2021 Annual Water Resources Report

Joint Legislative Oversight Commission on State Water Resources
November 2021

Prepared by the

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

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Water Resources Protection and Management Overview

The Water Resources Protection and Management Act, W.Va. Code §22-26 (Act) was passed into law in 2004. The Act recognized the need to protect and conserve the water resources of the state and directed the West Virginia Department of Environmental Protection (WVDEP) to develop a State Water Resources Management Plan (Plan). The WVDEP formed the Water Use Section (WUS) in 2008 to initiate a comprehensive review of the state's waters resources. The Plan was published in 2013 and adopted by the Legislature in 2014. The WUS has continued to implement the provisions and recommendations within the Act and Plan with several ongoing programs, projects, and studies in support of WVDEP's responsibility for the state's waters. This annual report is submitted to the Joint Legislative Oversight Commission on State Water Resources in accordance with the requirements of W.Va. Code §22-26-8(e).

2020 – 2021 Water Resources Availability

Going back to the late 19th century, average annual rainfall in West Virginia has been between 44 and 46 inches. After a normal range of precipitation in 2019, annual precipitation was just slightly above West Virginia's average range at 54 inches during 2020 (Figure 1). Precipitation was greatest in the high mountains west of the continental divide and lowest in the rain shadow from those same mountains, occurring in the Eastern Panhandle (Figure 2) as typical for this area (Figure 3). Precipitation thru December 2020 has been above average, and higher than that of 2019 (Figure 4). Groundwater recharge is typically between 15-18% of annual precipitation. As a result of extreme 2018 precipitation, groundwater levels throughout much of the state were also at record levels by the latter part of that year. Groundwater levels in 2019 slowly returned to average range but have remained below average throughout 2020 (Figures 5a-b).

Although late September through the majority of October 2019 there was a period of severe drought (D2) in West Virginia, 2020 conditions were more average (Figures 6a-c). West Virginia experienced abnormally dry (D0) conditions June through the end of December 2020. Late July through the end of August and October through mid-November were moderate drought conditions (D1).

Large Quantity User Water Withdrawals

Any person that withdraws more than 300,000 gallons in 30 days from state's waters – except for farm use – and any person that bottles water for resale regardless of quantity withdrawn is considered a Large Quantity User (LQU) per the Act. These LQUs use the WVDEP Electronic Submission System (ESS) to report their withdrawals annually to the WUS. The LQU surveys are collected between January 1 and March 31 of the year following water withdrawal; we will receive 2021 reports beginning January 1, 2022. The WUS has been collecting LQU information since 2006 and monitoring trends in water use. We share water withdrawal data with research partners including state universities and the U.S. Geological Survey (USGS).

The LQU data represents our best insight into water use throughout West Virginia but is by no means definitive. The WUS does not collect any water withdrawal information on users below the LQU threshold; the cumulative impact of such withdrawals is unknown. For existing LQUs, as with any user-input dataset, the opportunity for error or omission exists. The WUS conducts limited audits and field visits to verify reported information and register new LQUs.

Annual Data & Trends

In 2020, 288 LQUs reported withdrawing almost 600 billion gallons of water (Table 1). An additional 11 hydroelectric facilities reported more than 238 trillion gallons withdrawn. Total withdraws from West Virginia water resources continues to decline (-8.17% total change from 2019), driven primarily by the decrease (-8.34%) in water used by thermoelectric operations, the largest water use sector overall – excluding hydroelectric. The chemical and public water supply users round out the top 3 in total quantity at over 111 billion and 57 billion gallons in 2020, respectively. The largest water use category change in 2020 was industrial at an increase of 101.07% although this sector is only 6.72% of the total withdraw with 17 users defined as general manufacturing other than chemical. The largest water use category decrease was oil & gas at -35.73% although this use is very small at only 0.49% of the total with 16 users. The number of LQUs dropped 25% from 2019. The 2021 data will be further reviewed with more outreach and enforcement of the LQU reporting requirement to determine if there is an actual decrease in use or compliance concerns.

Table 1. Total 2020 water withdrawals (WD) from the LQU database (WVDEP).

WVDEP Water Use Category	LQUs	Total 2020 WD (Gallons)	Category %	% Change from 2019
Agriculture/aquaculture	11	9,568,490,855	1.60%	-15.82%
Chemical	12	111,383,530,431	18.65%	-16.66%
Industrial	17	40,129,250,348	6.72%	101.07%
Mining	60	9,896,635,282	1.66%	-25.37%
Oil & gas	16	2,923,297,711	0.49%	-35.73%
Petroleum	1	296,017,675	0.05%	-1.79%
Public water supply	142	57,304,394,679	9.60%	-16.19%
Recreation	18	1,209,768,769	0.20%	3.39%
Thermoelectric (coal)	8	363,483,322,266	60.87%	-8.34%
Timber	3	957,057,719	0.16%	-11.00%
TOTAL	**288**	**597,151,765,735**	**100.00%**	**-8.17%**
Hydroelectric	11	238,238,328,699,050		

Most LQUs withdraw from the surface (96%) with only 4% using groundwater (Table 2). Thermoelectric (coal) used the most surface water with over 363 billion gallons in 2020. Public water supply still used the most groundwater with over 10 billion gallons followed by chemical users with over 8 billion gallons in 2020. Groundwater use is concentrated in the alluvium along the Ohio River, southern coalfields, and karst aquifer systems of eastern WV (Figure 11). Both surface water and groundwater total withdrawals have decreased slightly from last year.

Table 2. Breakdown of Surface Water (SW) and Groundwater (GW) withdrawals from the 2020 LQU database (WVDEP).

WVDEP Water Use Category	Surface WD (Gallons)	Category % of SW	Groundwater WD (Gallons)	Category % of GW
Agriculture/aquaculture	9,314,772,855	1.63%	253,718,000	1.02%
Chemical	103,209,506,559	18.04%	8,174,023,872	32.79%
Industrial	39,530,383,024	6.91%	598,867,324	2.40%
Mining	5,151,533,696	0.90%	4,745,101,586	19.04%
Oil & gas	2,883,783,564	0.50%	39,514,147	0.16%
Petroleum	105,882	0.00%	295,911,793	1.19%
Public water supply	47,163,330,957	8.24%	10,141,063,722	40.68%
Recreation	892,155,849	0.16%	317,612,920	1.27%
Thermoelectric (coal)	363,134,903,686	63.46%	348,418,580	1.40%
Timber	943,676,820	0.16%	13,380,899	0.05%
SUB TOTAL	572,224,152,892	100.00%	24,927,612,843	100.00%
Breakdown % of Total WD	**572,224,152,892**	**95.83%**	**24,927,612,843**	**4.17%**
Hydroelectric	238,238,297,811,050		30,888,000	

Discussions with local water operators over the last few years have led to the observation that above-average spikes in water use correlate with unseasonably cold winters. The prevailing theory is that this is a result of water loss from burst pipes and leaks during unusually cold months. While January 2018 was abnormally cold, January 2019 through present was a more typical for West Virginia (Figure 7). Reported public water supply withdrawal was up nearly half a billion gallons in 2019 from 2018, but 2020 saw almost a 10 billion gallon decrease with warmer temperatures. The WUS will continue to research variations in public water supply use from year to year. It could very well be from water loss but may not be related to burst pipes in cold winter months.

Seasonal Trends

Total 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 pipes in winter and increased outdoor water use in the summer. The recreation water use sector also has a substantial increase in wintertime water use, driven by snowmaking at ski resorts. However, of approximately 100 golf courses in West Virginia, very few currently report as LQUs. Therefore, the WUS believes that many golf courses may be missing from the current database and will work toward improving reporting rates in 2022. This will likely shift the bulk of recreation water use to the summer months for irrigation.

Much of the water use categories have peak withdrawals in late summer and early fall (Figure 8). This season typically coincides with the lowest water levels of the year throughout West Virginia (Figure 9). This seasonal flux in demand for water – and a mismatch with potential supply – highlights a need for further analysis. Previous work by the WUS has shown that on an annual level the state enjoys abundant water resources. However, we now believe that water stress may be possible on smaller spatial or temporal scales. We are pursuing additional research in this area.

Oil and Gas Water Management Plans

The WUS of the WVDEP is responsible for the processing, analysis, and approval of operator-submitted water management plans. Pursuant to the Natural Gas Horizontal Well Control Act, W. Va. Code §22-6A-7 and the Rules Governing Horizontal Well Development, W.Va. C.S.R. §35-8, natural gas operators developing horizontal wells that use water more than 210,000 gallons during any 30-day period, shall submit a Water Management Plan (WMP) application as part of the well work permit application. All applicants must identify all potential water sources prior to any use. The WUS evaluates each proposed water source (surface water, groundwater, purchased water, or recycled frac water) for suitability based on a variety of considerations. The use of recycled frac water is always encouraged.

All water needs to be acquired from approved sources, during approved conditions. The WUS considers, to the extent possible, estimates of flows necessary to protect aquatic life, the location of existing withdrawals and the anticipated future demand for water in the area including a margin of safety. The WUS strongly encourages that operators plan (to the greatest extent possible) in such a manner to allow withdrawals from streams in periods of traditionally higher stream flows (typically November through June). The WUS's approval of a withdrawal location conveys no property or riparian rights. It always remains the operator's responsibility to ensure protection of aquatic life. The approved WMP is part of the permit issued and the terms for withdrawal established therein are enforceable as such.

For Fiscal Year 2021, the WUS received and reviewed all individual WMPs associated with horizontal well work permits, including new pad-level plans and existing WMP modifications, all relating to the planned withdrawal of surface and groundwater used in horizontal well drilling operations. The actual volume of water used in these operations is captured by the LQU program.

Water Resources Research

To carry out mandates of the Act, the WUS has routinely collaborated on research initiatives with various state, federal, and nonprofit partners. These projects support the data and informational needs of the WUS to understand, protect, and conserve state water resources. Previous projects have included stream gauge statistical analysis, water budgets, and water infrastructure. The WUS is currently funding and managing four projects:

Water Use and Consumption

In 2017 the WUS received a grant from the USGS to provide information in support of their Water Use Data Research (WUDR) program. The WUDR program provides a comprehensive overview of water use across the nation, aggregated by county, every five years. In addition to supplying WUDR staff with annual LQU water withdrawal data, the WUS has conducted field audits across all water use categories. The on-site audits determine the consumptive portion of their water withdrawal, e.g. the portion that does return to the local waterbody (Table 3) as a consumption coefficient in decimal value. Since consumption is not directly measured, it is calculated by multiplying the consumption coefficient which ranges from zero for no water consumed (all returned) to one for all water consumed (none returned) with the total reported amount of water withdrawn.

Table 3. Current consumption coefficients applied to 2019 withdrawal data (WVDEP).

WVDEP Water Use Category	2020 Total Gallons Withdrawal	Consumptive Coefficient	2020 Calculated Gallons Consumed	Category % of Consumed
Agriculture/aquaculture	9,568,490,855	0.03	287,054,726	0.10%
Chemical	111,383,530,431	0.12	13,366,023,652	4.84%
Industrial	40,129,250,348	0.59	23,676,257,705	8.57%
Mining	9,896,635,282	0.48	4,750,384,935	1.72%
Oil & Gas	2,923,297,711	1	2,923,297,711	1.06%
Petroleum	296,017,675	0.16	47,362,828	0.02%
Public water supply	57,304,394,679	0.15	8,595,659,202	3.11%
Recreation	1,209,768,769	0.41	496,005,195	0.18%
Thermoelectric (coal)	363,483,322,266	0.61	221,724,826,582	80.27%
Timber	957,057,719	0.39	373,252,510	0.14%
Total	**597,151,765,735**		**276,240,125,047**	**100.00%**
Hydroelectric	238,238,328,699,050			

The 2019 estimates for water consumption were approximately 9% of the total statewide water withdrawal broadly based on Great Lakes reported values and climatically similar areas. However, the September 2020 USGS WUDR report compiled West Virginia data from 2015-2019 and estimated a new consumption coefficient of 46.26%. While the total water withdrawal may be slightly decreasing in WV, the now estimated consumptive portion of the remaining withdrawal is much higher based on the local data and recent study (Figure 10). This rise in consumption may have implications for water resources management beyond the apparent "savings" from the total withdrawal. Aside from oil & gas which still has 100% water consumption, the next highest consumption coefficient is now thermoelectric (coal) at 61% which also had the biggest increase in the recent consumption coefficient estimate compared to the previously utilized value of 2.5%. Although the water use categories of agriculture, chemical, petroleum, public water supply and recreation all had a slight decrease in the recent consumption coefficient estimates, the increases among the other four categories were much greater (Table 4).

Table 4. 2019 versus 2020 consumption coefficients (WVDEP).

WVDEP Water Use Category	Prior Consumption Coefficients (2019)	Current Consumption Coefficients (2020)	Change
Agriculture/aquaculture	0.12	0.03	-0.09
Chemical	0.2	0.12	-0.08
Industrial	0.13	0.59	0.46
Mining	0.17	0.48	0.31
Oil & Gas	1	1	0
Petroleum	0.27	0.16	-0.11
Public water supply	0.18	0.15	-0.03
Recreation	0.5	0.41	-0.09
Thermoelectric (coal)	0.025	0.61	0.59
Timber	0.25	0.39	0.14
Total	**2.845**	**3.94**	**1.095**

Geophysical Groundwater Well Logging

The WUS and the USGS have continued a collaborative five-year project to assess geophysical and hydrologic properties of groundwater wells throughout West Virginia. The data from this project will be used to characterize the aquifers within the state through a better understanding of the bedding planes, joints, faults, and other fractures through which most of our groundwater flows or is stored. This research will increase knowledge of the depth and location of these water bearing features throughout the state. Fieldwork for the project was completed September 2019 with over 120 well logs containing geological and hydrological data (Figure 11). The WUS and USGS will collaborate on the final report and data models, expected in spring 2022.

Abandoned Underground Coal Mine Aquifers

The WUS has been involved in many projects to determine the location, quantity, quality, and sustainability of water within Abandoned Underground Coal Mine Aquifers, also known as mine pools. Several municipalities and PSDs in southern West Virginia obtain their water supply from groundwater in mine pools and there has been additional interest in putting these accessible water resources to beneficial use. In 2012, WVDEP collaborated with the W.V. Geological and Economic Survey (WVGES) to map the extent of potential mine pools (Figure 12). Since then, we have worked with the USGS to obtain data from more than 770 water samples from 294 mines. A final report summarizing mine pool water quality and hydrogeology was provided in 2020. Future research could focus on the sustainable yield from this water resource and monitoring inter-basin flow resulting from mine pools that transcend surface watershed boundaries.

Water Stress and Critical Planning Areas

The Act directs WVDEP to “establish criteria for designation of critical water planning areas comprising any significant hydrologic unit where existing or future demands exceed or threaten to exceed the safe yield of available water resources." The WUS and West Virginia University are working together to improve our understanding of water stress throughout the state and, if needed, support the designation of critical planning areas. The two-year study, initiated in fall 2019, will provide improved spatial and temporal resolution of current and potential water use along with an understanding at what point water withdrawals have consequences for in-stream biology and ecosystem services that include dilution, filtration, and drinking water. The estimated completion date is December 2022 based on the spring 2020 semester start.

Online Water Resources Information

In cooperation with WVDEP's TAGIS group, the WUS maintains a suite of internet-based tools that display water resources management data in online Geographic Information Systems (GIS).

Water Resources Management Mapping Tool

The Water Resources Management Mapping Tool acts as a clearinghouse for all manner of data relevant to water management, including LQU withdrawals, watershed delineations, karst, monitoring wells, springs, mine pools, National Pollutant Discharge Elimination System (NPDES) permits, geology, and more (Figure 13). The tool is available at: http://tagis.dep.wv.gov/WVWaterPlan/

Water Withdrawal Guidance Tool

TAGIS and the WUS also maintain a Water Withdrawal Guidance Tool. Developed in 2009, this tool helps direct potential water withdrawals towards only those surface waters with sufficient flow (Figure 14). The WUS is currently investigating improvements to this tool, including the incorporation of groundwater resources, stream ecology, and higher spatial resolutions. The tool is available at: https://tagis.dep.wv.gov/wwts/

Water Resources: Plans & Priorities

The WUS is developing future projects and plans to support our continued efforts to improve water resources management, data collection, and analysis consistent with the Act.

Upgrade Data Entry and Management

The WUS is collaborating with other groups within WVDEP's Division of Water and Waste Management (DWWM) and the WV Business Technology Office to develop new data entry and data management programs. Feedback on the current ESS remains mixed and data entry error rates for LQUs approaches 40%. The WUS is pursuing a new system to improve the public's experience, reduce errors, and provide better data analytics to staff.

Detailed Public Water Supply Information

The public water supply is the most complex water use category and higher resolution of withdrawal information is needed. Current figures for the public water supply include water deliveries to domestic, commercial, and industrial customers. To report on water use and trends more accurately, commercial and industrial portions of the public supply should be aggregated with their self-supplied counterparts in similar water use sectors. Additionally, leaks and losses are estimated to be between 20-30% of the total public supply withdrawal. These leaks and losses serve no beneficial purpose and vary greatly from year to year, skewing data for trend analysis. The WUS will seek to improve the LQU survey as it relates to public water supplies to obtain more detail and clarity on their water withdrawals. The WUS will also consider implementing the USGS WUDR grant report recommendations to revise all LQU water use categories.

Update Water Withdrawal Guidance Tool

The Water Withdrawal Guidance Tool was initially launched in 2009 with the assistance of Marshall University. The Water Withdrawal Guidance Tool has found limited use in certain DWWM permitting applications; however, a 2011 Legislative Audit of the WVDEP indicated that the tool should be considered for implementation as a mandatory requirement for all water withdrawals. The WUS believes that the current iteration of this tool may not stand up to the increased legal and environmental scrutiny that would follow the use of the tool in such manner. Therefore, the WUS is pursuing modifications and improvements needed to strengthen the tool, including the incorporation of stream ecology, groundwater resources, and higher spatial/temporal resolutions.

Water Resources Program Needs

The WUS respectfully requests the continued support from the Legislature and all concerned state agencies regarding funding and cost-sharing solutions for the 188 stream gauges and 18 groundwater level monitoring wells in the network managed by the USGS (Figure 15). The WUS is deeply reliant upon these federal resources. The WUS uses stream gauges to generate thresholds for WMPs under the Natural Gas Horizontal Well Control Act, W. Va. Code §22-6A-7 and the Rules Governing Horizontal Well Development, W.Va. C.S.R. §35-8. Similarly, the WUS's Water Withdrawal Guidance Tool fetches data from the stream gauge servers to provide recommendations for withdrawals across the state. The WUS has other requirements under the Act, including a surface water inventory, estimating safe yield/water budget, identifying potential problems with water availability, monitoring detrimental low-flow conditions, and assessing/projecting public water supply capabilities. Many of these duties are heavily dependent, if not entirely contingent, upon the stream gauge and groundwater level monitoring network for understanding the supply of water throughout West Virginia.

Water Use Section Staff

Since last year's report, there has been a complete change in the WUS staff. All local relationships have been maintained therefore this transition supports additional professionals with fresh eyes and energy to continue this important endeavor and future growth.

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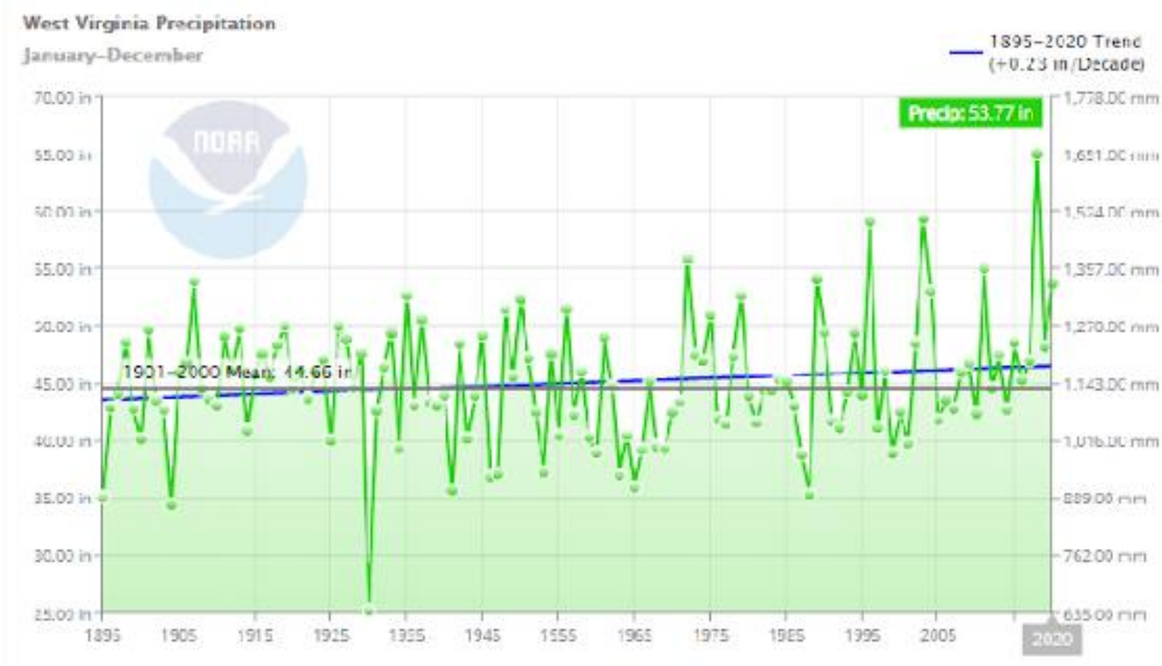

Figure 1. WV's annual precipitation from 1895 – 2020 (from National Oceanic and Atmospheric Administration).

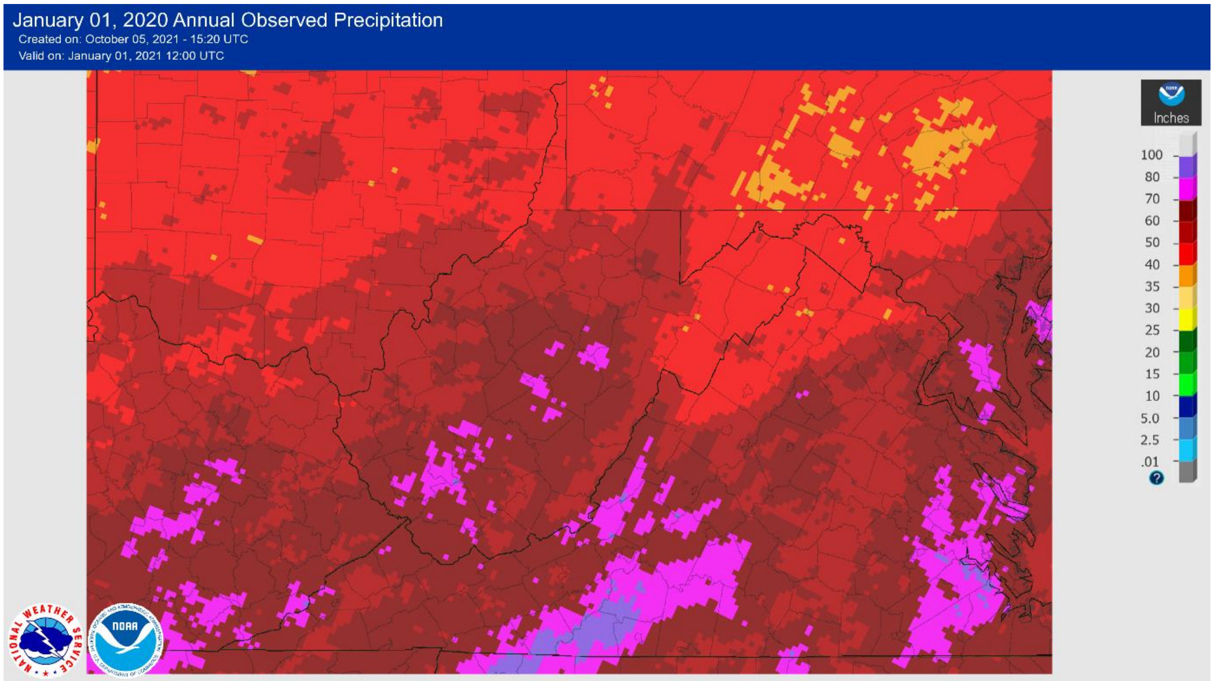

Figure 2. Total 2020 precipitation (from National Weather Service).

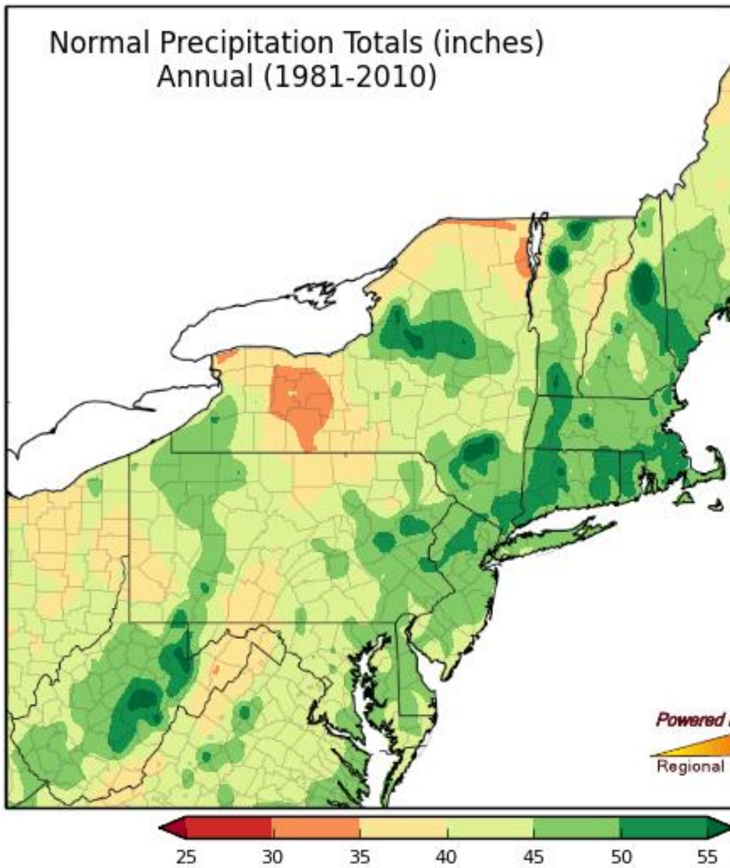

Figure 3. Statewide annual precipitation from 1981 – 2010 (from Northeast Regional Climate Center).

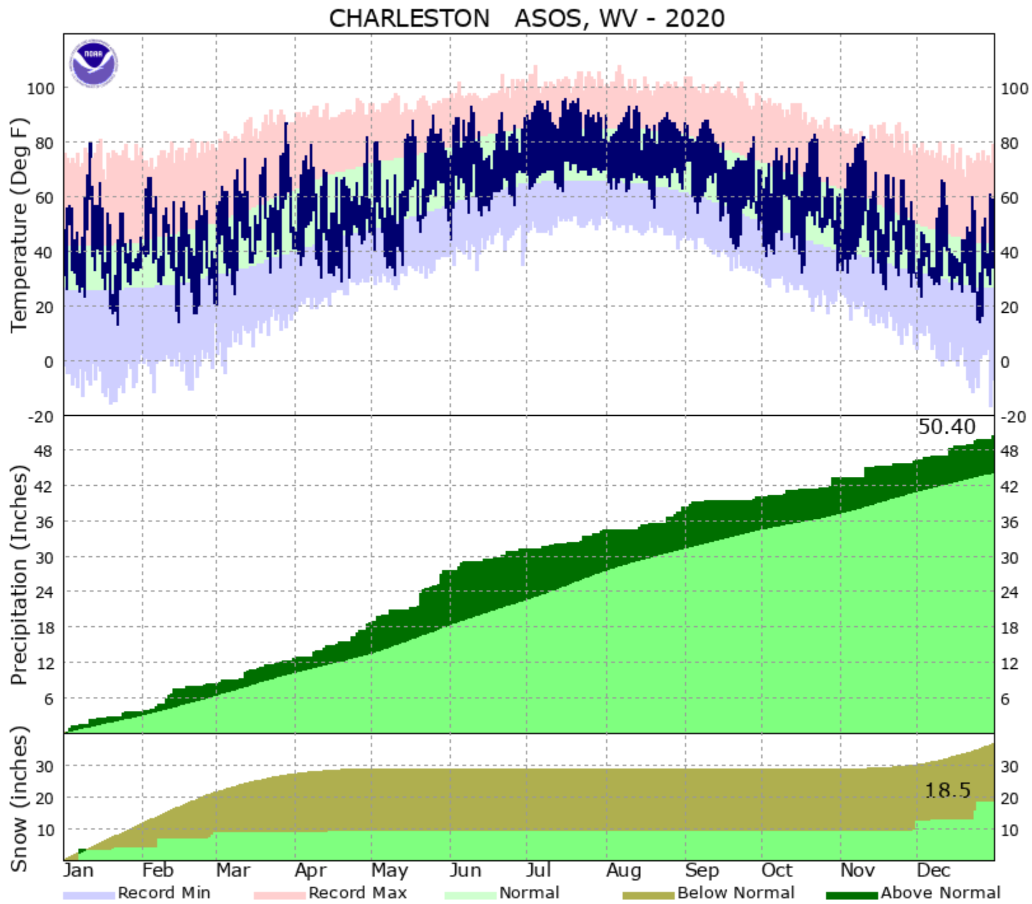

Figure 4. Climate data for Charleston, WV from January – December 2020 (from National Weather Service).

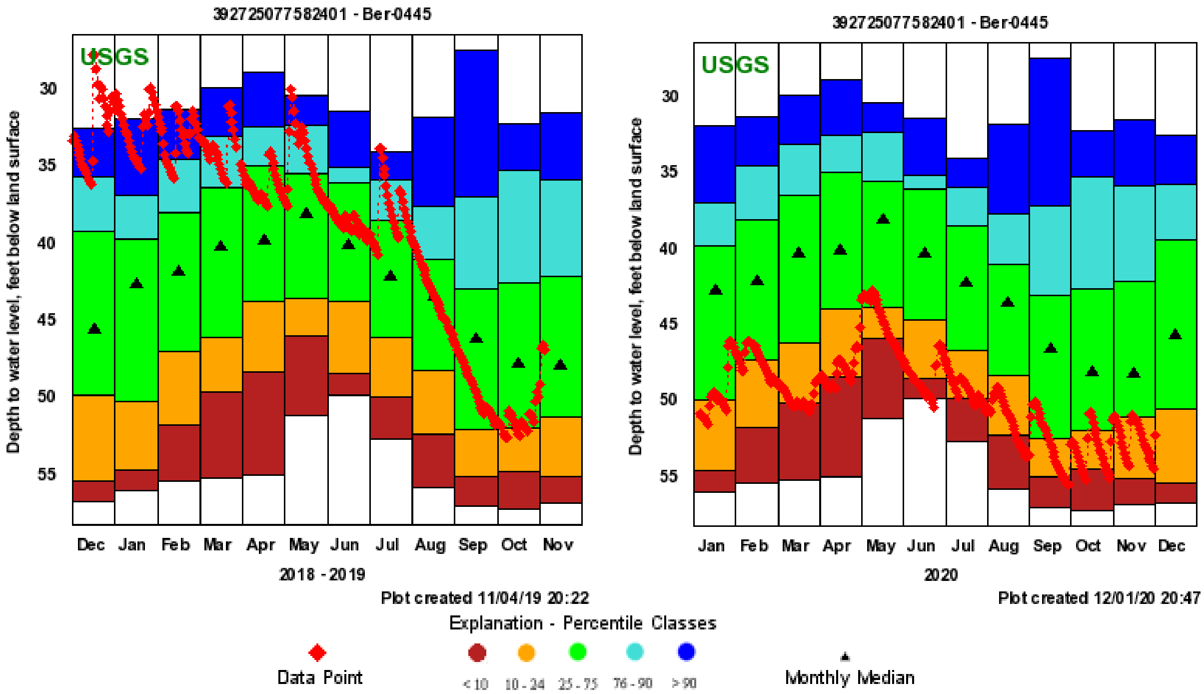

Figure 5a. Groundwater levels Dec 2018 – Nov 2019 and Jan – Nov 2020 in Martinsburg, WV (from USGS).

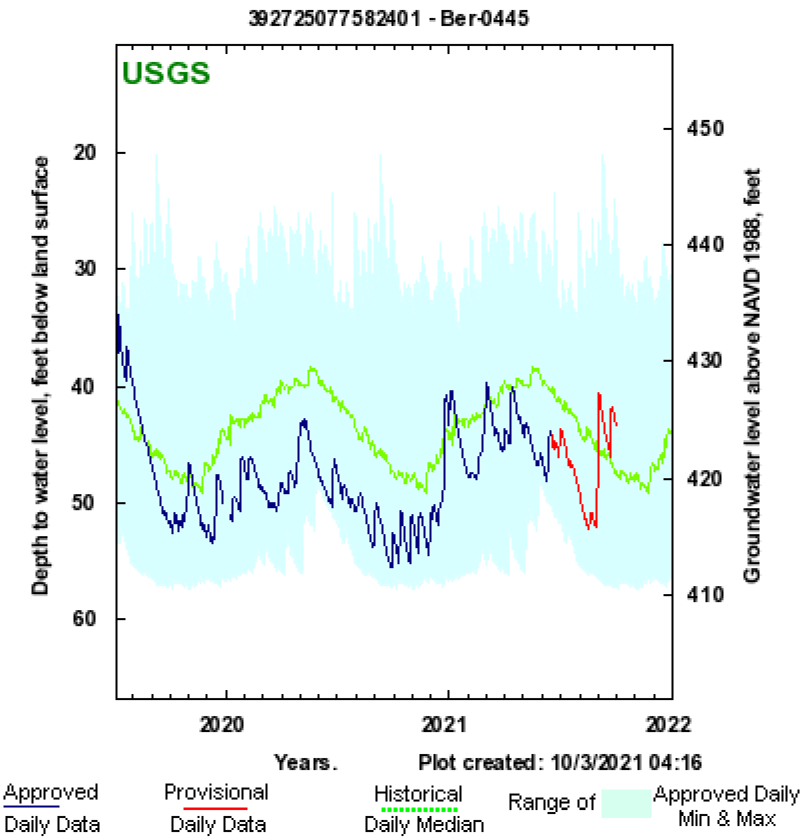

Figure 5b. Groundwater levels Aug 2018 – Sep 2021 in Martinsburg, WV (from USGS).

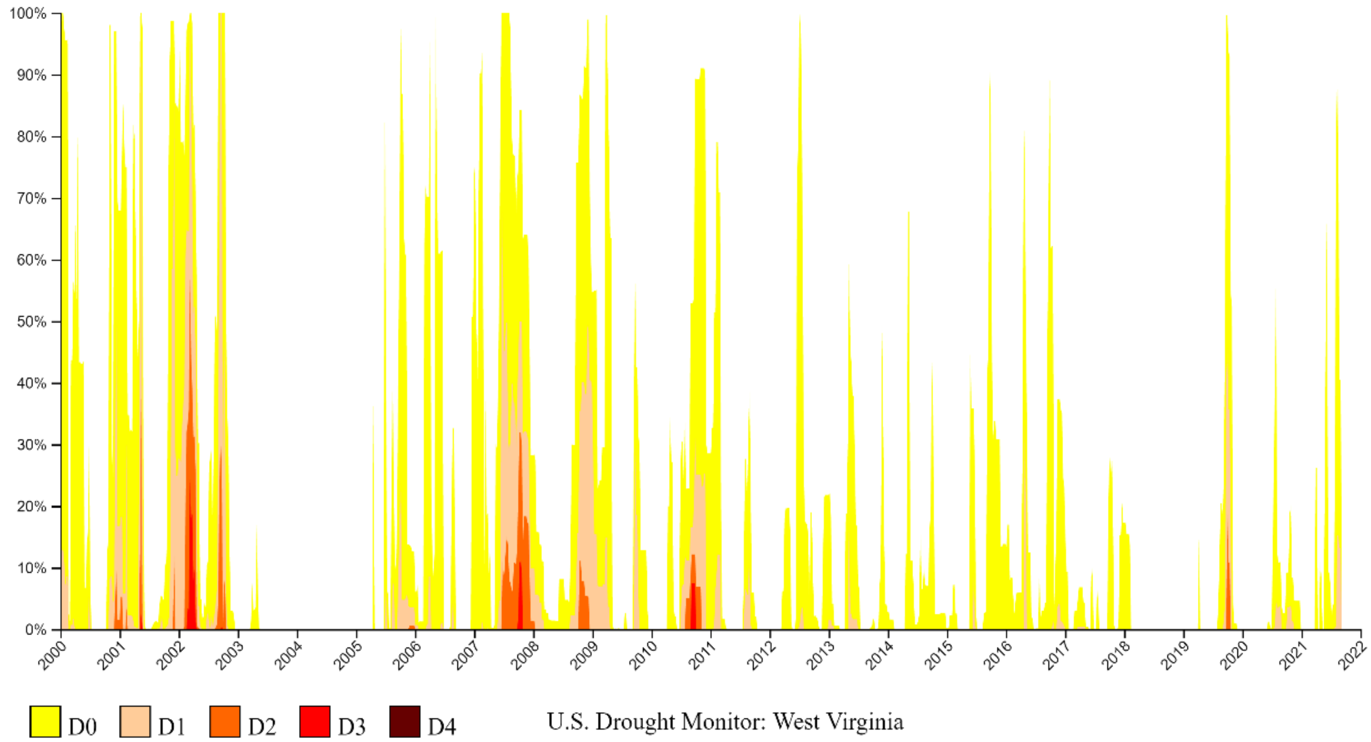

Figure 6a. Drought conditions in WV since 2000 (from US Drought Monitor).

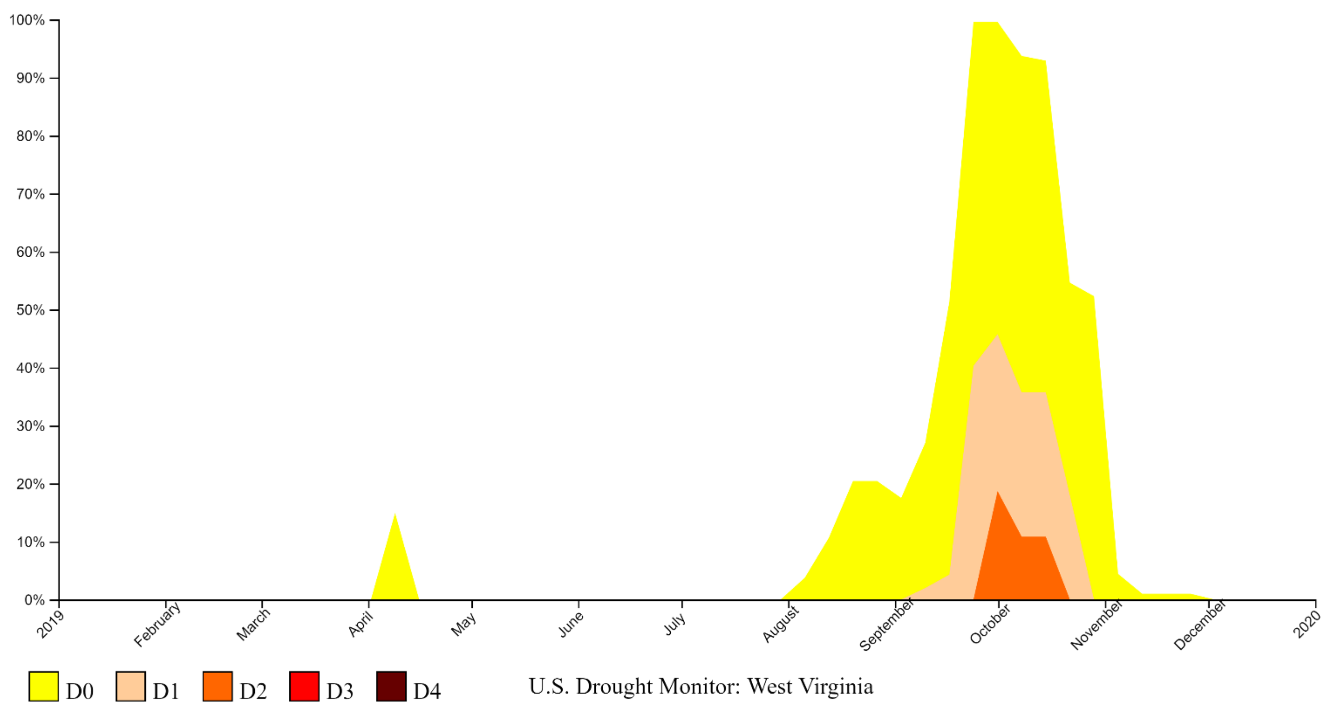

Figure 6b. Drought conditions in WV in 2019 (from US Drought Monitor).

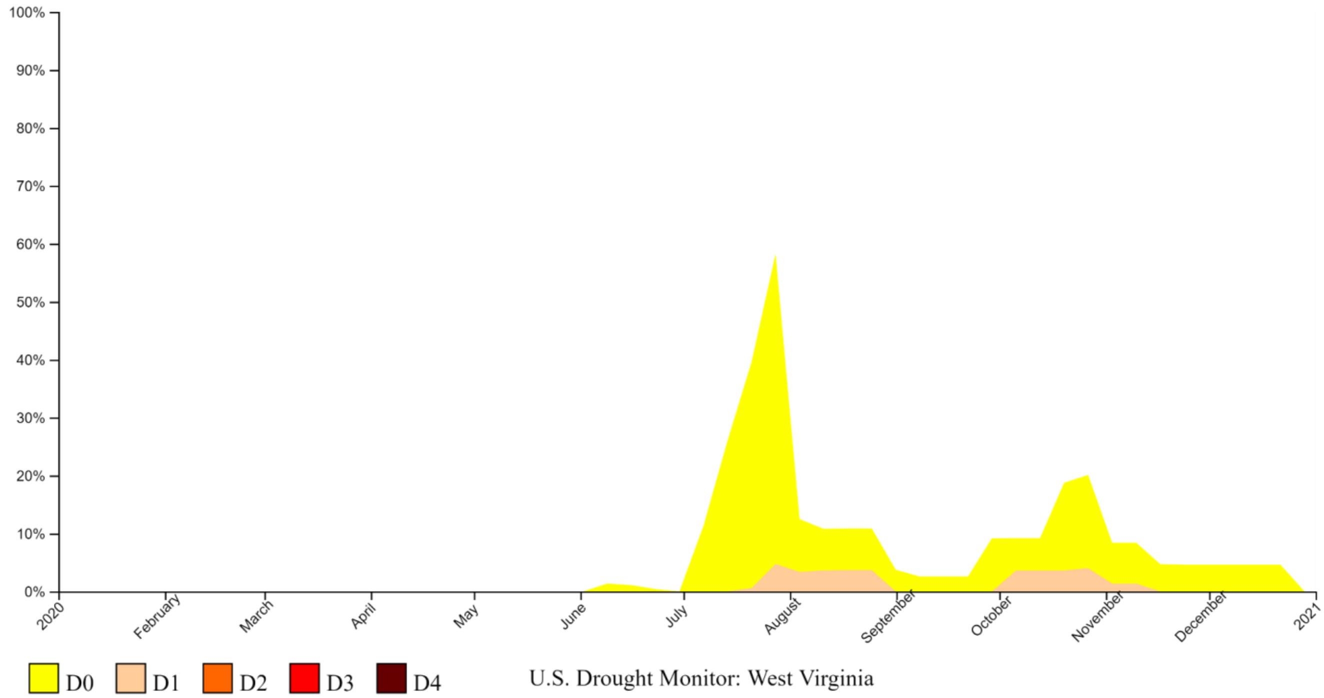

Figure 6c. Drought conditions in WV in 2020 ([from US Drought Monitor]).

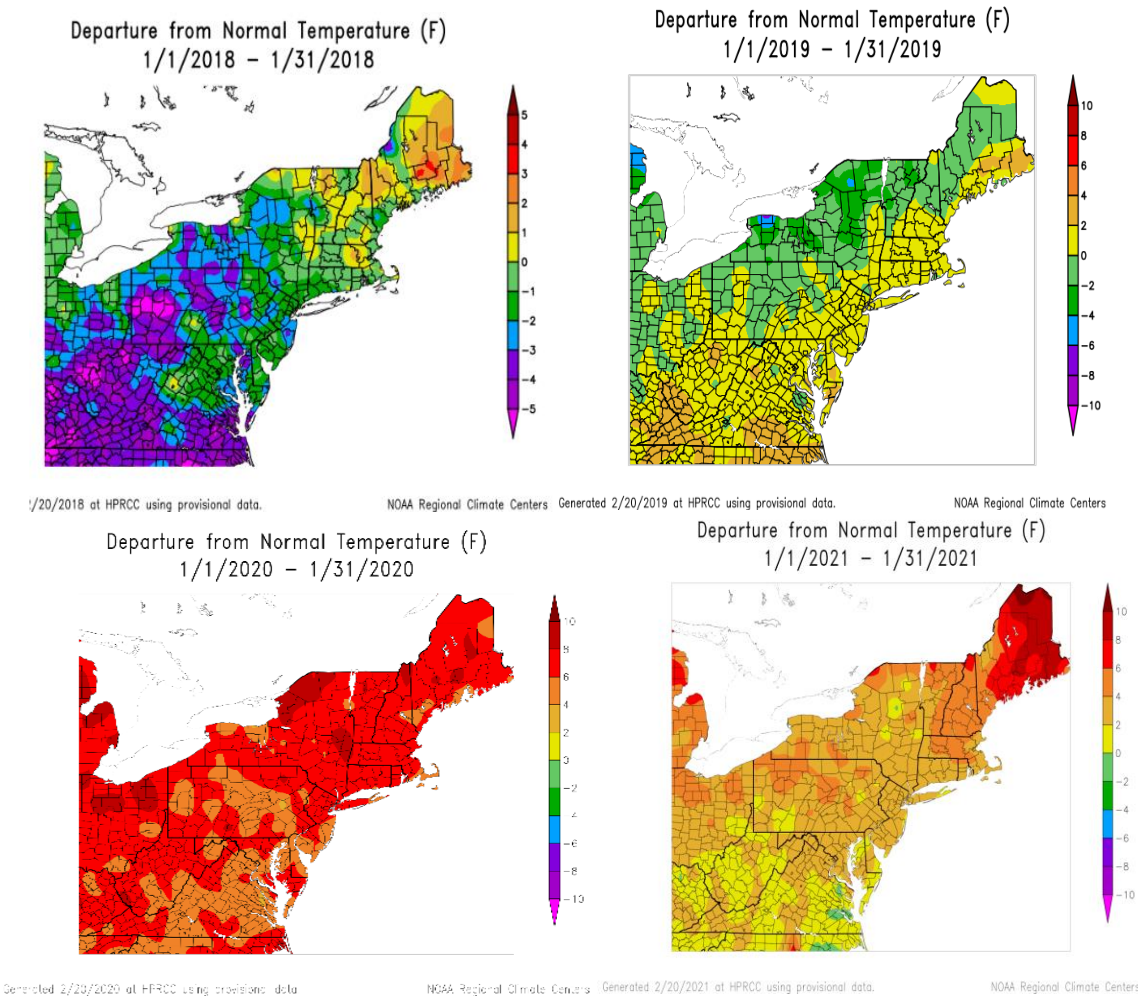

Figure 7. Departure from normal temperatures in January from 2018-2021 (from Northeast Regional Climate Center).

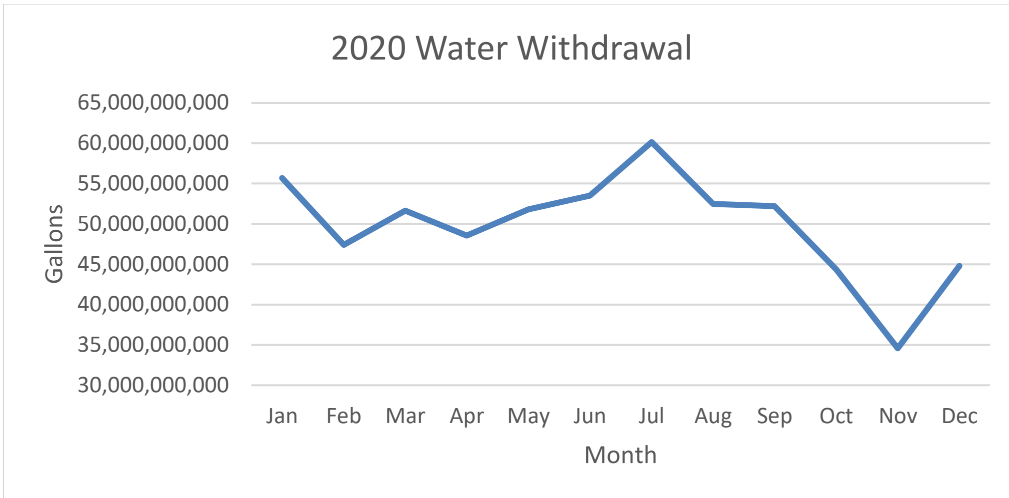

Figure 8. 2020 monthly trends in total withdrawal from the LQU database (WVDEP).

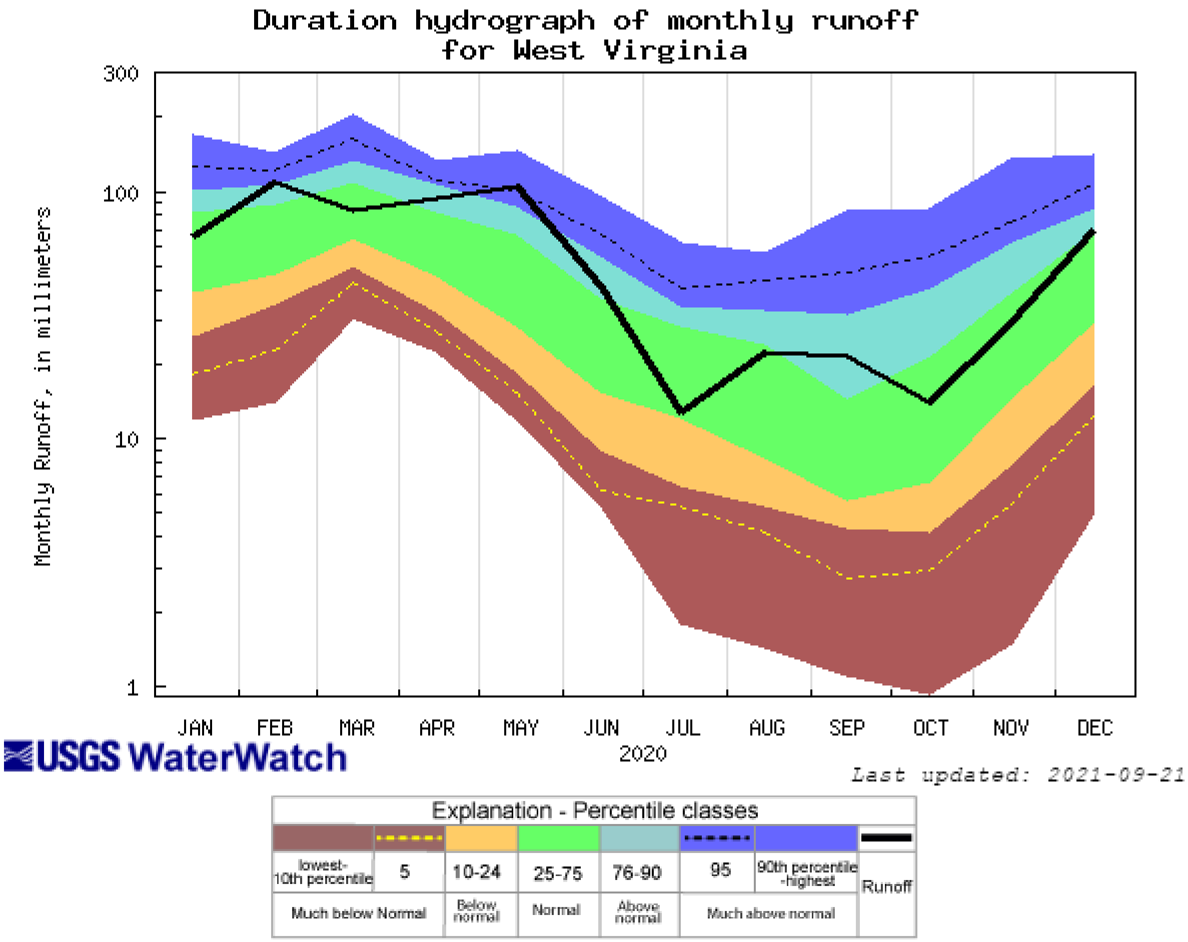

Figure 9. WV 2020 monthly hydrograph. Note logarithmic scale (from USGS).

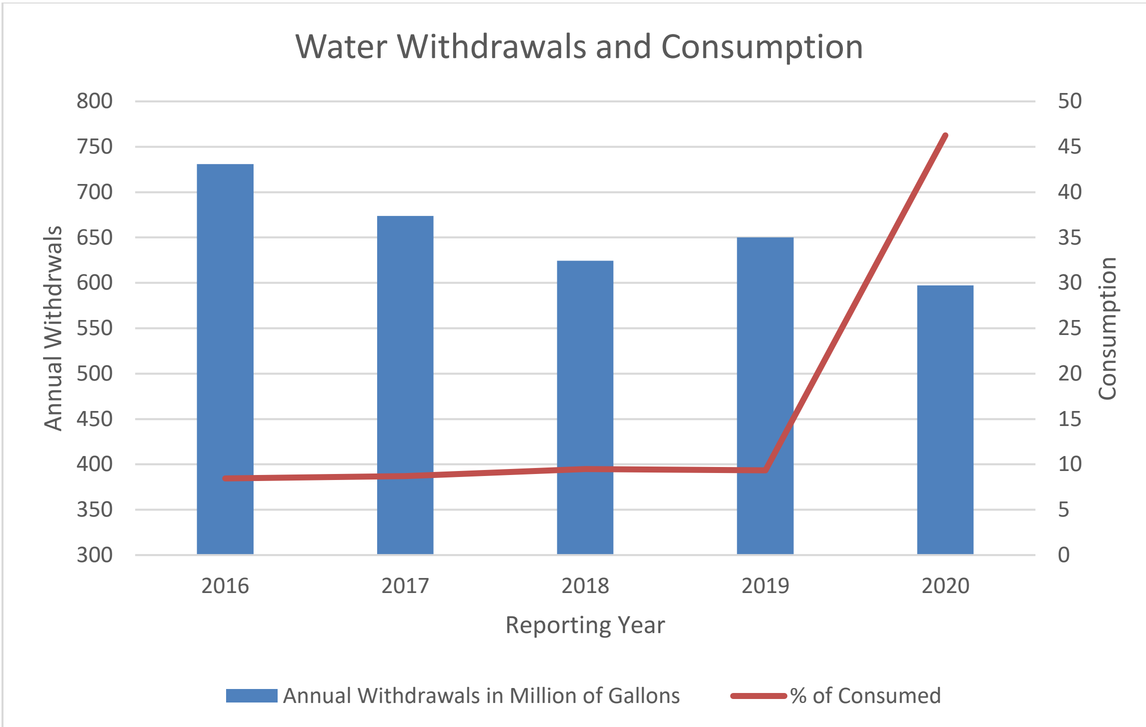

Figure 10. An increase in water consumption estimates contrasts with the decline in total LQU water withdrawal. Note different axis scales (WVDEP).

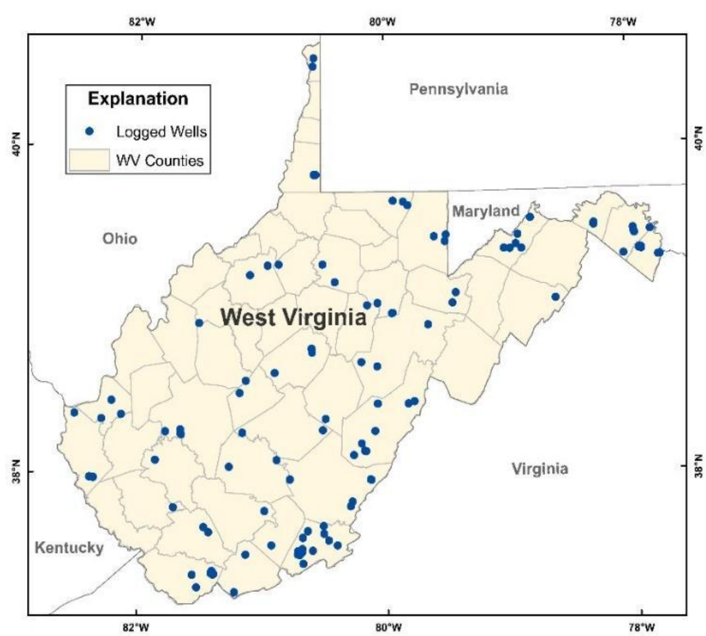

Figure 11. Location of USGS-WVDEP borehole geophysics well logs 2015-2019 (USGS).

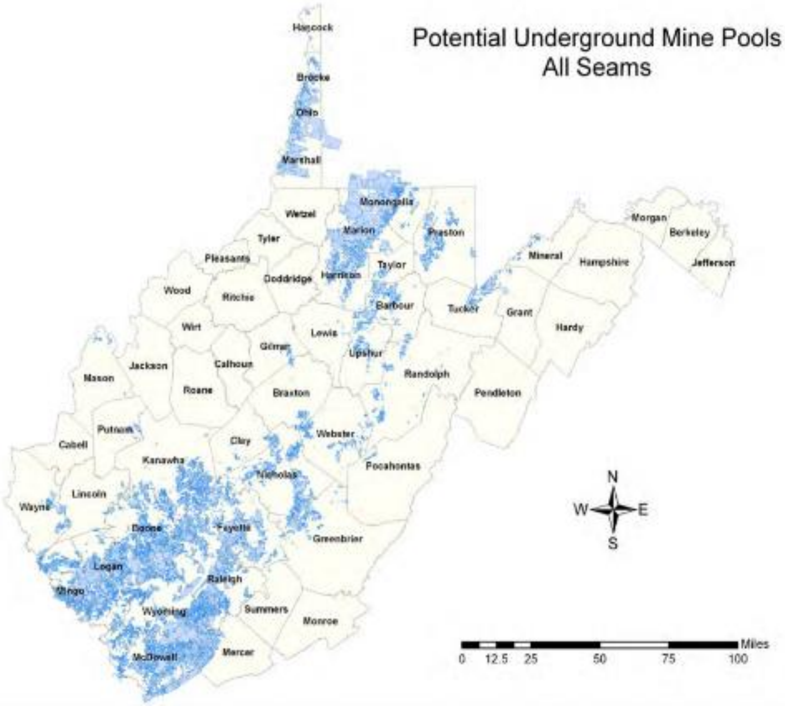

Figure 12. Estimated extent of Abandoned Underground Coal Mine Aquifers (WVGES & WVDEP).

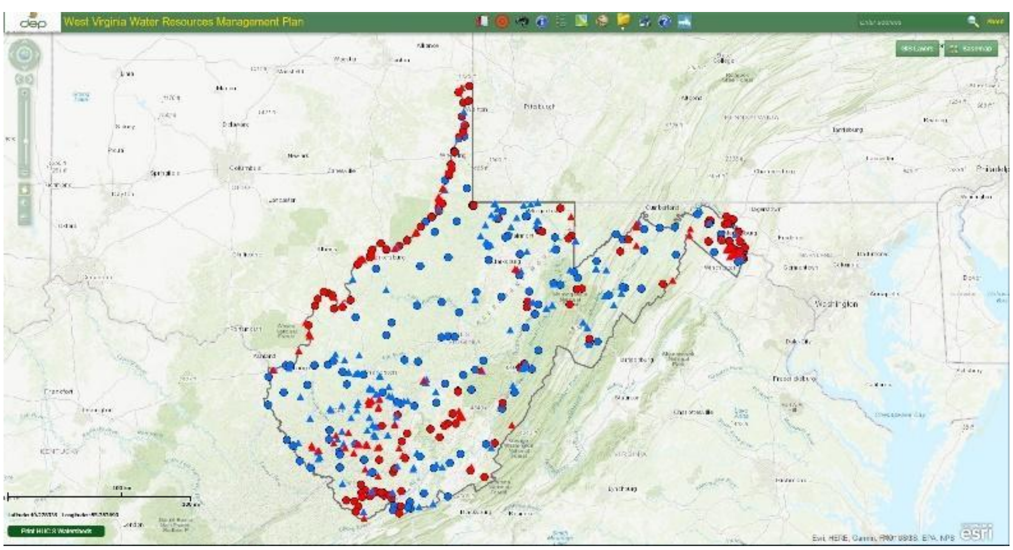

Figure 13. Large Quantity Users from the Water Resources Mapping Tool. Blue – surface water; red – groundwater (WVDEP).

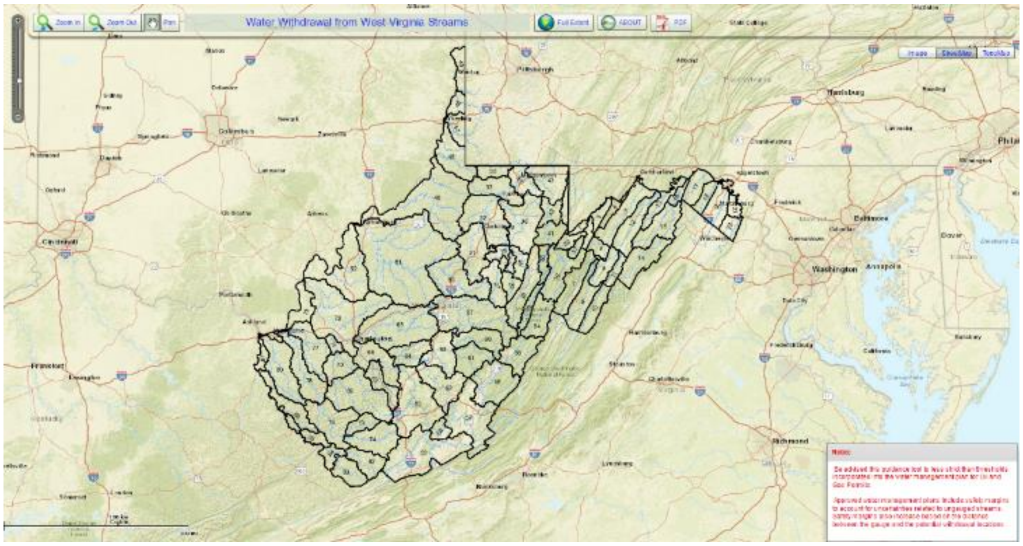

Figure 14. The 86 hydrologic zones of the Water Withdrawal Guidance Tool (WVDEP).

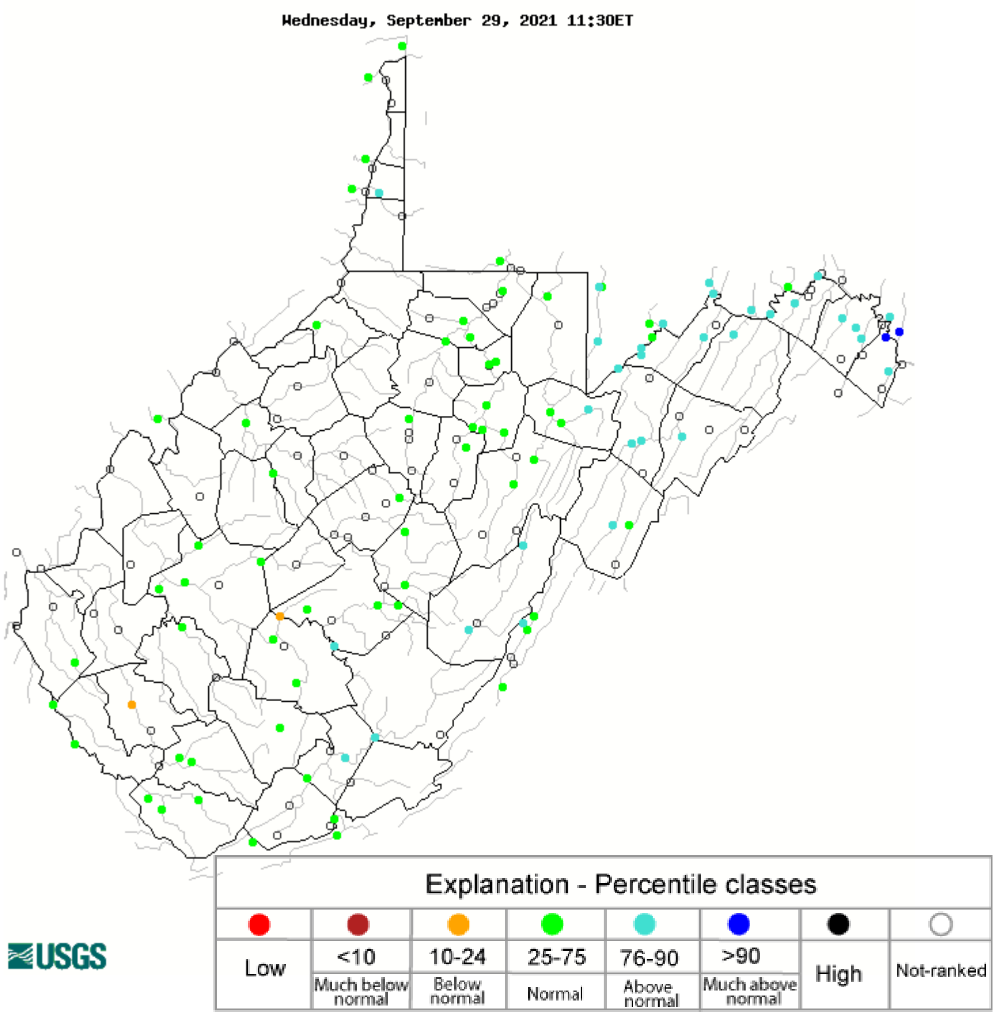

Figure 15. The stream gauge network in WV (from USGS).