2022 Annual Water Resources Report

Joint Legislative Oversight Commission on State Water Resources
November 2022

Prepared by the

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

Table of Contents

Figures

Water Resources Protection and Management Overview

The Water Resources Protection and Management Act (WV Code §22-26*)* 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. WVDEP formed the Water Use Section in 2008 to initiate a comprehensive review of the state's water resources. The State Water Resources Management Plan was published in 2013 and adopted by the Legislature in 2014. The Water Use Section 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 WV Code §22-26-8(e).

2021 – 2022 Water Resources Availability

Going back to the late 19th century, average annual rainfall in West Virginia has been approximately 45 inches. Total annual precipitation has been variable with a slight increase over the long record period, with the driest in the early 1930s and late 1960s and the wettest in the early 2000s and late 2010. After a slightly above normal range of precipitation in 2020 (54 inches), annual precipitation was just slightly below West Virginia's average range at 43 inches during 2021 (Figure 1). As typical, 2021 precipitation was greatest in the high mountains west of the continental divide (over 60 inches observed) and lowest in the rain shadow from those same mountains (just under 35 inches in some spots) in the Eastern Panhandle (Figure 2). Although precipitation totals were above normal amounts in 2019 and 2020, precipitation totals in 2021 were below normal amounts throughout all of 2021 except for a brief period in March (Figure 3). Winter and spring precipitation amounts are projected to increase due to overall temperatures in West Virginia rising 1 degree Fahrenheit since the beginning of the 20th century (Figure 4). This change in temperature will affect both the number and intensity of extreme precipitation events with more potential for flooding and drought.

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 2020 remained below average. In 2021, the groundwater levels were highest on April 14th at 40.16 ft and lowest on December 6th at 51.47 feet (Figure 5). The U.S. Geological Survey (USGS) Ber-0445 well is an unconfined aquifer where groundwater levels have been recorded since 2005 with measurements ranging from 26.59 feet to 55.58 feet with a median of 43.35 feet below land surface (as of October 6, 2022).

January 2022 was cooler than the warmer 2020 and 2021 and more average 2019 in West Virginia (Figure 6). Annual mean streamflow in West Virginia during water year 2021 (October 1, 2020-September 30, 2021) was normal with only spring streamflow below normal (https://waterwatch.usgs.gov/publications/wysummary/2021).

2020 drought conditions in West Virginia were more average with only some abnormally dry (D0) and moderate drought (D1) periods through summer and fall periods (Figure 7a). These same conditions continued through 2021 but affected more of the state for longer periods (Figure 7b). West Virginia

experienced abnormally dry (D0) conditions mid-March through the end of December 2021. August through the beginning of September and the second part of December 2021 were moderate drought conditions (D1). There have been no severe drought conditions (D2) since October 2019 and no extreme drought conditions (D3) since September 2010 (Figure 7c).

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 Water Resources Protection and Management Act. These LQUs use the WVDEP Electronic Submission System (ESS) to report their withdrawals annually to the Water Use Section. LQU surveys are collected between January 1 and March 31 of the year following water withdrawal; we will receive 2022 reports beginning January 1, 2023. The Water Use Section 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 USGS.

The LQU data represents our best insight into water use throughout West Virginia but is by no means definitive. The Water Use Section 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 Water Use Section conducts limited audits and field visits to verify reported information and register new LQUs.

Annual Data and Trends

In 2021, 329 LQUs reported withdrawing over 641 billion gallons of water (Table 1). Additionally, 11 hydroelectric facilities report more than 236 trillion gallons withdrawn. Total withdrawal from West Virginia water resources increased (7.44%) from 2020 to 2021. Thermoelectric operations continue to be the largest water use sector overall excluding hydroelectric. The chemical and public water supply users continue to round out the top 3 in total quantity at over 142 billion and 60 billion gallons in 2021, respectively. The 3 highest withdrawal sectors also all showed increases in quantity from 2020 to 2021. The increase from 288 to 329 LQU reports received is based on more outreach and enforcement of the LQU reporting requirement by program staff, not an actual increase in the number of water users statewide.

WVDEP Water Use Category	LQUs	Total 2021 Withdrawal (Gallons)	Category %	% Change from 2020
Agriculture/aquaculture	12	8,453,267,673	1.32%	-11.66%
Chemical	12	142,025,333,594	22.14%	27.51%
Industrial	18	15,478,774,963	2.41%	-61.43%
Mining	63	11,380,977,450	1.77%	15.00%
Oil & gas	17	3,603,079,370	0.56%	23.25%
Petroleum	1	290,570,264	0.05%	-1.84%
Public water supply	174	60,485,128,163	9.43%	5.55%
Recreation	20	935,428,884	0.15%	-22.68%

Thermoelectric (coal)	9	398,031,543,142	62.04%	9.50%
Timber	3	910,633,110	0.14%	-4.85%
TOTAL	**329**	**641,594,736,613**	**100.00%**	**7.44%**
Hydroelectric	11	236,309,036,343,208		

Table 1. Total 2021 water withdrawals from the LQU database (WVDEP).

Most LQUs continue to withdraw from the surface (96%) with only 4% using groundwater (Table 2). Thermoelectric (coal) continues to use the most surface water with over 397 billion gallons in 2021. The public water supply remains the single largest user of groundwater with over 12 billion gallons used, followed by the chemical and mining sectors. Groundwater use is concentrated in the alluvium along the Ohio River, southern coalfields, and karst aquifer systems of eastern West Virginia (Figure 8). Both surface water and groundwater total withdrawals have increased slightly from last year.

WVDEP Water Use Category	Surface Water (SW) Withdrawal (Gallons)	Category % of SW	Groundwater (GW) Withdrawal (Gallons)	Category % of GW
Agriculture/aquaculture	8,285,775,273	1.35%	167,492,400	0.59%
Chemical	133,072,309,878	21.70%	8,953,023,716	31.43%
Industrial	14,715,006,101	2.40%	763,768,862	2.68%
Mining	6,067,888,154	0.99%	5,313,089,296	18.65%
Oil & gas	3,585,815,732	0.58%	17,263,638	0.06%
Petroleum	6,305,762	0.00%	284,264,502	1.00%
Public water supply	48,273,294,295	7.87%	12,211,833,868	42.86%
Recreation	606,002,621	0.10%	329,426,263	1.16%
Thermoelectric (coal)	397,592,885,681	64.85%	438,657,461	1.54%
Timber	899,646,595	0.15%	10,986,515	0.04%
SUB TOTAL	613,104,930,092	100.00%	28,489,806,521	100.00%
Breakdown % of Total Withdrawal	**613,104,930,092**	**95.56%**	**28,489,806,521**	**4.44%**
Hydroelectric	236,309,036,343,208		0	

Table 2. Breakdown of surface water and groundwater 2021 withdrawal data (WVDEP).

The 2021 estimate for water consumption is approximately 44.91% of the total statewide water withdrawal (Table 3) which is slightly less than 2020's 46.26% (Figure 9a). Although based on more regional consumption coefficients prior, there was also a slight decrease in water consumption between 2018 and 2019 (Figure 9b).

WVDEP Water Use Category	2021 Total Gallons Withdrawal	Consumptive Coefficient	2021 Calculated Gallons Consumed	Category % of Consumed
Agriculture/aquaculture	8,453,267,673	0.03	253,598,030	0.09%

Chemical	142,025,333,594	0.12	17,043,040,031	5.91%
Industrial	15,478,774,963	0.59	9,132,477,228	3.17%
Mining	11,380,977,450	0.48	5,462,869,176	1.90%
Oil & Gas	3,603,079,370	1	3,603,079,370	1.25%
Petroleum	290,570,264	0.16	46,491,242	0.02%
Public water supply	60,485,128,163	0.15	9,072,769,224	3.15%
Recreation	935,428,884	0.41	383,525,842	0.13%
Thermoelectric (coal)	398,031,543,142	0.61	242,799,241,317	84.26%
Timber	910,633,110	0.39	355,146,913	0.12%
TOTAL	**641,594,736,613**		**288,152,238,374**	**100.00%**
Hydroelectric	236,309,036,343,208			

Table 3. Current consumption coefficients applied to 2021 withdrawal data (WVDEP).

Total monthly water withdrawals are generally highest in the summer and winter (Figure 10). 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. The summer's higher demand for water coincides with the lowest water levels of the year throughout West Virginia (Figure 11).

Oil and Gas Water Management Plans

The Water Use Section of the WVDEP is responsible for the processing, analysis, and approval of operator-submitted water management plans. Pursuant to WV Code §22-6A-7 and the Horizontal Well Development Rule 35CSR8, 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 as part of the well work permit application. H6A well work permit applicants must identify all potential water sources with the inclusion of a Water Management Plan along with their horizontal well permit application. The WVDEP evaluates each proposed water source (surface water, groundwater, purchased water, or recycled frac water) for suitability based on a variety of considerations.

For Fiscal Year 2021, the Water Use Section received and reviewed all individual Water Management Plans associated with WV Code §22-6A well work, including new pad-level plans and existing Water Management Plan 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 from the Water Resources Protection and Management Act, the Water Use Section has routinely collaborated on research initiatives with various state, federal, and nonprofit partners. These projects support the data and informational needs of the Water Use Section to understand, protect, and conserve state water resources. Previous projects have included stream

gauge statistical analysis, water budgets, water consumption, and water infrastructure. The Water Use Section is currently funding and managing three projects:

Geophysical Groundwater Well Logging

The Water Use Section 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.

All the fieldwork for the project was completed by September 30, 2019, with over 120 well logs containing geological and hydrological data (Figure 12). The USGS final report and data models were anticipated in spring 2022, however due to staffing issues and other high priority local projects such as perfluoroalkyl and polyfluoroalkyl substances (PFAS), completion of this project is now planned for spring 2023. Although aspects of the study are time consuming and manpower intensive, the borehole geophysics data collected for this project are the only mechanism which allow a detailed characterization of the fracture-controlled bedrock aquifers upon which so many residents and commercial and industrial entities rely as a primary source of water. Results of the study will aid in future assessment and management of groundwater resources within the state.

Abandoned Underground Coal Mine Aquifers

The Water Use Section has been involved in many projects to determine the location, quantity, quality, and sustainability of water within Abandoned Underground Coal Mine Aquifers (AUCMA), 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 13). Since then, we have worked with the USGS to obtain data from more than 770 water samples from 294 mines. 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. The WVDEP Water Use section will discuss potential future collaboration projects with the WVGES on this topic.

Water Stress and Critical Planning Areas

The Water Resources Protection and Management 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.” Previous work by the Water Use Section has shown that on an annual level the state enjoys abundant water resources. However, there is potential for water stress on smaller spatial or temporal scales so additional research in this area is being pursued.

The Water Use Section and West Virginia University continue to work 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 31, 2022, based on the spring 2020 semester start.

Online Water Resources Information

In cooperation with WVDEP's Technical Applications and GIS Unit (TAGIS) group, the Water Use Section 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, NPDES, geology, and more (Figure 14). The tool is available at: http://tagis.dep.wv.gov/WVWaterPlan/

Water Withdrawal Guidance Tool

TAGIS and the Water Use Section 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 15). The Section 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 and Priorities

The Water Use Section is developing future projects and plans to support our continued efforts to improve water resources management, data collection, and analysis consistent with the Water Resources Protection and Management Act. The Water Use section continues to discuss with the USGS and other research entities on a variety of potential proposals to enhance water quantity data and use. All current projects are also encouraged to include recommendations for future pursuits within their findings.

Upgrade Data Entry and Management

The Water Use Section 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 LQU approaches 40%. The Section is pursuing a system with a new interface to improve the user experience, reduce errors, and provide better data analytics to Water Use Section staff. The new system and data migration project is currently in progress and targets to be in production in 2024 reporting season.

Update Water Withdrawal Guidance Tool

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

Detailed Public Water Supply Information

The public water supply is the most complex water use sector 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 Water Use Section continues to seek improvements in the LQU survey as it relates to public water supplies to obtain more detail and clarity on their water withdrawals.

Water Resources Program Needs

Nationally, the USGS stream gaging network is a multipurpose network that comprises more than 10,000 stream gages. The stream gages are primarily operated and maintained by the USGS, but most are funded in partnership with one or more of about 1,800 Federal, State, local, and Tribal agencies or organizations. This unique cooperation results in nationally consistent and impartial data that also aids local decision making. The shared costs result in the operation of far more stream gages than would be possible if financed solely by USGS appropriations, which provide less than one-third of the needed funding. These partnerships also enable fixed costs (such as costs associated with data storage and delivery infrastructure) to be broadly distributed, resulting in more economical stream-gaging information for all. It encompasses several smaller networks that produce specific information or support specific needs. The data are quality assured and served online-most in near real time-to meet many diverse needs. Data users include emergency responders, water managers, environmental and transportation agencies, universities, utilities, recreational enthusiasts, and consulting firms. Specific uses of the data include the following:

- planning, forecasting, and warning about floods and droughts;
- managing water rights and transboundary water issues;
- operating waterways for power production and navigation;
- monitoring environmental conditions to protect aquatic habitats;
- describing impacts to streamflow from changing land and water uses;
- assessing water quality and regulating pollutant discharges;
- determining if streams are safe for recreational activities; and

- designing reservoirs, roads, bridges, drinking water and wastewater facilities.

Locally, the Water Use Section is deeply reliant upon these federal resources. The Water Use Section uses stream gauges to generate thresholds for water management plans under the Horizontal Well Control Act. Similarly, the Water Use Section's Water Withdrawal Guidance Tool fetches data from the stream gauge servers to provide recommendations for withdrawals across the state. The Water Use Section has other requirements under the Water Resources Protection and Management 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.

The Water Use Section respectfully requests the continued support from the Legislature and all concerned state agencies regarding funding and cost-sharing solutions for the 183 stream gauges and 19 groundwater level monitoring wells in the local network managed by the USGS (Figure 16). In federal fiscal year FY 2022 which runs from October 1, 2021 through September 30, 2022, West Virginia contributed $820,000. There is a slight (4%) increase in the FY 2023 state budget for this network to cover operational and maintenance costs associated with supply and travel, however this is still only approximately one third (37%) of the total network cost.

Federal Fiscal Year (October 1 through September 30)	State of WV	Sum of USGS Funding	Other Locality, Federal and Private Funding	Total Funding	Overall Annual Increase
FY 2019	$765,000	$545,320	$809,330	$2,119,650	N/A
FY 2020	$800,000	$562,800	$805,380	$2,168,180	2.24%
FY 2021	$800,000	$561,765	$841,440	$2,203,205	1.59%
FY 2022	$820,000	$560,234	$882,500	$2,262,734	2.63%
FY 2023	$876,230	$549,730	$937,460	$2,363,420	4.26%

Table 4. WV stream gage funding (from USGS).

The Water Use Section along with other WVDEP program staff continue to participate in the quarterly stream gaging council meetings to support continued cooperation and prioritization of statewide water resources data development.

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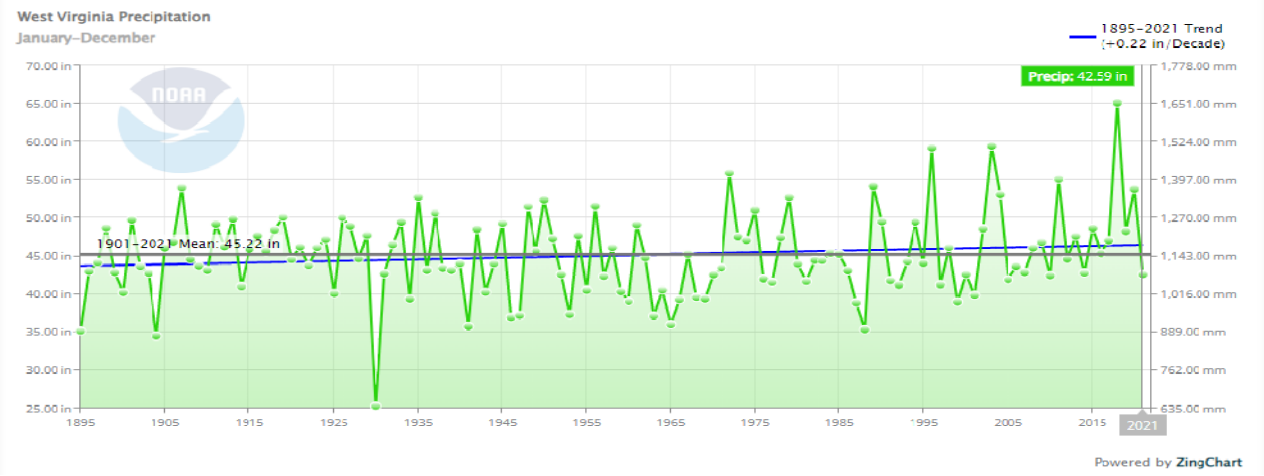

Figure 1. WV's annual precipitation from 1895 - 2021 (from National Oceanic and Atmospheric Administration).

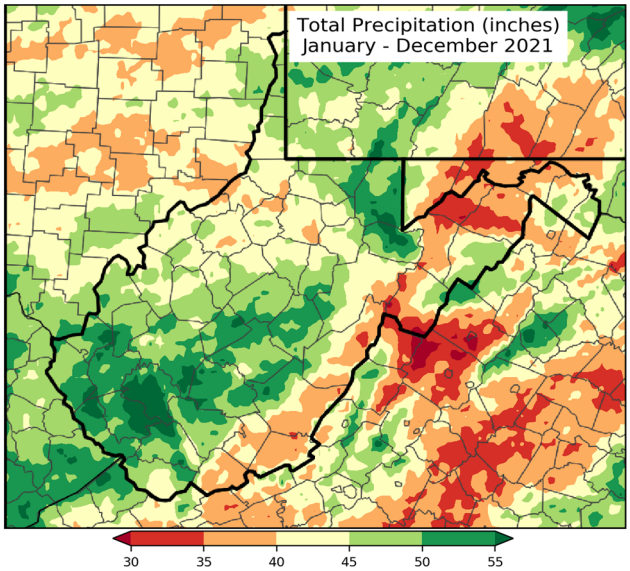

Figure 2. Total 2021 precipitation (from Northeast Regional Climate Center).

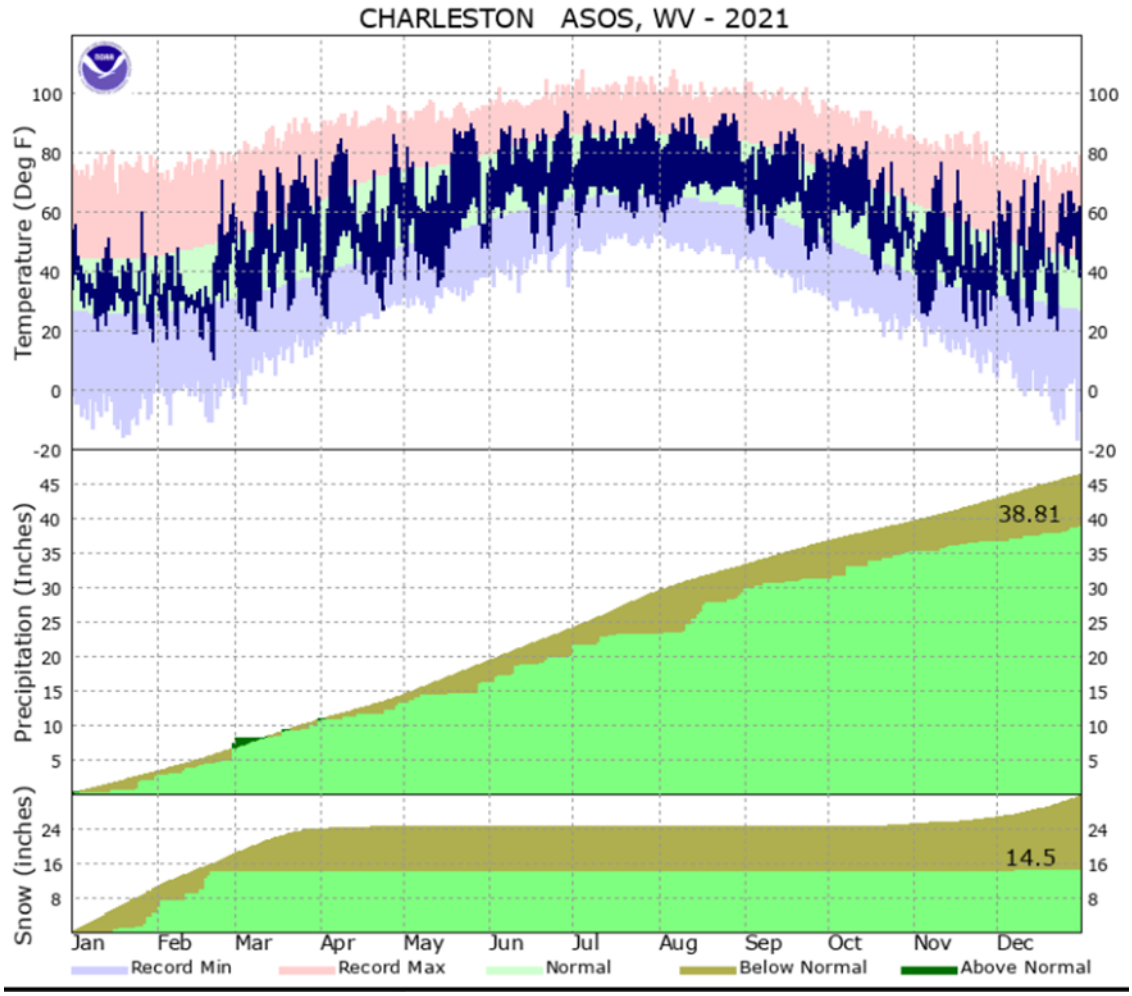

Figure 3. Climate data for Charleston, WV from January – December 2021 (from National Weather Service).

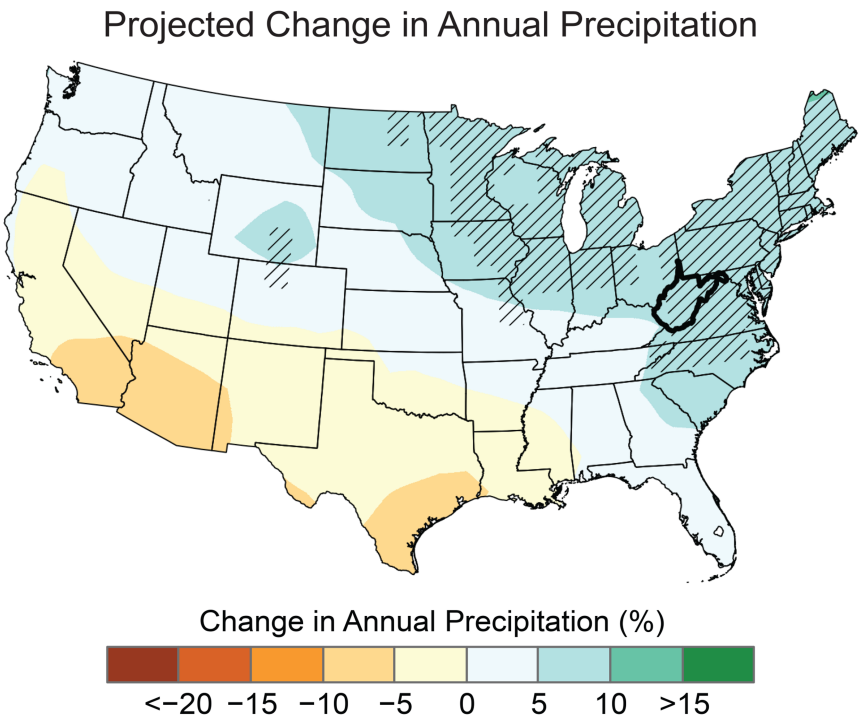

Figure 4. Projected change in annual precipitation (from National Oceanic and Atmospheric Administration).

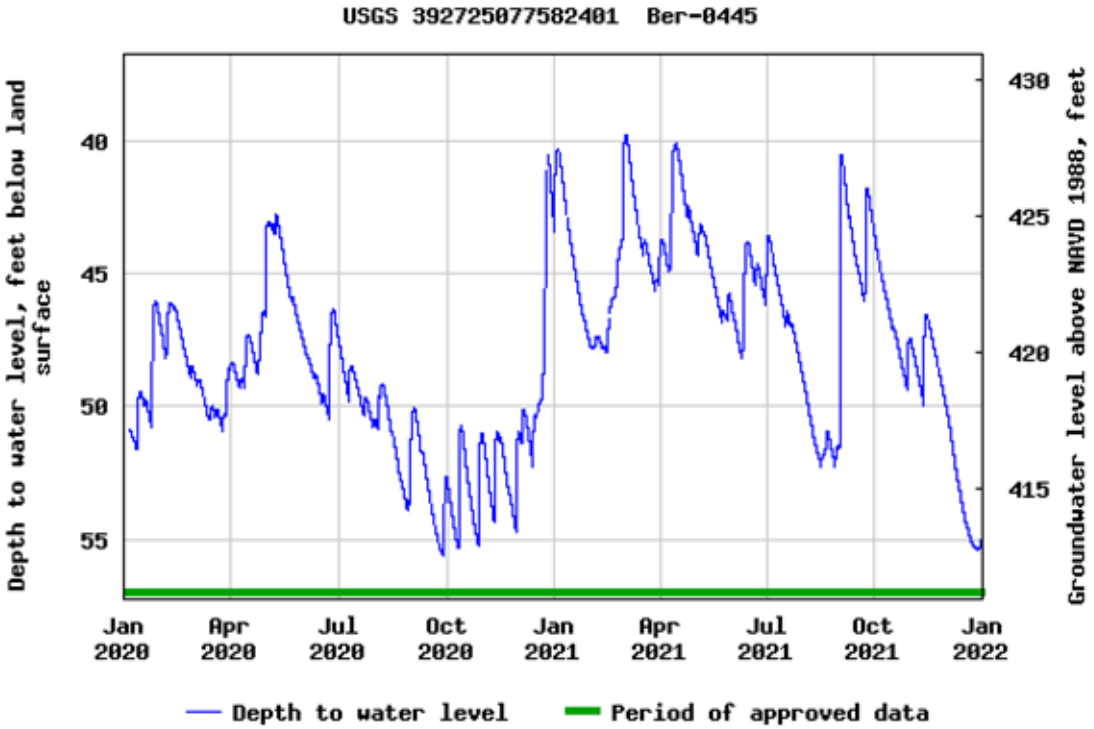

Figure 5. Groundwater levels 2020 and 2021 in Martinsburg, WV (from USGS).

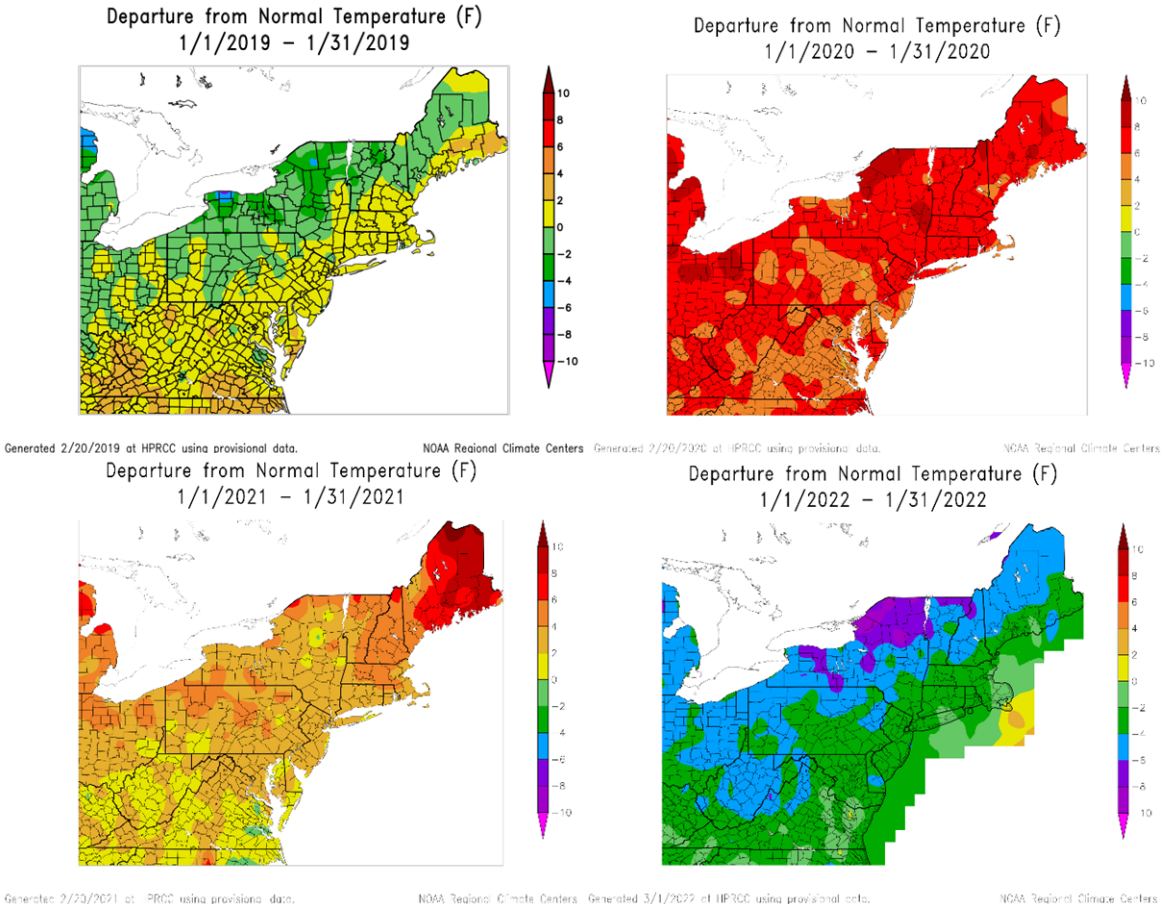

Figure 6. Departure from normal temperature in WV for January 2019-2022 (from the Northeast Regional Climate Center).

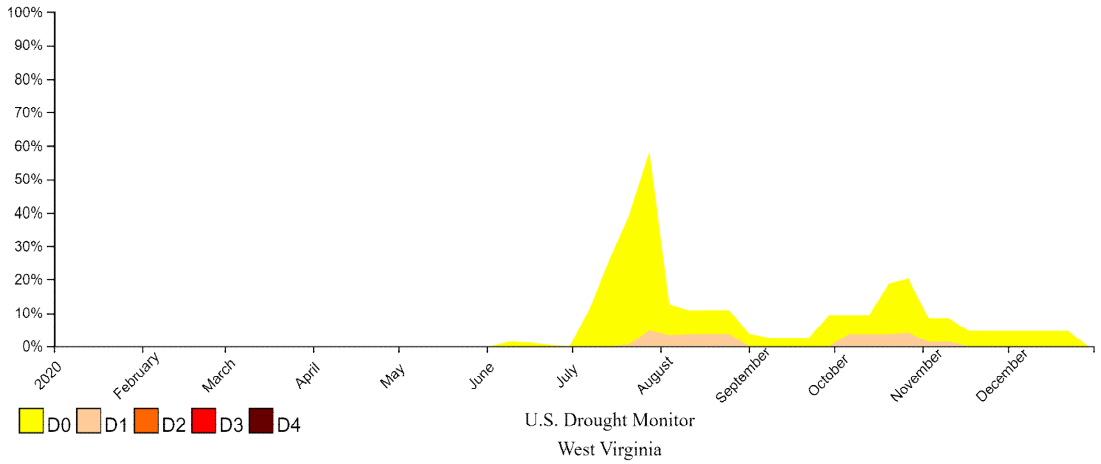

Figure 7a. Drought conditions in WV in 2020 (from US Drought Monitor).

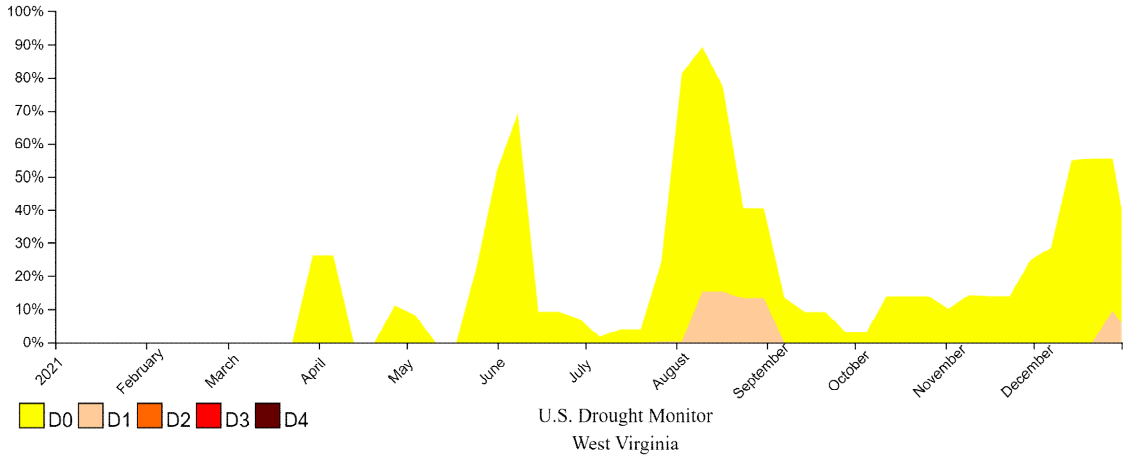

Figure 7b. Drought conditions in WV in 2021 (from US Drought Monitor).

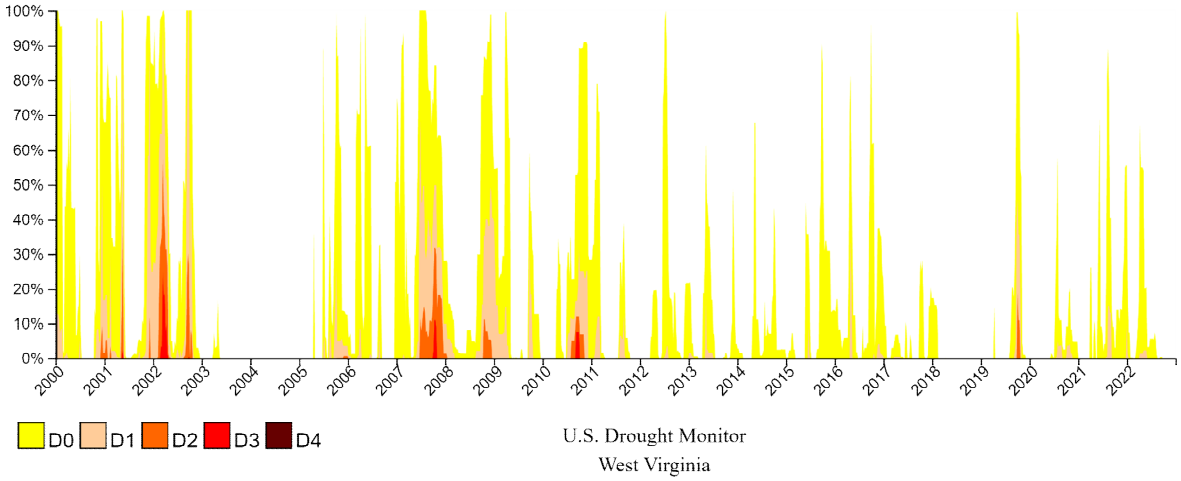

Figure 7c. Drought conditions in WV since 2000 (from US Drought Monitor).

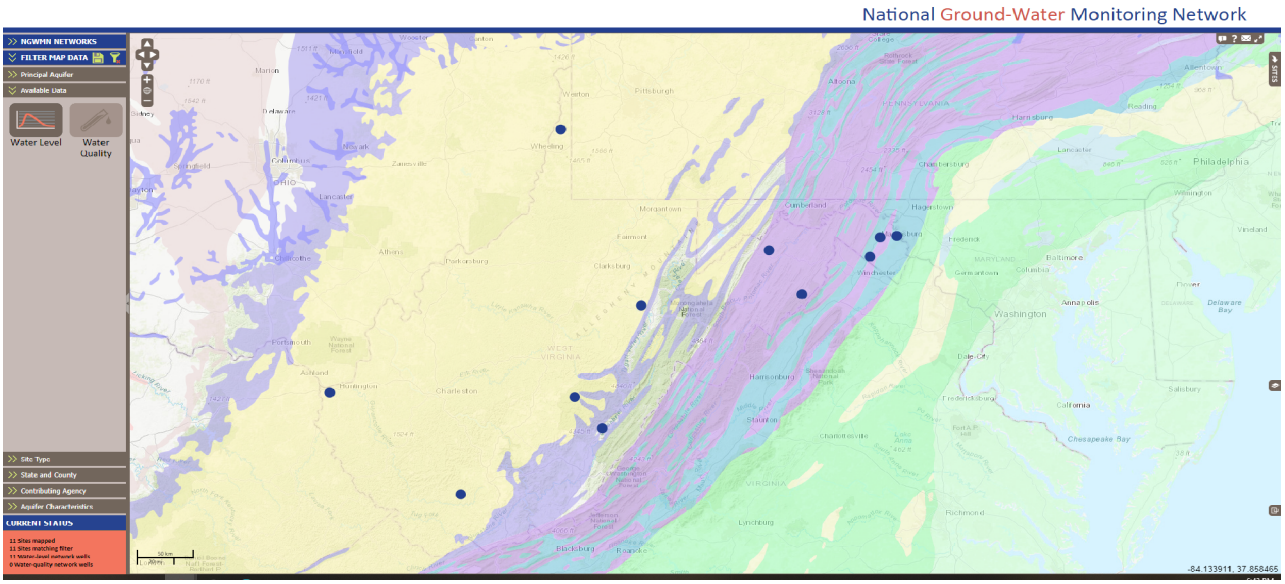

Figure 8. Groundwater use is concentrated in the alluvium along the Ohio River, southern coalfields, and karst aquifer systems of eastern WV (from the National Ground-Water Monitoring Network).

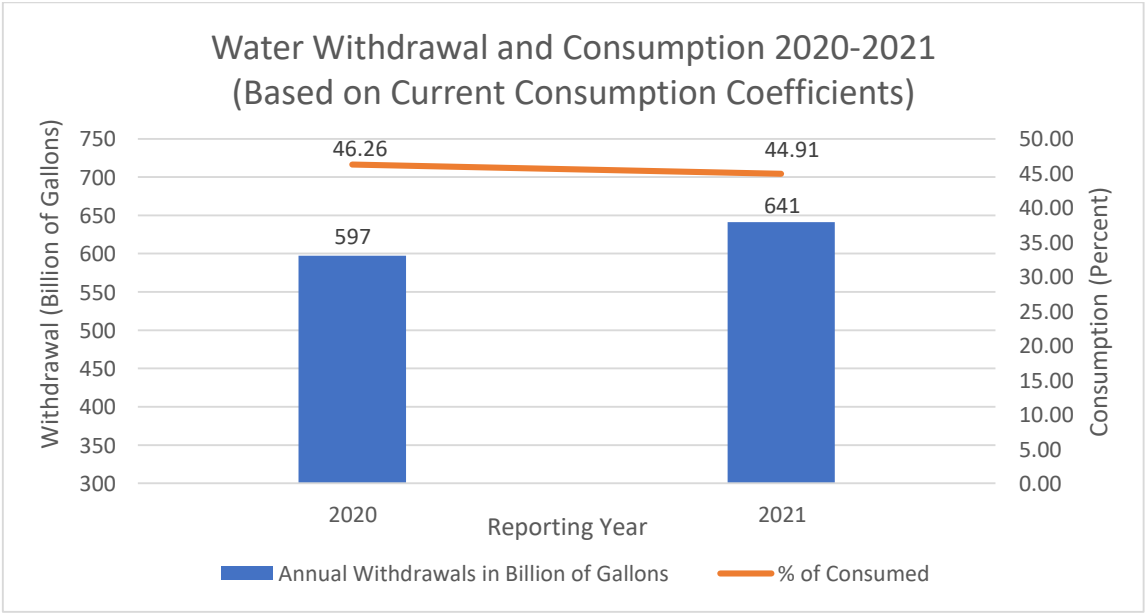

Figure 9a. Water withdrawal and consumption 2020-2021 (based on current consumption coefficients).

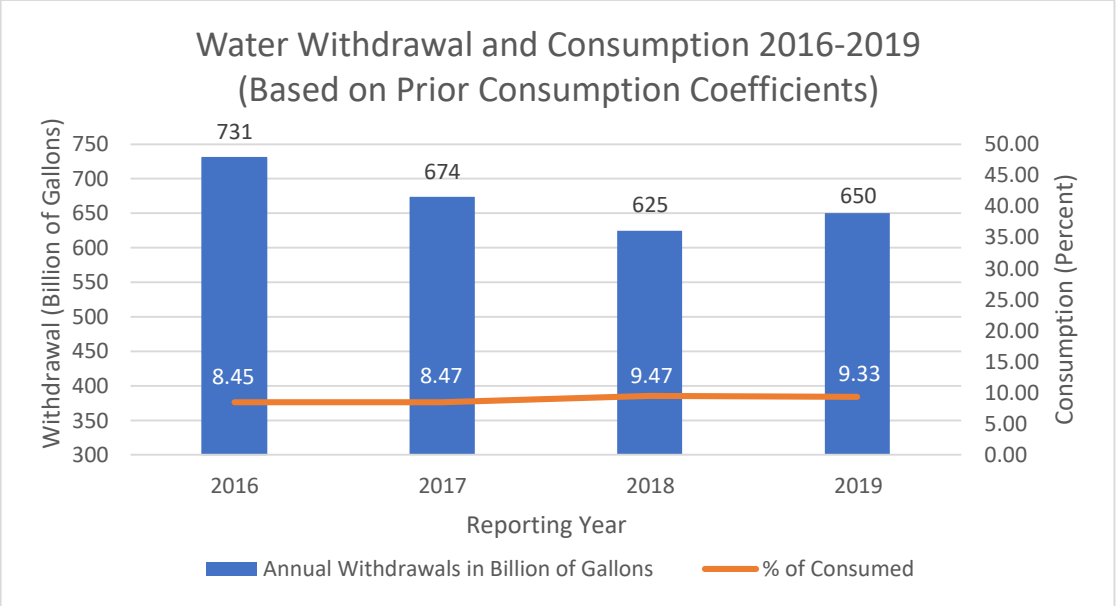

Figure 9b. Water withdrawal and consumption 2016-2019 (based on prior consumption coefficients).

Figure 10. 2021 monthly trends in total withdrawal from the LQU database (WVDEP).

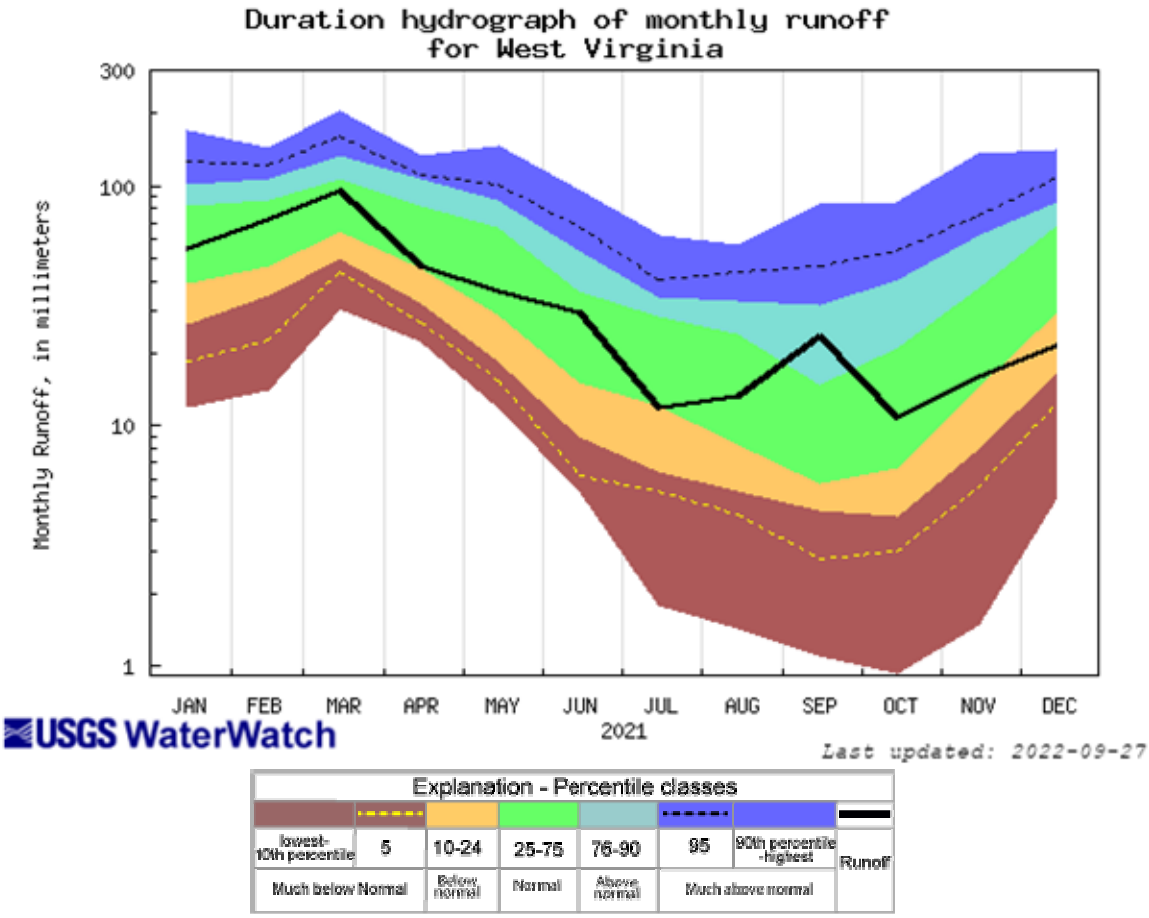

Figure 11. WV 2021 monthly hydrograph. Note logarithmic scale (from USGS).

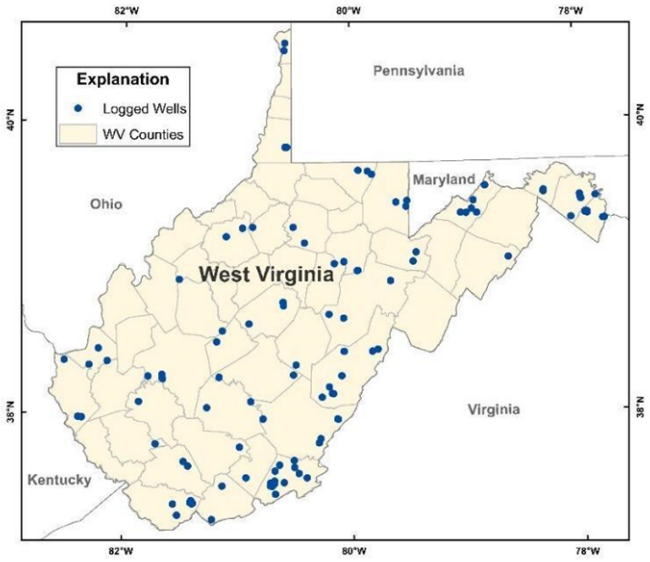

Figure 12. Location of USGS-WVDEP borehole geophysics well logs 2015-2019 (USGS).

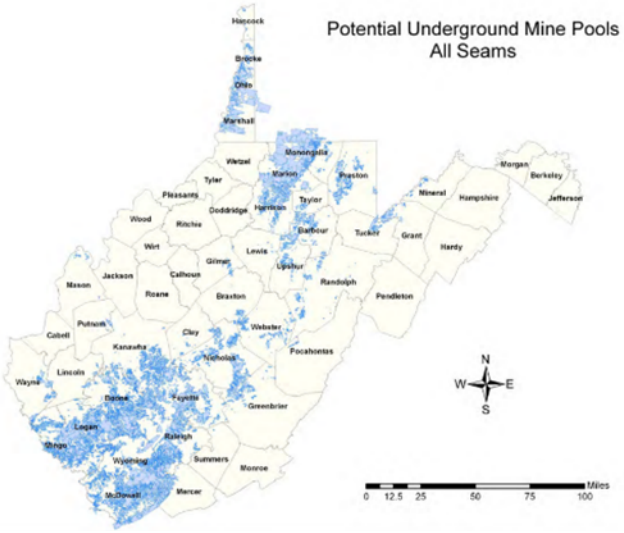

Figure 13. Estimated extent of Abandoned Underground Coal Mine Aquifers (WVGES & WVDEP).

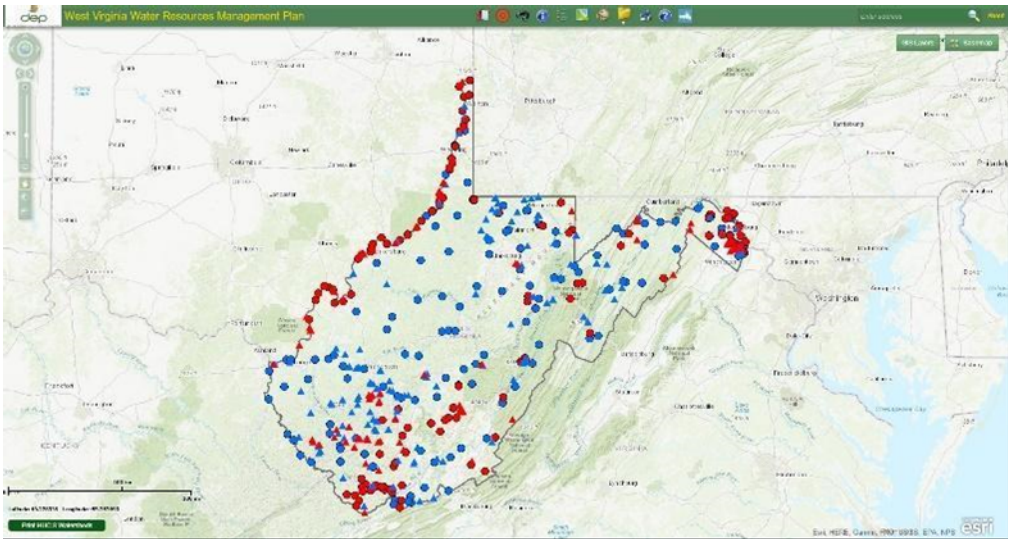

Figure 14. Large Quantity Users from the Water Resources Mapping Tool. Blue – surface water; Red – groundwater (WVDEP).

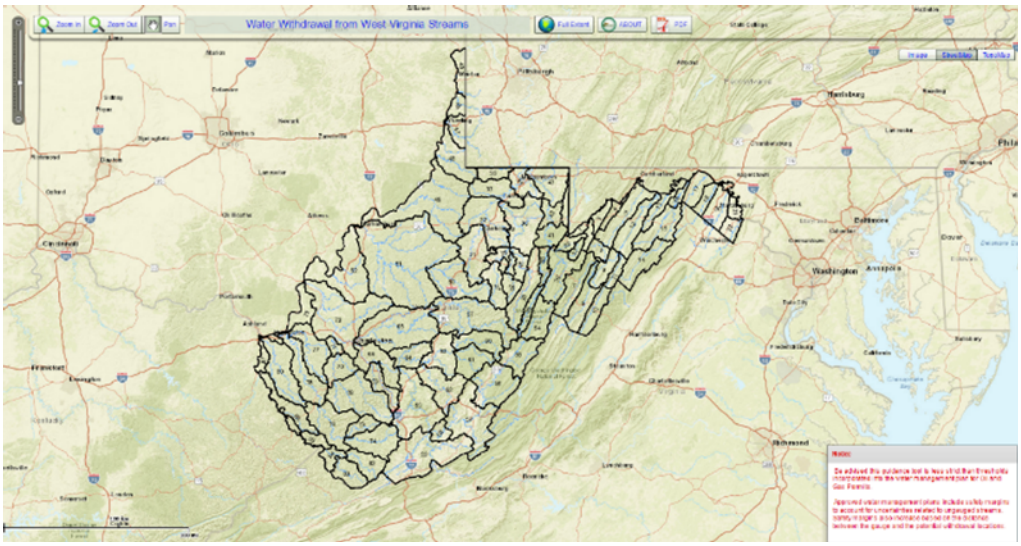

Figure 15. The 86 hydrologic zones of the Water Withdrawal Guidance Tool (WVDEP).

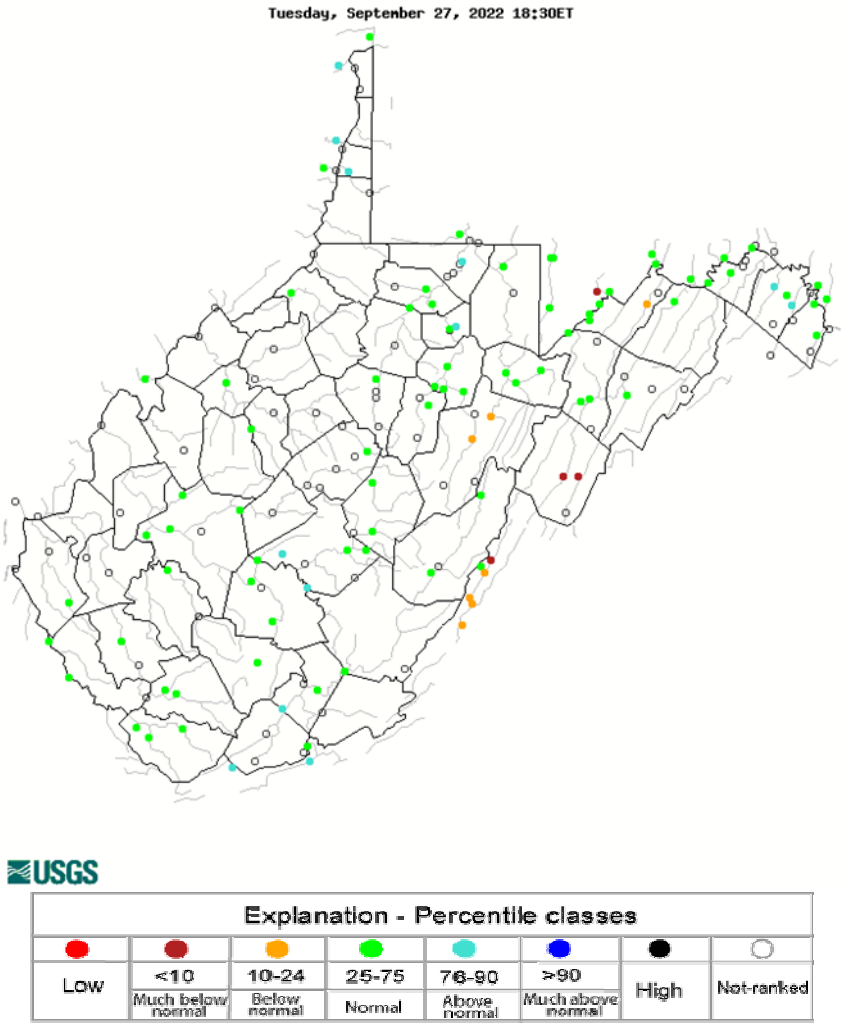

Figure 16. The stream gauge network in WV (from USGS).