. These monthly observations were treated individually to increase the number of observations for statistical analysis and to improve insight into the widest range of consumption scenarios. Selected statistics include the minimum, 25th percentile, median, mean, 75th percentile, and maximum values for the monthly consumption coefficients. Mean values reported here represent the mean of the monthly consumption values, not an annual mean calculated separately. The N value represents the number of LQU facilities that are included in this report for each economic sector category.

The LQU program began electronic reporting in 2016 (for water used in 2015). This coincided with updated water use survey questions, improving staff confidence in LQU reports for 2015 to present. Therefore this study only looked at LQUs for which water withdrawal data exists from 2015-2019. Supplemental information not derived from LQU data or Water Use Section research was obtained from the West Virginia Public Service Commission, West Virginia University, the United States Geological Survey (USGS), field audits, and personal conversations with the regulated community.

The USGS categorizes water use in eight economic sectors based on SIC/NAICS codes. WVDEP obtained a NAICS/SIC breakdown table directly from USGS. WVDEP currently assigns an LQU to one of 11 water use categories. These categories do not directly match USGS water use categories, but do provide slightly more detail for WVDEP's purposes. This report will generally follow USGS water use categorical breakdowns.

<u>Limitations of study</u>

There are a number of limitations within the LQU dataset. For one, West Virginia law does not require that water withdrawals are metered. Calculations and estimates are permissible, so long as they are "reasonable." 46% of the LQUs, particularly mining, construction, and recreation companies and small

public water suppliers, use different methods for estimating water withdrawal, the most common of which are pump rate estimates. However, pumps operate on a rating curve, depending on power and hydraulic head, and also wear out over time, meaning that pump rate calculations are not exact. Given the current LQU requirements, summarized values are the best estimates available.

Water consumption is generally calculated as the total of any water withdrawal (plus water purchases) minus the return flow or discharge. However, WV Code 22-26, which mandates water withdrawal reporting, does not establish clear requirements for return flow or discharge monitoring. As a result, discharge monitoring for both quality and quantity falls under the purview of the WVDEP's National Pollution Discharge Elimination System (NPDES). NPDES requirements vary based on the amount and makeup of discharge to state water resources. In general, water samples and accompanying discharge flow measurements are only required monthly or quarterly during a "significant" rain event. This single datapoint is often extrapolated to a larger timeframe, with the potential to greatly over(under)-estimate discharge values. As a result, the discharge information provided by LQUs is not calculated with the same confidence as withdrawals.

Further complicating the matter is that many LQU discharges include any stormwater that falls on the facility footprint. Stormwater is often mixed with withdrawn water in a combined outflow/discharge. The LQU survey does ask if stormwater is included in the discharge, but there is currently no way to apportion the return flow into subordinate components. About half of the LQUs in the study have stormwater as part of their return flow/discharge. Since a stormwater discharge would have the appearance of *lowering* the potential consumption of an LQU facility (adding water to the return/discharge), giving the users the benefit of doubt and a lower consumption coefficient, the combined discharge figures were included in certain calculations for this report and properly annotated.

Because of the variability in discharge information – with or without stormwater – there are months where some LQU facilities appear to have *negative* consumption coefficients, suggesting that more water was discharged than withdrawn. This is possible for a number of factors in data variability as explained above, but is not an accurate representation of how water is actually consumed. In general, negative monthly consumption values were permitted during the statistical analysis. But for final reporting in the subsequent tables of this report any negative consumption coefficients were assigned a value of 0 (zero). However, there were a number of LQU facilities where total *annual* discharges (including stormwater) ultimately surpassed the total *annual* withdrawal. These facilities were omitted from any subsequent calculations. Said another way, ensuring that total *annual* withdrawal was greater than total *annual* discharge was a fundamental requirement for inclusion in this report and the primary reason for LQUs to be excluded.

Any recycled water use is also difficult to accurately capture in the LQU survey. Some operations regularly withdrawal from an impoundment or other source which may also receive a portion of the facility's discharge. Additionally, impoundments also receive input from precipitation or runoff from other state water resources. Therefore each withdrawal contains a mix of recycled water and 'new' water derived from rainfall. The Water Use Section has not attempted to separate these portions in the LQU survey, as it would require extensive, individual research for each affected LQU. They are included here as if each gallon was new water.

The consumptive use study herein is limited to LQU data from 2015 – 2019. The WVDEP LQU database entries prior to 2015 are somewhat unreliable. In the years before 2015, WVDEP data collection

methods changed from paper to online and the LQU threshold was lowered from 750,000 to 300,000 gallons in 30-days. There was also a period of time when LQUs were allowed to certify that their withdrawal didn't vary more than 10% from the year before, instead of providing actual withdrawal amounts. Therefore despite records dating back to 2006, systematic changes in data reporting requirements and data collection methods complicate certain year to year comparisons. Only since reporting year 2016 (for water withdrawn in 2015) has the WVDEP LQU program stabilized enough for relatively consistent analysis.

The LQU data represents our best understanding of water use in West Virginia but by no means is it definitive. WVDEP does not collect any water withdrawal information on users below the LQU threshold; the cumulative impact of such withdrawals is unknown. LQU reports are checked for general accuracy before approval by WVDEP staff, but the entire LQU program is self-reported. As with any self-reported dataset, the opportunity for error or omission exists. Staff flag reports that substantially vary in withdrawal amounts from year to year or that contain obvious discrepancies in location or other administrative information. There is currently limited capacity to verify water withdrawal volumes. WVDEP staff performed 42 water use field visits between 2015 and 2018. However, field visits were typically limited to discussions about the water withdrawal purpose and process, and to ascertain the reliability of self-reported LQU data and confidence in any estimates or calculations. Volumetric analysis or verification of pump rates, etc. were not conducted as a part of field audits.

Results & Discussion

Public Water Supply Consumption

The public water supply category consists of water utilities regulated by the West Virginia Public Service Commission. Systems that only purchase water are not included because state law only requires the entity withdrawing the water to report as an LQU. State law also does not require public water suppliers to report on discharge or any inter-basin transfers as part of their LQU survey. Therefore, WVDEP does not have values for the consumption of public water supply available from the collected data itself. However, we can estimate the consumptive portion of the water withdrawal in an attempt to refine the current consumption coefficient.

It is key to understand that not all water coming from public water suppliers is for residential/domestic use. In some instances, particularly in bigger cities or towns, half of the water withdrawn is for commercial and industrial use. And on average, 20% of water withdrawn is lost to leaks. The water loss is may be *much* higher in small or old public water systems, particularly those in southern West Virginia.

2019 represented the first time that WVDEP modified the annual survey to collect a breakdown of the customer makeup – as a percent of water sold – from each public water supplier. 199 public water suppliers provided useable data. The water suppliers self-reported estimated loss percentage was applied to the total annual withdrawal. The remainder of the water was apportioned according to the self-reported breakdown of each customer component: residential/domestic, industrial, and commercial users.

Applying individual consumption coefficients to each component of the public water supply and its portion of overall use would permit the estimate of a singular consumption coefficient. This of course would vary from system to system as the percentage of leaks and the breakdown of domestic/

commercial/industrial water use vary greatly. However, using statewide totals, 15% consumption is suggested.

Public Water Supply Component	2019 Gallons	Cons. Coeff.	Cons. Coeff. Source	Gallons Cons.
Residential	40,293,393,700	0.13	USGS, Shaffer and Runkle 2007	5,238,141,181
Commercial	9,556,957,397	0.10	USGS, Shaffer and Runkle 2007	955,695,740
Industrial	4,187,563,242	0.10	USGS, Shaffer and Runkle 2007	418,756,324
Leaks	14,064,107,724	0.25	WVDEP estimate	3,516,026,931
Total	**68,102,022,063**			**10,128,620,176**
			Est. Cons. Coeff.	**0.15**

Table 4. Public water supply consumption coefficients derived from 2019 WVDEP LQU data

Commercial Water Consumption

WVDEP understands that from a national program standpoint, USGS stopped collecting commercial water use data. However it is included here as a catch all for water use applications that did not fit other USGS water use categories, predominately including recreational use of water for snow making, lodging, & campgrounds.

Commercial Water Use Consumption Coefficients		
	With Stormwater	**No Stormwater**
Min	0.00	0.00
25th	0.41	0.23
Median	0.90	0.46
75th	0.92	0.83
Max	1.00	0.96
Mean	0.67	0.50
N	9	5
SIC	4226, 4491, 4939, 7011, 7033, 7999	
NAICS	493190, 488310, 221330, 721110, 721211, 713920	
Seasonality	Highest Nov-Feb (snow making) and Jul-Aug (all others)	

Table 5. Commercial water use consumption coefficients derived from WVDEP LQU data 2015-2019

As will be seen elsewhere in this report, the authors were surprised to find that the consumption coefficient *increased* with the inclusion of LQU facilities that reported stormwater as a part of their return flow. The original assumption was that the additional stormwater in the return flow would have the appearance of lowering the overall consumption. But our new hypothesis is that the quantities of stormwater – especially amongst the known variability of discharge information even without the inclusion of stormwater – aren't as substantial as previously thought. Furthermore, by removing those facilities with stormwater flows, likely larger facilities to begin with, we may have inadvertently excluded some of the bigger, more consumptive LQUs.

Golf Irrigation Consumption

USGS breaks out irrigation water for golf as a standalone water use category, whereas WVDEP includes it with other recreational water uses. Unfortunately, of approximately 100 active golf courses in West Virginia, only a few currently report as LQUs. Some courses use public water and are exempt from LQU reporting (they don't withdraw it themselves). Most smaller golf courses (9 hole) and larger courses that irrigate only their greens were generally found to be below the LQU reporting threshold. Nonetheless, the Water Use Section believes that many golf courses may be missing from the current database.

Recent initiatives to improve golf course reporting rates were complicated by COVID-19, limiting state employee travel.

Golf Irrigation Water Use Consumption Coefficients		
	With Stormwater	**No Stormwater**
Min	0.00	0.85
25th	0.75	0.98
Median	0.99	0.99
75th	1.00	1.00
Max	1.00	1.00
Mean	0.59	0.98
N	3	2
SIC	4971, 7992, 7997	
NAICS	221310, 713910	
Seasonality	Highest May - Sep. Often no water use in winter/off season	

Table 6. Golf course irrigation water use consumption coefficients derived from WVDEP LQU data 2015-2019

Industrial Water Consumption

The USGS industrial water use category is the most diverse, with over 20 different individual classifications. Included within this category are chemical companies, metalworks, wood and timber products, and other heavy and light manufacturing. WVDEP has traditionally subdivided the industrial category, especially after finding that the chemical industry withdrawals the vast majority of water in this economic sector.

Industrial Water Use Consumption Coefficients		
	With Stormwater	**No Stormwater**
Min	0.00	0.00
25th	0.09	0.09
Median	0.21	0.23
75th	0.46	0.61
Max	1.00	1.00
Mean	0.31	0.36
N	28	19
SIC	2086, 2491, 2611, 2631, 2812, 2813, 2821, 2865, 2869, 2911, 3069, 3241, 3312, 3313, 3355, 3356, 3472, 3531, 3764	
NAICS	237990, 312112, 321114, 322130, 324110, 324199, 325110, 325119, 325120, 325181, 325188, 325192, 325194, 325199, 325211, 327310, 331111, 331112, 331315, 331491, 332812, 336413, 336415	
Seasonality	Fairly consistent. Slightly highest in July	

Table 7. Industrial water use consumption coefficients derived from WVDEP LQU data 2015-2019

Mining

Due to the disparity that exists within the data and category definitions between USGS and WVDEP, this category is broken down into two parts: Oil & Gas (fracking) and all other Mining. In West Virginia, Oil & Gas (fracking) is the only water use category subject to a cradle-to-grave Water Management Plan reporting system detailed under a separate legal authority, in addition to the LQU program. Water Management Plans often impose withdrawal limits to during the driest periods of the year, resulting in operators storing large quantities of water for use at another time. The difference between monthly withdrawal and discharge would skew calculations as made elsewhere in this report, making these figures incompatible with the rest of the mining dataset.

Water used for fracking is considered 100% consumptive in previous WVDEP reports. The water is injected thousands of feet below the water table and so long as there are no accidents or cracked casings, will never meaningfully interact with the hydrological cycle on a human timescale again. The fracturing process does produce "flowback" water, either a portion of the fracking fluid or water trapped in the fracked geological formation. This flowback water is laden with salts. It is often blended with freshwater for use in another fracking operation or reinjected into deep disposal wells. Occasionally it can be recycled by removing the salt content. However, West Virginia's only frack water recovery facility was idled in 2019.

Oil & Gas (Fracking) Water Use Consumption Coefficients		
	With Stormwater	**No Stormwater**
Min	1.00	1.00
25th	1.00	1.00
Median	1.00	1.00
75th	1.00	1.00
Max	1.00	1.00
Mean	1.00	1.00
N	15	15
SIC	1311, 1381	
NAICS	211120, 213111	
Seasonality	WV regulations generally limit withdrawal to winter & spring	

Table 8. Oil and gas fracking water use consumption coefficients derived from WVDEP LQU data 2015-2019

All other mining activities are represented by the "Mining" category as used in this report, to include coal mining, coal processing, quarrying, and other oil and gas activities (pipeline and well pad construction). Besides washing and processing coal, most of the remainder of the water used in mining applications is for dust suppression, both at the mine face and along haul roads.

Mining Water Use Consumption Coefficients		
	With Stormwater	**No Stormwater**
Min	0.00	0.00
25th	0.17	0.03
Median	0.67	0.66
75th	0.93	0.83
Max	1.00	1.00
Mean	0.55	0.51
N	47	15
SIC	1200, 1211, 1220, 1221, 1222, 1241, 1300, 1422,1446	
NAICS	211112, 211130, 212111, 212112, 212312, 212322, 213113, 488310	
Seasonality	Highest Jun - Sep. Lowest Feb - Mar	

Table 9. Mining water use consumption coefficients derived from WVDEP LQU data 2015-2019

<u>Energy</u>

By far, the largest water use in West Virginia - over 60% of all water withdrawn - is for thermoelectric power generation. Of the 9 thermoelectric facilities that report as LQUs, the majority are recirculating systems with large cooling towers. Water is withdrawn for 'make up' water to replace that lost to evaporation. Compared to once-through systems, recirculating systems typically withdraw less water but often have a higher consumption coefficient (Diehl et al. 2013). WV has only one once-through thermoelectric LQU facility, but it is the biggest power plant in the state. Mt. Storm uses a large, manmade lake for its cooling water. The annual withdrawal volume is enormous, but the water is

recirculated through the lake multiple times. However the data from Mt. Storm shows that there still is substantial consumption from evaporation – both in the turbines and from the artificially warmer temperatures after the cooling water is discharged.

Thermoelectric Water Use Consumption Coefficients		
	With Stormwater	**No Stormwater**
Min	0.00	0.00
25th	0.35	0.00
Median	0.60	0.61
75th	0.65	0.63
Max	0.98	0.69
Mean	0.51	0.40
N	9	3
SIC	4911	
NAICS	221112	
Seasonality	Highest Jun - Sep & Nov - Mar. Likely tied to degree days	

Table 10. Thermoelectric water use consumption coefficients derived from WVDEP LQU data 2015-2019

While data on hydroelectric facilities is collected during the annual LQU survey, hydropower has been generally excluded from WVDEP water use calculations. Most hydropower in WV is located in river basins with drainage areas that extend beyond West Virginia, complicating calculations pertaining to in-state water use and water availability. Furthermore, a single drop of water could travel through multiple hydropower facilities, as they are often located consecutively downstream of each other: the Ohio River system has four and the Kanawha River system has five. WVDEP is working on determining a better way to control for these effects in hydropower LQU numbers. However, hydropower is generally considered to be a non-consumptive use of water; therefore, WVDEP assigns a consumption coefficient of zero.

<u>Farming</u>

West Virginia state law (WV 22-26) exempts farm use from the definition of Large Quantity Users. Therefore comprehensive water use figures for aquaculture, agriculture, livestock, and poultry are not available from WVDEP to the USGS or other interested parties. However, a few entities report on a voluntary basis to assist with the annual water report, currently assembled into the "Agriculture/ Aquaculture" WVDEP water use category. As such, the following values for farm use are *estimates only*.

The only voluntary farm use category with more than one LQU report is aquaculture, with water use data received predominately from government run hatcheries. Aquaculture typically has a low consumption coefficient. While most facilities report "0" consumption, they often only measure their discharge for WVDEP NPDES permitting purposes. Evaporation from the raceways and ponds, and deliveries from stocking trucks suggest that there is at least some consumption with aquaculture. Therefore the mean value of 3% consumption is likely the best representation in this case.

Aquaculture Water Use Consumption Coefficients		
	With Stormwater	**No Stormwater**
Min	0.00	0.00
25th	0.00	0.00
Median	0.00	0.00
75th	0.00	0.00
Max	0.58	0.58
Mean	0.03	0.03
N	10	10
SIC	0273, 0921	
NAICS	112511	
Seasonality	Slightly highest Jun - Oct	

Table 11. Aquaculture water use consumption coefficients derived from WVDEP LQU data 2015-2019

Except for aquaculture, water consumption for other farm use is likely quite high. Most of the water is either used by crops or livestock in metabolic processes or it evaporates back to the atmosphere. Previous USGS estimates for agriculture and livestock consumption coefficients are 0.91 and 0.90 respectively (Shaffer and Runkle 2007). However, West Virginia's total water use for agriculture use is likely fairly low, especially relative to agriculture in other states. According to the 2018 USDA Irrigation and Water Management Survey, West Virginia has only 1,660 irrigated acres, the least amount of irrigated acreage in any state. West Virginia also applies the least amount of water to those irrigated acres, at 0.3 acre-feet per year. This makes for a total annual estimated water use of 498 acre-feet, or 162,300,000 gallons for West Virginia agriculture. Of that approximately 91%, or 147,693,000 gallons, is consumed.

Water used for livestock is more likely more substantial. A reasonable estimate can be obtained by combining data available from the WV Department of Agriculture/USDA National Agriculture Statistics Service Annual Bulletin and previous USGS estimates for median water consumption for livestock (Lovelace 2009). Combining these figures in the table below, statewide, livestock is estimated to use over 2.3 billion gallons of water. Again, using previously established USGS consumption coefficients, approximately 90% or 2,081,632,230 gallons of this is consumptive use.

Animal	Number of Head	Est. water per head per day (gal)	Total Annual Water Use (gal)
Beef Cattle	388,000	12	1,699,440,000
Dairy Cows	7,000	35	89,425,000
Swine	5,000	3.5	6,387,500
Sheep	35,000	2	25,550,000
Goats	21,500	2	15,695,000
Broiler Chickens*	14,350,000	0.06	314,265,000
Laying hens	1,238,000	0.06	27,112,200
Turkeys	3,700,000	0.1	135,050,000
TOTAL			**2,312,924,700**

Table 12. Statewide livestock water use estimate derived from WV Dept. Of Agriculture, USDA and USGS data
*Converted to annual figure, assuming 60 day broiler lifespan

Despite being the least consumptive of all farm use activities, the current WVDEP farm use LQU category is dominated by aquaculture reports. Therefore, until more farm use gets voluntarily reported to the LQU database (or the reporting requirements are amended) – despite the large difference in water use

volumes and consumption coefficients – WVDEP should adopt the aquaculture consumption coefficient of 0.03 for the category.

Recommendations

1. Close water use data reporting gaps

There are data collection gaps and challenges that the Water Use Section is aware of and working to improve upon in the future. As mentioned previously, the Water Use Section believes that many golf courses may be missing from the current LQU database. Tracking LQU data from mining and oil and gas companies is also troublesome. Companies frequently change ownership, change names, or idle production. Some operators may go years between meeting LQU requirements. Keeping up and keeping straight with all the changes can be difficult.

The biggest improvement in data collection would be a legal requirement for all withdrawals and water use to be metered. Adding a requirement for accurate and real time metering of discharges would allow WVDEP to calculate actual water use and consumption with far more accuracy than is currently available. Of course this would come at additional expense to water users but more concrete numbers for the amount of water withdrawn and consumed from our state waters would better support environmental protection and resource management.

An attempt to cross-check WVDEP's public water supply withdrawal data against records from the WV Public Service Commission proved quite difficult. PSC records are only available in individual PDFs for each water supplier; we were unable to find a comprehensive table of water data. Additionally, many fields relevant to water use data purposes are optional or left blank in the annual PSC reports. This undoubtedly stems from the different missions and purposes of WVDEP and WVPSC, but it also speaks to the overlapping, and at times confusing, jurisdictions and responsibilities for water resources management.

2. Propose new WVDEP water use consumption coefficients

As stated in the Introduction, WVDEP currently uses consumption coefficients obtained between the median and 75th percentile values within a USGS report on consumption coefficients for the Great Lakes and climatically similar areas (Shaffer and Runkle 2007). Based on this report's analysis of actual water use data in West Virginia, the Water Use Section proposes new consumption coefficients for future reports and updated water resources planning, as shown in the table below. These new consumption coefficients were obtained from the median monthly value of each economic sector (with the exception of aquaculture which uses the mean), including those LQU facilities with a stormwater discharge.

WVDEP Water Use Category	Current Cons. Coeff.	Proposed Cons. Coeff.
Agriculture/Aquaculture	0.12	0.03
Chemical	0.20	0.12
Hydroelectric	0.00	0.00
Industrial	0.13	0.59
Mining	0.17	0.48
Petroleum	0.27	0.16
Public Water Supply	0.18	0.15
Oil & Gas	1.00	1.00
Recreation	0.50	0.41
Thermoelectric	0.03	0.61
Timber	0.25	0.39

Table 13. Proposed revision to WVDEP water use consumption coefficients based on LQU data 2015-2019

When comparing the current and proposed consumption coefficients, it appears that most water use categories were previously under estimated, suggesting that more water is being consumed (and removed from the local ecosystem) than previously thought. Most concerning is the massive underestimation of water lost using thermoelectric consumption coefficients, since it is also the biggest user of water in the state. The current value is more appropriate for once-through thermoelectric systems, of which few exist in West Virginia.

WVDEP Water Use Category	CURRENT 2019 Est. Gal. Cons.	CURRENT % of Total Cons.	REVISED 2019 Est. Gal. Cons.	REVISED % of Total Cons.
Agriculture/Aquaculture	1,363,964,730	2.25%	340,991,183	0.12%
Chemical	26,731,134,549	44.07%	16,038,680,729	5.49%
Industrial	2,594,553,958	4.28%	11,775,283,346	4.03%
Mining	2,254,216,069	3.72%	6,364,845,370	2.18%
Oil & Gas	4,548,804,221	7.50%	4,548,804,221	1.56%
Petroleum	81,380,024	0.13%	48,225,200	0.02%
Public Water Supply	12,307,927,808	20.29%	10,256,606,507	3.51%
Recreation	585,067,934	0.96%	479,755,706	0.16%
Thermoelectric	9,914,280,776	16.35%	241,908,450,941	82.79%
Timber	268,826,597	0.44%	419,369,491	0.14%
TOTAL	**60,650,156,665**	**9.33%**	**292,181,012,692**	**44.93%**
Hydroelectric	0	0%	0	0%

Table 14. Comparison of estimated water consumption volumes using current and revised consumption coefficients from Table 13 as applied to reported 2019 LQU withdrawal volumes in Table 1.

Whereas the previous consumption calculations assumed that the chemical industry was the largest consumer of water, those figures were based on a very low consumption coefficient for thermoelectricity which is no longer supported by real world data in West Virginia. Therefore thermoelectricity is now both the largest user and consumer of water in the state, at a scale that dwarfs the state's other water use categories. Just as the Water Use Section has traditionally omitted hydroelectric water use from overall trends and calculations in water use reports, owing to the magnitude of hydroelectric withdrawals, future reports may want to consider keeping thermoelectric separate as well (or in an "Energy" category lumped with hydroelectric). If not, any statewide water use analysis will likely only mirror water use trends in the energy sector, obscuring or minimizing increased use or conservation in other important water use categories.

Applying the new consumption coefficients to current water use data suggests that overall water consumption has been greatly underestimated in West Virginia. While the state traditionally enjoys abundant water resources, these new figures should give water planners and water managers pause. We have been unknowingly taxing our water systems to a far greater extent than previously understood. If predictions for increased frequency and severity of seasonal drought with climate change prove correct (Fernandez and Zegre 2019), then it is likely that West Virginia can expect even greater stress to our state's water resources in the future. As seen during the Governor's Emergency Drought Declaration of September 2019, most water conservation efforts focus on the domestic consumer. However, the data in this reports shows that industrial and commercial activity account for 96% of all water consumed in West Virginia. Not only does this suggest that the burden of water conservation should fall equally on all water users, but that the health and security of West Virginia's economy – and environment – relies upon the sound planning and management of our state's water resources.

3. Propose new WVDEP water use categories and organization

The current organization and categorization of WVDEP water use data should be revised. Existing categories do not align particularly well with USGS categories, complicating apples to apples comparisons. The Petroleum category only contains one LQU. The Oil and Gas category is plagued with compatibility issues pertaining to the two different datasets that feed it – water for fracking and water for all other oil and gas industry needs. The Recreation category contains two large water users – golf courses and snow making – that use water at opposite times of the year. And the Aquaculture/Agriculture category, while containing all of the "voluntary" LQU reports, represents two water uses with enormous differences in consumption. By breaking up West Virginia water use data into new categories, WVDEP could better align with the USGS Water Use Data Research Program, provide better data and resolution to citizens and stakeholders, and apply more accurate consumption coefficients to each economic sector. The proposed revision to the WVDEP Water Use Categorical System is included in the table below. Coding each water use type would allow for easy data retrieval and relationships: for example the total for the oil and gas industry would be category 43 + 44. Categories would be defined by the appropriate SIC and NAICS industrial classification codes. The public water supply breakdown would be reported by the water providers and/or obtained from PSC reports.

10	**Public Water Supply**	**30**	**Industrial Manufacturing**	**50**	**Energy Production**
11	Residential	31	Chemicals	51	Thermoelectric (OT)
12	Commercial	32	Metalworks	52	Thermoelectric (RC)
13	Industrial	33	Wood Products	53	Hydroelectric
14	Resale	34	Other	54	Other
15	Leaks	**40**	**Mineral Extraction**	**60**	**Farm Use**
16	Other	41	Coal Mining	61	Agriculture
20	**Commercial Activity**	42	Other Coal Operations	62	Aquaculture
21	Golf Course Irrigation	43	Oil & Gas Fracking	63	Livestock
22	Snow Making	44	Other Oil & Gas Operations	64	Other
23	Lodging/Resort	45	Quarries		
24	Institutions	46	Other		
25	Bottled Water				
26	Other				

Table 15. Proposed revision to WVDEP water use categories

4. WVDEP should provide both reported and estimated water use data

Since the State Water Resources Management Plan was published in 2013, WVDEP has traditionally only reported on actual LQU numbers received during the annual survey to the state Legislature and other interested parties. However, as previously acknowledged, the LQU water withdrawal dataset is by no means definitive. The LQU survey does not apply to water users below the LQU reporting threshold. Additionally, the LQU survey is voluntary for important water use sectors like agriculture and livestock production. WVDEP should continue to use other sources of information, including WV Dept. Of Agriculture, other state agencies, USGS, and research universities to provide reasonable estimates for the water use that fall outside its direct purview. Water used for livestock is both substantial in quantity and also highly consumptive; modern feedlots and chicken houses are little different from a water use perspective than other large industrial facilities. Private wells, small farms, and other water uses below the LQU threshold may have a small but cumulative impact on state water resources, particularly on local groundwater or in small headwaters watersheds. Future water use reports should contain water use data from the annual LQU survey, plus any additional estimates determined by WVDEP, properly annotated of course. Combining all available water use information will allow for the greatest understanding of our water system and the best possible management of state water resources.

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