

## 2019 ANNUAL REPORT



*West Virginia*  
**WEST VIRGINIA**

## Cover Photos

*Top:* Fold in the Foreknobs Formation, Greenbrier County

*Inset:* Blackwater Falls in the Connoquenessing sandstone of the Kanawha Formation, Pottsville Group, Tucker County



A misty morning at Mont Chateau, home of the West Virginia Geological and Economic Survey

## **West Virginia Geological and Economic Survey**

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Sign at WVGES office

## EXECUTIVE SUMMARY

*B. Mitchel Blake, Jr., Ph.D., Director and State Geologist*

The mission of the West Virginia Geological and Economic Survey (WVGES) is to conduct long-term and project-specific, independent and unbiased analysis of the geology of the state and provide scientific expertise, information, and education to all of West Virginia's stakeholders regarding the coal, natural gas, petroleum, non-fuel resources, environmental concerns, karst, and geologic hazards of the state.

Fiscal Year 2019 (July 1, 2018 to June 30, 2019) was a wonderful year for the West Virginia Geological and Economic Survey (WVGES). State revenues were steady, relieving downward pressures on budgets and allowing us to provide some much needed attention to the Mont Chateau property, the Survey's spectacular home. Aside from routine painting and repairs, we were finally able to replace our antiquated slow-speed copper internet circuit with high-speed fiber. WOW, what a vast improvement! Increased bandwidth and communication speed will allow us to increase our public offerings. In addition, we hired a contractor to bury our electrical lines and prevent the frequent power interruptions we experienced in the past from downed trees. This task should be completed soon.

Deciding on which accomplishments to share in a report like this is difficult. Do I write about the important work we do here investigating the State's energy resources? Do I discuss the downturn in coal production, or the large volumes of natural gas and related liquids being produced in West Virginia? While trying to overcome writer's block, I noticed several young visitors to our museum. Some people believe that geology is a rather small and arcane field of inquiry, but I disagree! I am thrilled to see the total awe on the faces of our young guests as they come face-to-face with actual skeletons and life-sized reproductions of dinosaurs. Looking our juvenile *Allosaurus* in the eye leaves little doubt that she was a fierce predator with her binocular vision and mouth full of teeth.

Our topographic sandbox is another museum feature immensely popular with kids of all ages. As patrons "play" in the sandbox and build hills or dig valleys, the computer recognizes the highs and lows and creates a topographic map on the fly – all in color. When visitors hold their hand over the sand, virtual rain causes rivers to flow and lakes to fill. It is fascinating! Inevitably a little sand spills out, but what a small price to pay for the possibility that one of these young investigators might be motivated to pursue science as a career.



*Fleshed-out juvenile *Allosaurus fragilis* dinosaur model housed at the [WVGES Mini-Museum](#).*

WVGES geologists engage in additional outreach activities to help spread the word about the exciting geology of our beautiful State. Several of us are privileged to participate in the "Stump the Paleontologist" program held twice yearly at the Grave Creek Archeological Complex in Moundsville. I am amazed how many people show up with boxes full of treasures for us to identify. Clearly, there is a lot of interest in geology. I am sorry to report, however, that I frequently play the role of heartbreaker, having to tell someone that their prized rock is not a fossil turtle or a fossilized leg bone. WVGES geologists also engage in other outreach and educational projects such as our popular "Visiting Geologist Program" at various State Parks, and our cooperation with the USGS and WVU on the Appalachian Geoscience GeoCamp (<https://adventurechallenge.wvu.edu/usgs-geocamp>).

So in the end, I have to disagree with those who think geology is a small and arcane field. While geologists do appreciate the earth differently than others, we happily share our understanding with the citizens of West Virginia. Therefore, I invite everyone to visit our small, but growing museum and peruse the following pages detailing the work of WVGES and our partners over the past fiscal year.



*Geologists examine a coal bed in the field*

## COAL RESOURCES PROGRAM

FY2019 was a busy year and a year of changes for the Coal Program. Staff were involved in field mapping, sample collection, service requests from the public, semi-annual updates submitted to the West Virginia Department of Revenue – Property Tax Division (WVPTD), and various outreach projects throughout the Mountain State.

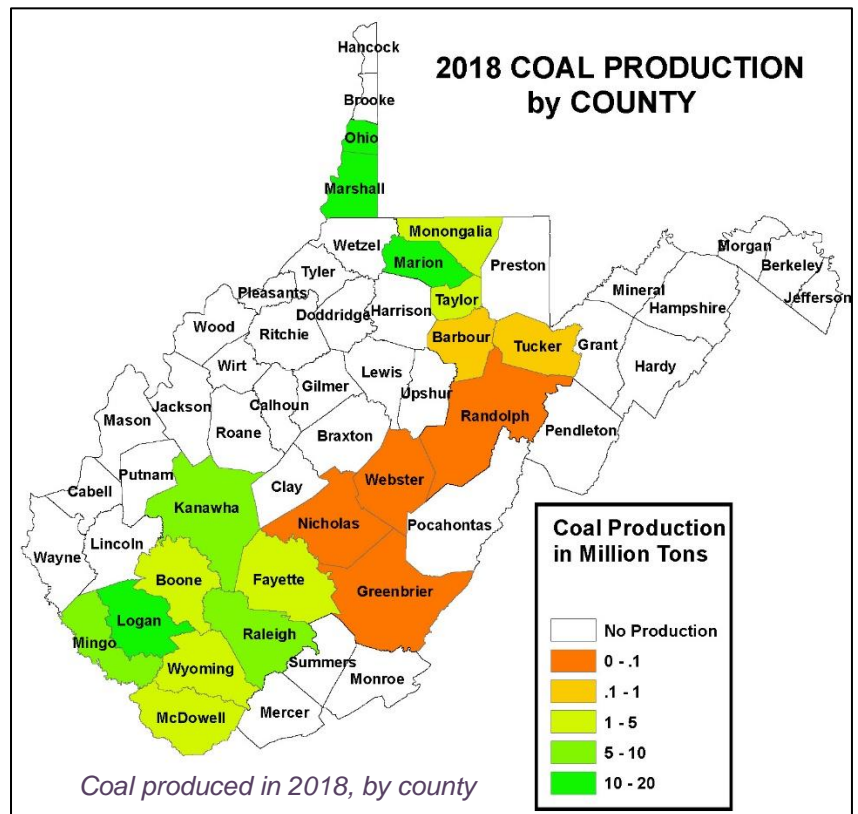
### Coal Bed Mapping

Although coal mining in the Mountain State has decreased from a production high of 165 million tons in 2008 to 104 million tons in 2018, it is important to maintain a reliable, accurate, and up-to-date database of mined and mineable coal for environmental, safety, and property-tax valuation purposes.

Coal Program staff are continuing a legislatively mandated, multiyear project to update and map all mineable coal beds in West Virginia in a modern GIS format. While the majority of coal beds in the state have been mapped, new data continuously received from industry, WVPTD, and the Office of Miners Health, Safety and Training necessitate constant updating of the coal data GIS layers. In addition, a few problem areas remain in the central and eastern portions of the state where data are sparse.

Industry and WVPTD provided several hundred new drill-core logs, and Miners Health, Safety and Training delivered a large volume

of newly scanned mine maps for Coal Program staff to process and analyze in FY2019. All of this information was incorporated into the data model, and GIS-based feature classes were created for 85 coals seams and associated splits. These feature classes include study area, outcrops, mined and remaining coal by mining type, structural contours and associated grids showing total seam thickness, total coal thickness, percent coal partings, and overburden. Staff continually update coal bed parameter maps as new data become available and serve all products to the public via the Survey’s website at <http://www.wvgs.wvnet.edu/www/coal/cbmp/coalims.html>.





View from the Highlands Scenic Highway, WV Rt 150, Pocahontas County

- **Underground Mine Mapping Project**

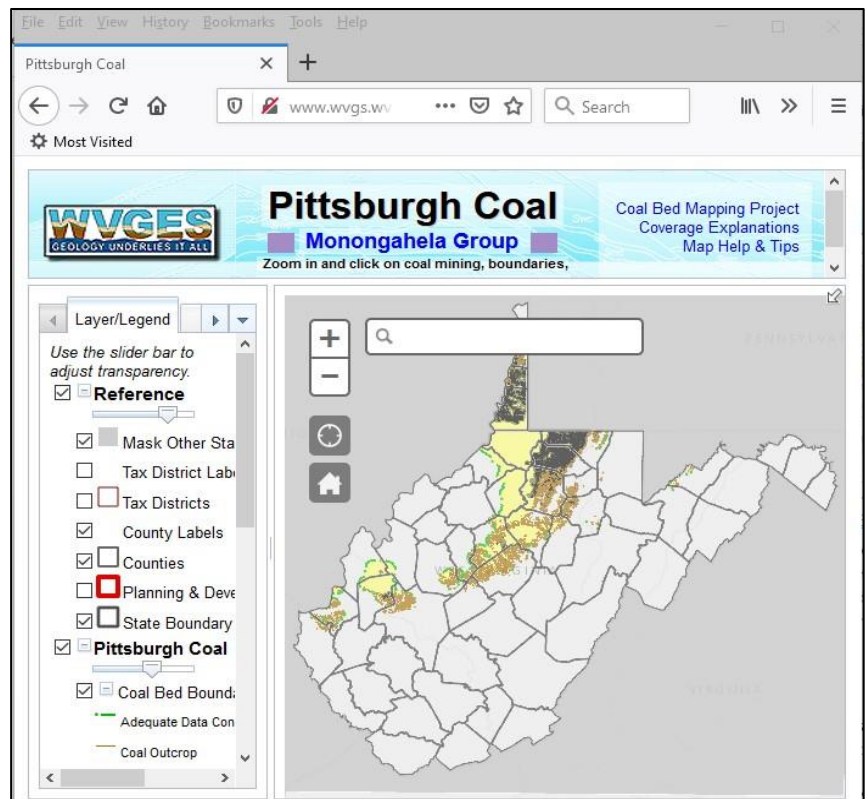
WVGES Coal Program geologists, in cooperation with the West Virginia Office of Miners Health, Safety and Training, process new and legacy mine maps delivered quarterly to the WVGES. Miners Health, Safety and Training collects and scans modern and vintage mine maps and property maps obtained from various sources, including engineering companies, coal companies, and private individuals who possess legacy data. In FY2019 WVGES received 1,332 mine maps representing

5,805 individual mines, most of which were processed and added to the data model in FY2019. Processing continues on the remainder.

Many of the newly obtained mine maps depict mines already in the WVGES database. However, due diligence requires that each map be georeferenced and examined for potential new data. Using this method, small portions of existing mines have been added to the database and several entire mines have been added in areas of known historic mining where maps had been previously unavailable. In addition to updating mined areas from these maps, several

thousand new coal thickness and elevation points were added to the Coal Bed Mapping Project (CBMP) model. Some of these

areas were previously underpopulated with data, and areas not known previously to be extensively mined were located with this additional mapping. These additions to the CBMP database increase the accuracy of the data model and the information available to the public, industry, government, and WVPTD, and serve to protect miners, land owners, and citizens from current and previously unknown hazards while allowing for more accurate property tax valuation.



A screenshot of the Pittsburgh Coal from the online Coal Bed Mapping Project, [www.wvgs.wvnet.edu/GIS/CBMP/Pittsburgh.html](http://www.wvgs.wvnet.edu/GIS/CBMP/Pittsburgh.html)



Debris and melting ice damming against the Ices Ferry Bridge on Cheat Lake, March 4, 2015

- **Mine Information Database System**

The WVGES Mine Information Database System (MIDS) houses publically accessible information collected from mine maps, including mine location (county and quadrangle with latitude and longitude coordinates), coal bed name, company name, mine name, permit numbers, and other notes. MIDS contains records for every mine map publically available at WVGES, including more than 49,000 documents representing over 89,000 mines. WVGES strongly encourages comments and submissions from the public to make a better and more complete database. These data can be accessed on the WVGES website at <http://www.wvgs.wvnet.edu/www/mids/main.php>.

#### **Rare Earth Elements (REE) Study**

*In FY2019 WVGES staff continued to examine West Virginia coal measures and associated strata to increase our understanding of where REEs may be concentrated.*

*REEs are a strategically important resource for the United States' defense, industrial goods, and personal products, and identifying domestic sources is a high priority for both state and federal governments. Following the culmination of a project funded by the US Department of Energy to identify potential REE feedstocks in the Northern and Central Appalachian coal measures, WVGES continues to collect and analyze samples for REEs to refine our understanding of the distribution of these important elements. Much of this work is performed via analytical laboratory services at West Virginia University's National Research Center for Coal and Energy.*

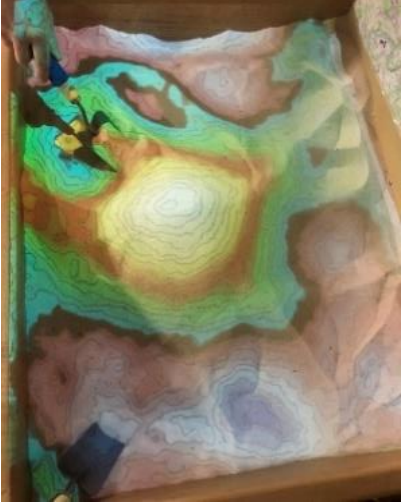
*This follow-up work not only characterizes REE concentrations, but also adds information to the Coal Chemistry database with data such as moisture, ash content, sulfur yield, volatile matter, and BTUs. Results of the analyses will be used to inform future detailed, site-specific studies in West Virginia.*

- **Bi-Annual Updates for Property Valuation**

Coal Program geologists completed the review, updating, remapping, and quality control for each of the 85 mapped coal seams in the state, and delivered these data digitally to WVPTD during the fiscal year. WVPTD in turn used these updated data sets to assess coal severance taxes for the state, a major source of revenue for West Virginia.

- **Coal Bed Chemistry Database**

The CBMP Coal Bed Chemistry Database serves non-confidential coal analyses on West Virginia coal samples to users. Following decades of coal sampling and accumulating volumes of data from coal company records and other sources, a robust database has been created which includes coal analyses, accessory minerals, and Rare Earth Element (REE) data. WVGES houses a large collection of processed coal analyses from coal samples. Researchers have been reanalyzing selected samples for REEs, and those results are added to the database. Currently the database is not readily accessible to the public, but the Coal Program is creating an online interface to allow users to search, query and download coal and chemical analyses from our inventory. In the meantime, individual requests for data are answered by Coal Program staff.



*The Augmented Reality Sandbox: A computer projector overlays an interactive topographic map onto sand. By modifying the sand, visitors learn how geomorphologic processes change a landscape and how that landscape is represented on a topographic map*

### **State Park Sandbox Program**

WVGES staff began a partnership with West Virginia State Parks to build and set up three “Augmented Reality Sandbox” units which will be placed at various State Parks. These special sandboxes are similar to the existing sandbox located in the WVGES museum and discussed by the Director in his introductory remarks. These displays are hands-on exhibits that combine a common sandbox with 3D visualization applications created by researchers at the University of California at Davis. The sandboxes project topographic lines onto the “mountains” and “valleys” that users create by molding the sand; it is a powerful teaching tool that allows users to better understand topographic maps and geomorphology.



*A geologist collects a field measurement.*



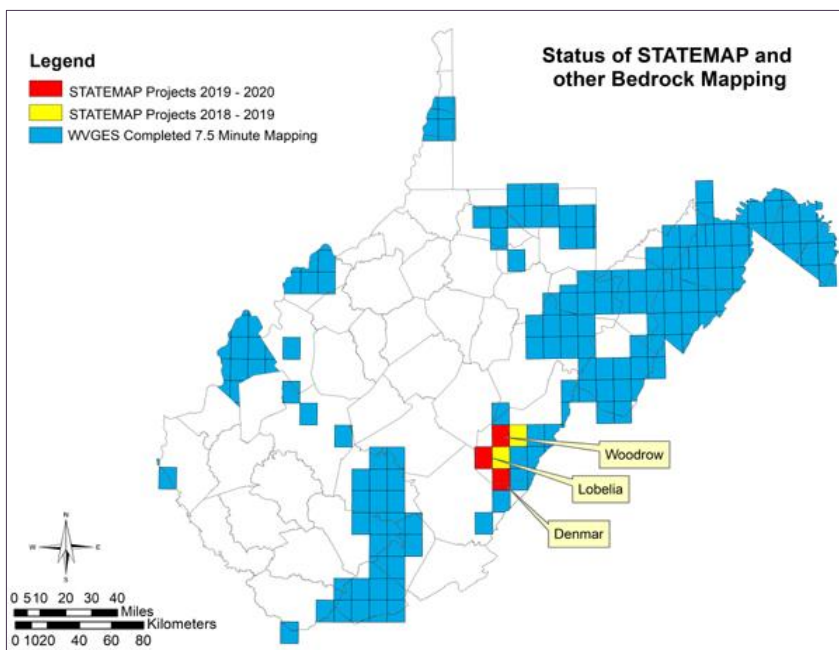
Vertical view of mudcracks in the Greenville Shale, Pocahontas County

## GEOSCIENCE AND MAPPING PROGRAM

### Geologic Mapping

Some of the most important products a geological survey can provide are bedrock geologic maps. Geologic mapping at WVGES includes the direct acquisition of new geological information through field reconnaissance, examination of new high-resolution digital imagery, and geochemical analysis of rock samples, in addition to the compilation of new and legacy data into digital format. Currently, WVGES geologists are mapping in southeastern West Virginia, primarily in Greenbrier and Pocahontas counties. As part of these bedrock-mapping projects, geologists are endeavoring to map the constituent formations of the Greenbrier Group of limestones that create the karst terrain so prevalent in this region.

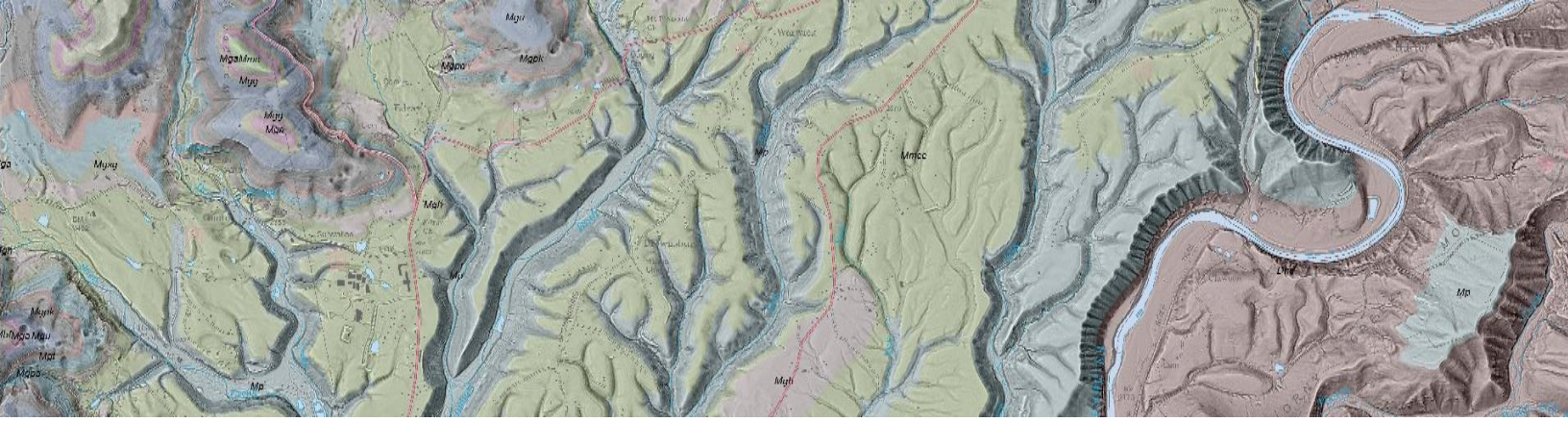
- Acquisition of new geological data is carried out under the STATEMAP program funded jointly by the United States Geological Survey (USGS) and WVGES. During Fiscal Year 2019, WVGES geologists completed field work on the Edray and Hillsboro 7.5-minute quadrangles in Pocahontas County, West Virginia, shown in yellow on the map below. Published as WVGES Open File Reports, these geologic quadrangles are available as paper maps, PDF files, and geographic information systems (GIS) geodatabases.



- In August 2018, the STATEMAP Advisory Committee, composed of individuals from industry, government, and academia, met to evaluate new potential areas to map within West Virginia for the upcoming field season. In November 2018, WVGES submitted a proposal to the USGS and in March 2019 received partial funding to map the Lobelia, Denmark, and Woodrow quadrangles in Greenbrier, Pocahontas, and Webster Counties (shown in red on the map to the left).

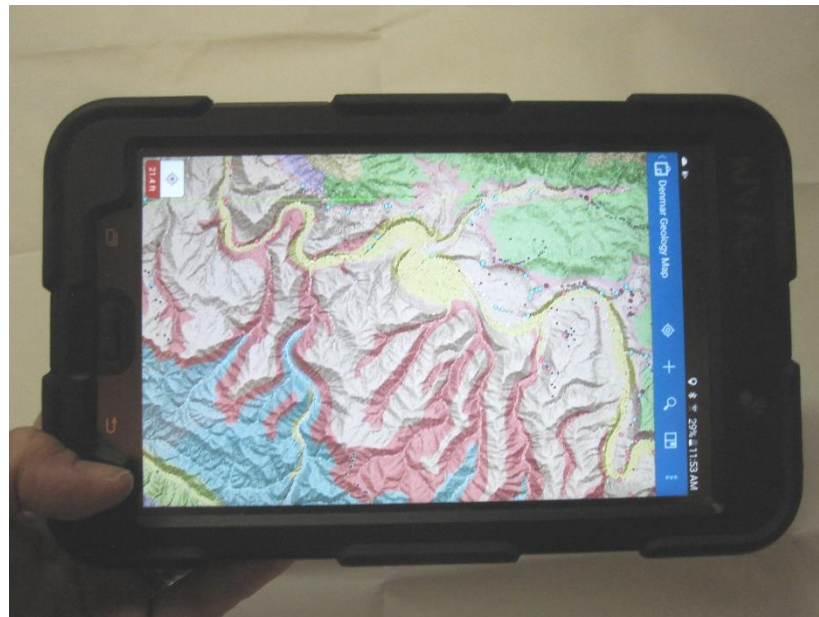
STATEMAP Bedrock Mapping Status for Fiscal Year 2019





*A portion of the geology of the Edray quadrangle draped over enhanced LiDAR imagery*

- Tools available for field mapping are continuously evolving and changing. WVGES mappers now collect and utilize digital data in the field with handheld mapping units (shown below) which help standardize data collection. Geologists transfer field-collected data to in-house desktop computers and use powerful GIS software to create geologic maps. Prior to conducting field work, staff utilize high-resolution LiDAR imagery to “see through” dense vegetation and identify previously hidden topographies, allowing for better-planned field investigations and improved efficiencies in field-data collection.
- This fiscal year, WVGES sent a representative to the first Geologic Mapping Forum where geologists from state, federal, and partner agencies gathered to discuss current trends in geologic mapping using GIS facilities.



*Handheld mapping unit using GIS software showing geologic contact lines on a LiDAR imagery base.*

- WVGES acquired a Gigapan camera system this year to document geological features in the field. Extremely high-resolution image products created from this setup are used in technical reports, detailed scientific study, and outreach. These images are used in [A Geologic Transect Across West Virginia!](http://www.wvgs.wvnet.edu/www/geology/geologic_transect.html) found on our website at [http://www.wvgs.wvnet.edu/www/geology/geologic\\_transect.html](http://www.wvgs.wvnet.edu/www/geology/geologic_transect.html).



*Lost World Caverns in Greenbrier County, taken with the WVGES Gigapan system*

## **Karst**

Rocks commonly containing sinkholes, springs, caves, disappearing streams, and similar karst features are gathering attention due to their unique characteristics and environmental susceptibility. WVGES geologists are focusing on documenting and characterizing karst-bearing rocks, features, and landforms using recently acquired high-resolution LiDAR imagery and field observations. Moreover, the area of current geologic mapping was chosen because it contains karst-bearing rocks. Understanding karst systems is key to understanding groundwater flow and the potential effects of oil and gas drilling and other industrial construction through karst terrains.

## **Geochemical Analysis**

WVGES continues to add new data to its stratigraphic geochemical database. Geochemical analyses for 49 rock samples were added to the existing database this fiscal year, bringing the total number of samples up to 1,152 and covering West Virginia rock units ranging in age from Precambrian through Pennsylvanian. The geochemical database is available as a GIS layer that can be combined with other maps of West Virginia for use in environmental and economic assessments of the near-surface bedrock of a particular geographic location.



*WVGES geologists examine the Bob's Ridge sandstone in Pocahontas County*

WVGES has been collecting rock samples, in addition to coals, to aid in the understanding and availability of Rare Earth Elements (REEs) in selected geologic units in West Virginia. To accommodate REE studies, WVGES has increased the number of elements analyzed from each sample. As discussed under the Coal Program, WVGES has been examining the potential for REEs in coal beds and associated intervals for several years. More recently, WVGES has been sampling and analyzing the Devonian Bob's Ridge sandstone for REE potential.



Ooids in the Union Limestone, Pocahontas County

## Geothermal Resources

During the fiscal year, WVGES continued to participate in a U.S. Department of Energy-sponsored project entitled *Feasibility of Deep Direct Use Geothermal on the West Virginia University Campus – Morgantown, WV*. The goal of this ongoing project is to assess the possibility of replacing an existing gas-fired steam generation facility with one using geothermal formation water derived from a reservoir below the WVU campus in Morgantown. WVGES geologists are tasked with investigating the reservoir characteristics of the Silurian Tuscarora Sandstone to help determine its suitability as an alternative

energy source and have collected over 2,200 permeability measurements from Tuscarora cores stored in the WVGES core holdings. More information on this project is included in the Oil and Gas Program portion of this report.

### Geoscience and Mapping for FY2019

#### By the Numbers:

- 2 new bedrock geologic maps completed
- 3 new bedrock geologic maps in progress
- 6 active seismic (earthquake) monitoring stations throughout the state
- 1,152 total number of rock samples analyzed geochemically (49 new this fiscal year)

## Seismic Monitoring

One small earthquake occurred in West Virginia during the fiscal year. Summaries of this earthquake, other earthquakes recorded in West Virginia, Maryland, Ohio, Pennsylvania, and Virginia, as well as large ( $\geq 6.0$  magnitude) earthquakes from around the world are posted on the WVGES website at

[www.wvgs.wvnet.edu/www/earthquakes/seismic.html](http://www.wvgs.wvnet.edu/www/earthquakes/seismic.html).

WVGES maintains a permanent seismic-monitoring station at its office in Morgantown. In addition, five other seismic-monitoring stations continue to operate in the state. These five stations remained at the end of the Transportable Array Project, formerly part of the Central and Eastern United States Network operated by the Incorporated Research Institutions for Seismology with funding from the National Science Foundation. USGS has now taken over their support.



*GeoCamp students in the classroom*

## **Outreach Activities**

Beyond the aforementioned projects and tasks, geoscience personnel consistently provide geologic information to the state in many different outreach capacities. In the past year this included responding to inquiries directly at the WVGES office but also included visits to schools, public meetings, interviews, science fairs, and responding to state government inquiries about geology. These inquiries include, but are not limited to, earthquakes, landslides, water-well contamination, and radon risk potential.

- WVGES geologists, in partnership with the USGS and West Virginia University's Adventure WV Outdoor Education Center, conducted a week-long summer GeoCamp for high school students interested in science, technology, engineering, and math activities focusing on the earth sciences (GEOSTEM). Mini-classes hosted by WVGES geologists in the classroom and in the field included earthquakes, orienteering, fossil collecting, mapping, caving, a geologic whitewater rafting trip, a geologic field trip to Seneca Rocks, Judy Gap, Canaan Valley, and Blackwater Falls, a bicycle trail ride along reclaimed mined areas, a geocaching trip to Coopers Rock State Forest, and discussions about acid-mine drainage, mining processes, and earthquakes.



*WVGES geologists and GEOSTEM GeoCamp students at Laurel Caverns in nearby Pennsylvania, explaining geologic concepts, caving, and safety*

- For over 25 years, in cooperation with the West Virginia Division of Natural Resources, WVGES staff have visited selected state parks to give presentations on state and local geology. This fiscal year, a Visiting Geologist gave popular evening presentations at seven state parks on *The Geology of West Virginia* followed by a morning field trip showcasing local park geology.

## **Geoscience Education Web Page**

WVGES continues to host a vast amount of digital content on our website, <http://www.wvgs.wvnet.edu/www/geoeduc/geoeduc.htm>, providing K-12 teachers with products designed for their classroom use. New content has been added to this website and more content is being developed.



*The Alderson Limestone in Pocahontas County*

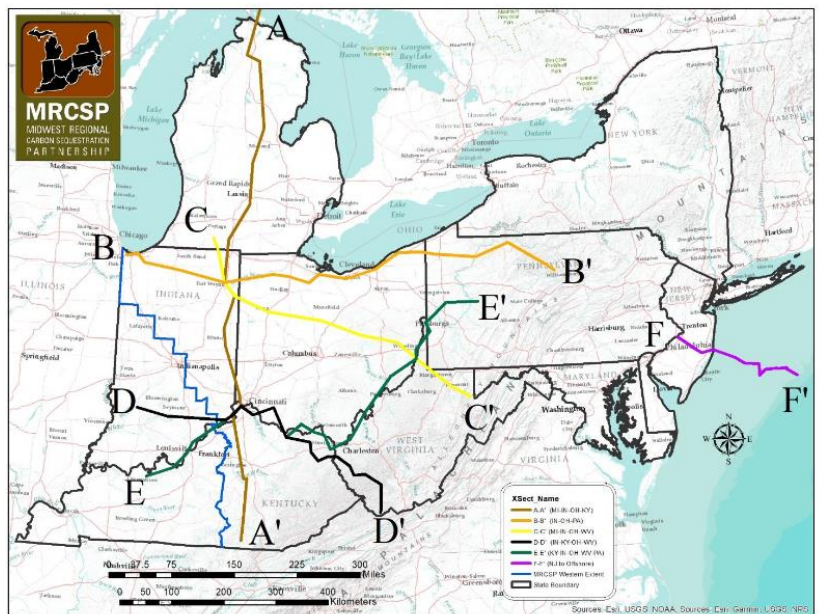
## OIL AND GAS PROGRAM

During FY2019 WVGES staff prepared a comprehensive GIS-based database of oil and gas fields, encompassing a ten-state region and accompanied by a set of cross-sections, to illustrate subsurface opportunities for CO<sub>2</sub> storage and utilization; assessed the viability of the Tuscarora Sandstone as a low-temperature geothermal reservoir for West Virginia University; developed enhanced cataloging techniques to inventory and preserve physical samples; and continued to monitor the production and development of unconventional natural gas targets such as the Marcellus, Utica/Point Pleasant, and Rogersville shales.

### CO<sub>2</sub> Storage and Utilization: Historical Fields and Future Trends

The Oil and Gas Program continues to research aspects of reservoir characterization related to carbon capture, utilization, and storage conducted as part of the Midwestern Regional Carbon Sequestration Partnership, or MRCSP, a project compiling data related to the geologic framework of a ten-state region extending from Michigan to New Jersey.

During FY2019, our geoscientists worked to finalize a database of field-level characteristics of reservoirs amenable to enhanced oil or gas recovery via CO<sub>2</sub> floods. The Oil and Gas Fields database contains more than 60,000 individual entries and includes information on acreage, porosity, permeability, and CO<sub>2</sub> storage capacity. This database serves as a complement to a set of regional cross-sections constructed to illustrate the geologic framework of individual reservoirs. Six east-to-west cross-sections neared completion as of June 30, 2019: one north-to-south section extending from Michigan to Kentucky (A-A'), five west-to-east sections extending from the western portion of the MRCSP region to various locations in Pennsylvania and West Virginia (B-B' to E-E'), and one onshore to offshore section in New Jersey (F-F'). Each cross-section utilized 15 to 25 deep wells preferentially selected to provide information on depth, unit thickness, subsurface location, and subsurface geometry. In addition, the subsurface units are color-coded based on the unit's potential as



*Locations of the six regional cross-sections constructed as part of the MRCSP. WVGES served as task leader for MRCSP Phase 3, Task 1.4.*



The vertical Tuscarora Sandstone forms Seneca Rocks in Pendleton County

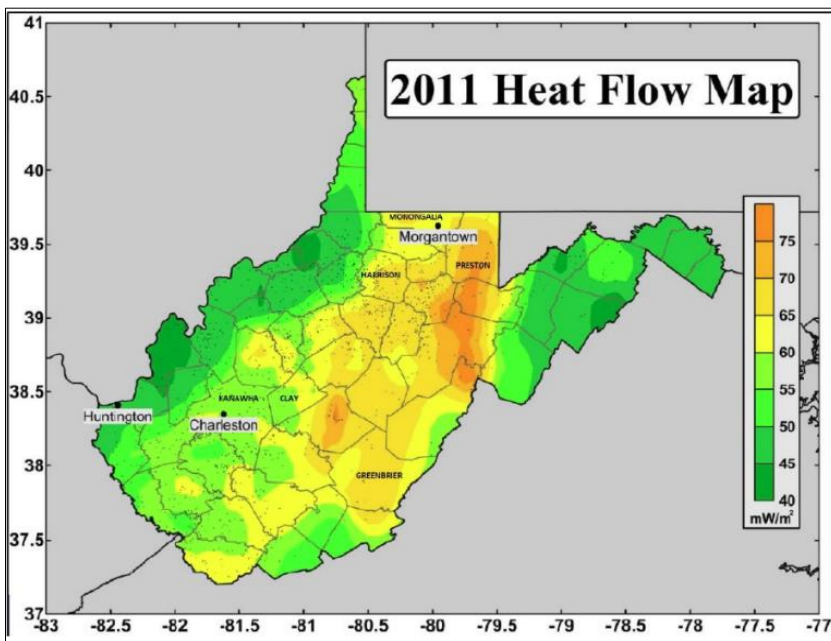
either a storage reservoir, a confining interval, or a unit with localized storage potential. These cross-sections are designed for use by a variety of stakeholders, including fellow geoscientists, policy makers, and the general public, and will be available on the WVGES web site when the project is completed in FY2020. In the meantime, poster presentations with information on the database and the cross sections are available on our web site at

[http://www.wvgs.wvnet.edu/www/presentations/posters\\_presentations.htm#MRCSP\\_Database](http://www.wvgs.wvnet.edu/www/presentations/posters_presentations.htm#MRCSP_Database) and [http://www.wvgs.wvnet.edu/www/presentations/posters\\_presentations.htm#MRCSP\\_Cross\\_Sections](http://www.wvgs.wvnet.edu/www/presentations/posters_presentations.htm#MRCSP_Cross_Sections).

### Tuscarora Sandstone: Geothermal Reservoir for WVU?

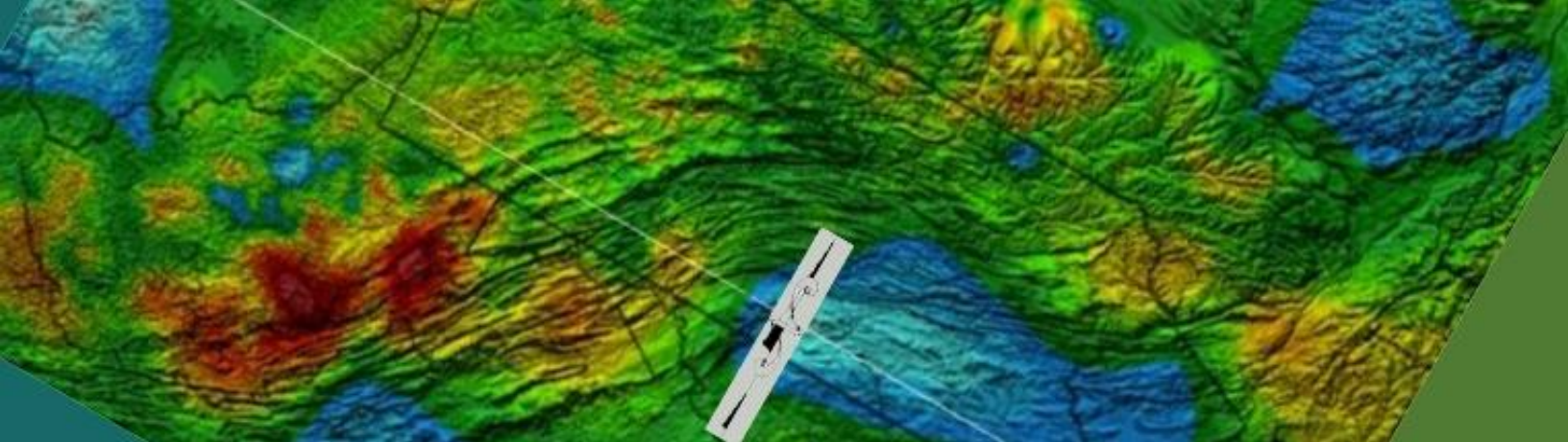
In outcrop, the Silurian Tuscarora Sandstone forms some of West Virginia's most impressive peaks, including the iconic Seneca Rocks, where the white, super-mature, quartz sandstone is thrust almost vertically and exposed at the surface. In FY2019 WVGES geoscientists worked on a very different study

of the Tuscarora, this time from subsurface samples. The study, conducted by the West Virginia University Energy Institute and funded by the U.S. Department of Energy, looked at another unique feature of the reservoir – its ability to serve as a geothermal heat source for West Virginia University. The Tuscarora sits approximately 10,000 feet below land surface near Morgantown and is in proximity to a geothermal hot spot identified in Southern Methodist University's Geothermal Laboratory Heat Flow Map of the Conterminous United States (Blackwell et al., 2011). Working in coordination with the West Virginia University Energy



Blackwell (2010) and Garapati (2019)

Institute, WVGES investigated the porosity and permeability of the Tuscarora. The permeability was measured on a core collected from nearby Preston County and compared to qualitative measurements of permeability obtained from CT scans acquired by the U.S. Department of Energy's National Energy Technology Laboratory. Project scientists at WVU, Cornell University, and the University of California at Berkeley used this information to develop geologic and heat-flow models of the reservoir.



Portion of geothermal heat flow map from Blackwell et al., 2011 showing West Virginia and nearby states (redder is hotter)

### Data Preservation: Curating the State’s Rock Collection

Physical samples warehoused within WVGES’ auxiliary storage facilities represent the most comprehensive collection of rock-core and well-cuttings samples in the state of West Virginia. Many of these samples, particularly the coals, were collected from locations that are no longer accessible. Requests for access to these samples by industry and academia are frequent: as scientists develop new analytical techniques and make new discoveries, the physical samples are revisited for new testing and new data. By requiring outside researchers to submit the results of their analyses to the state, WVGES is able to collect advanced analytical data sets at no cost to the taxpayer.

Unfortunately, properly curating such a large, physically unwieldy, and diverse collection is complicated. In support of these efforts, the USGS makes funds available to the states to inventory, preserve, and rescue collections at risk, and to make information on these collections digitally available. During FY2019 the National Geological and Geophysical Data Preservation Program funded our efforts to continue implementing bar-code inventory systems for the WVGES Oil and Gas Program’s core and cuttings collections and to acquire core boxes and shelving to re-box and store core from key wells within our core-sample collection.



WVGES drill cuttings samples before bar-coding (A.) and after (B.). Inset image shows database information embedded in the bar code

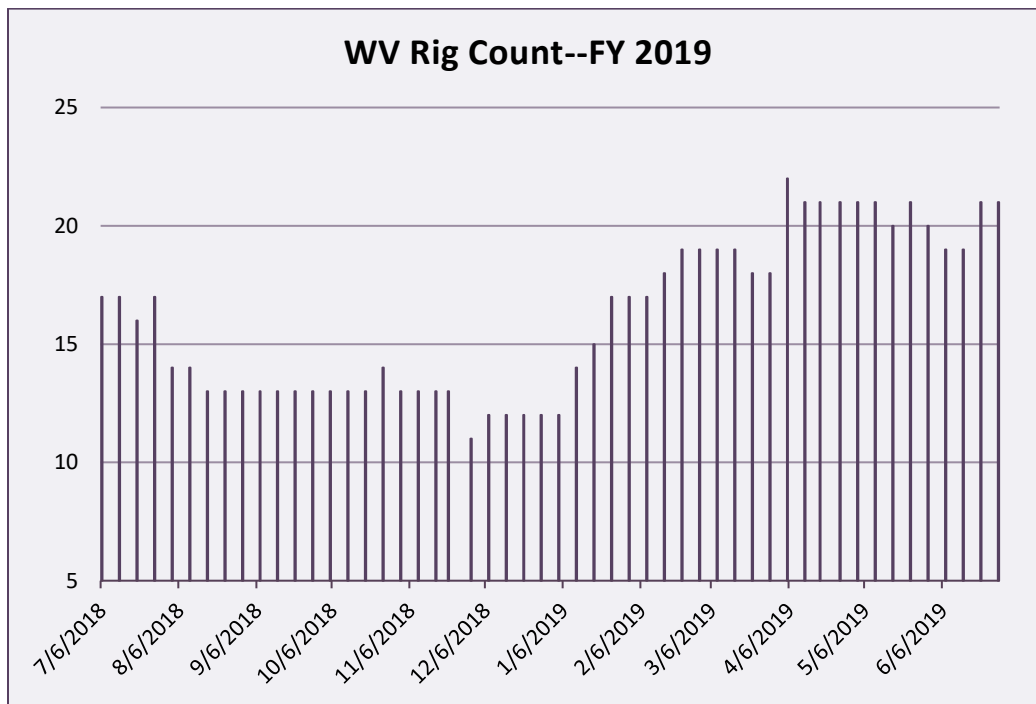
### The Marcellus, Utica, and Rogersville Shale Plays: Annual Developments

Staff in the WVGES Oil and Gas Program continue to report on the nuances of subsurface geology that influence production trends throughout the state. In a narrower perspective, we observe the industry tightening their radius of development, honing in on the regions and technologies that will sustain efforts to operate through relative downturns in the industry.



*The Taggard Formation in Pocahontas County*

Rig counts in West Virginia varied throughout the fiscal year. At the beginning of FY2019 (July 1, 2018), seventeen rigs were operating in the state, according to industry service company Baker Hughes (see below). This number declined to a low of eleven the week of November 30, 2018, but then climbed steadily to a maximum of 22 in April of 2019. Twenty rigs were operating at the end of the fiscal year (June 30, 2019).

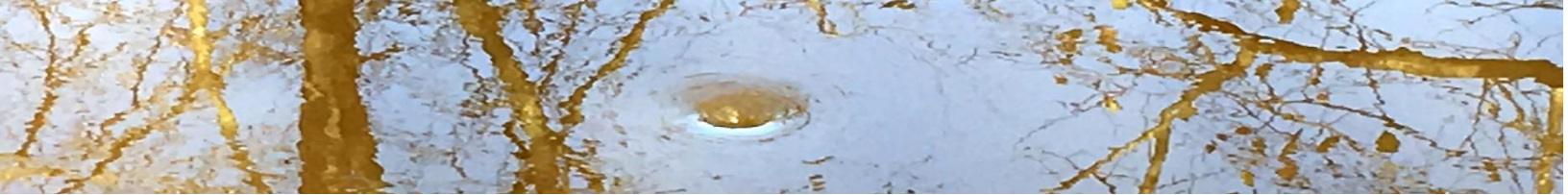


*West Virginia rig counts, recorded weekly, during FY2019*

- **Marcellus**

The number of wells completed this fiscal year in the Middle Devonian Marcellus Formation increased significantly from the previous year. Ninety-eight Marcellus wells were completed in FY2018, while this year, in FY2019, 198 wells were completed in the Marcellus, more than double the previous year. The number of Marcellus wells permitted for drilling during the same time frame remained fairly static: 473 wells permitted in FY2018 and 461 in FY2019. Lateral length for wells in the Marcellus ranges from 4,375 feet to 15,556 feet, with an average lateral length of 9,520 feet. The number of completion stages ranged from 19 to 105, with an average of 48 stages per well. Antero Resources Appalachia completed the highest number of wells; the number of deviated (mostly horizontal) well completions in FY2019 by operator is listed in the table on the next page.





Whirlpool in a cenote (water-filled sinkhole), Greenbrier County

- **Utica/Point Pleasant**

Understanding the distribution of the individual shale units in the Upper Ordovician “Utica” lags behind the Middle Devonian Marcellus for several reasons. The Utica/Point Pleasant is a deeper target, which increases drilling costs and limits the number of wells that can be economically drilled. It is positioned stratigraphically below the Salina Formation, a thick and complex succession of halite, anhydrite, shale, and limestone. The unpredictable bedding of the Salina, coupled with complexities of fluid-based drilling through these evaporites, also increases drilling costs. Then, once the borehole reaches its target, the formation itself presents several challenges. Original reservoir pressures in the Point Pleasant, as estimated by operators on well permits, are greater than 10,000 pounds per square

inch (psi), with pressure gradients ranging from 0.53 psi/ft. to a staggering 0.95 psi/ft.

For those willing to assume the additional drilling risk, the Utica/Point Pleasant presents an attractive target. At the conclusion of FY2019, WVGES records show 21 Utica/Point Pleasant wells online and reporting production. Cumulative production as of the end of calendar year 2018 for the 21 wells is more than 77 Billion cubic feet (Bcf), and most of those wells have been online for fewer than four

Operator Name	Number of Completions	Formations Completed
Antero Resources	108	Marcellus
Chevron Appalachia	22	Marcellus
CNX Gas Company	5	Marcellus
Core Appalachia	2	Lower Huron
EQT Production Company	15	Marcellus
HG Energy II Appalachia	2	Marcellus
Jay-Bee Oil and Gas	1	Marcellus
Noble Energy*	1	Marcellus
Northeast Natural Energy	3	Marcellus (2), Price (1)
Stone Energy*	1	Marcellus
SWN Production Company	34	Marcellus (32), Burket (2)
XTO Energy	4	Marcellus
<b>Total FY 2019 Completions</b>	<b>198</b>	<i>*Wells may have been completed by joint venture operator or purchase partner.</i>

Number of deviated wells completed, by operator, for FY2019

years. Annual production for 2018, the latest year for which production data are available, is 22.5 Bcf, with individual well production totals ranging from 0.87 to 4.6 Bcf. The gas stream is predominantly methane with little ethane or other liquids, as the wet/dry gas boundary is located west of the Ohio River outside the borders of West Virginia. The possibility of a single well producing more than 4 Billion cubic feet of gas in a single year was unthinkable just a few years ago, and is a testament to both advances in drilling technology and the incredible resource potential of Appalachian basin shale-gas reservoirs. A full report, written by WVGES staff and detailing the most productive wells, location, and drilling activity (Dinterman, 2019) is included on the WVGES web site at

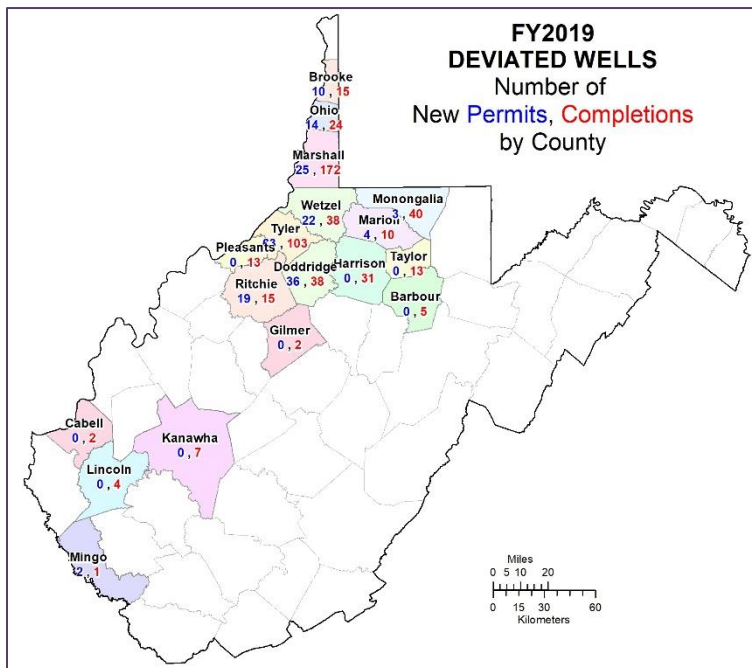
[www.wvgs.wvnet.edu/www/datastat/Marcellus/reports/WVGES2018MarcellusandUticaPtPleasantProductionSummary.pdf](http://www.wvgs.wvnet.edu/www/datastat/Marcellus/reports/WVGES2018MarcellusandUticaPtPleasantProductionSummary.pdf)



*Crinoid fossils in the Oriskany Sandstone sample located near the WVGES parking lot*

- **Rogersville**

A third unconventional reservoir, the even-deeper Rogersville Shale of Middle Cambrian age, was also a focus of activity during FY2019. Together with the Kentucky Geological Survey and West Virginia University, WVGES participated in a funding proposal submitted to the U.S. Department of Energy to characterize the Rogersville and analyze completion design techniques via a “science well” in Kentucky. This effort, the Conasauga Shale Research Consortium, has been selected for funding and initial work will commence in October of 2019.



### Donations, Awards, and other News

The Oil and Gas Program is extremely grateful to IHS Markit, Ltd. for continued software support through its University Grant Program. During FY2019, WVGES received a seven-seat network license for IHS Markit’s Kingdom software. This powerful software package enables our geoscientists to create and interpret subsurface maps and to calculate reservoir properties via an additional Petrophysics module. These capabilities help advance our knowledge of West Virginia’s subsurface framework, and acquisition of this software would not be possible within state budget constraints. The total value of the software package is approximately \$525,000.

*Number of deviated (most are horizontal) wells permitted and completed in FY2019*

We would also like to recognize all of our partners in industry, academia, and sister agencies. Quality science does not occur in a vacuum; communication and collaboration are essential. Geology does not end at state lines, after all, and we value the input from our professional partners.



Fossilized horn corals in limestone of the Greenbrier Group

## INFORMATION SERVICES PROGRAM

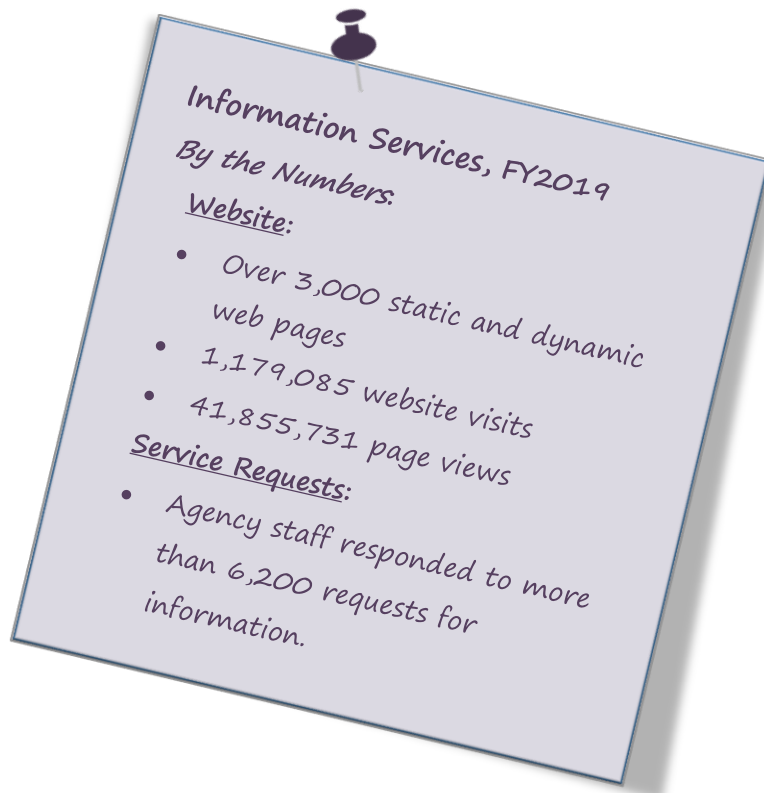
The Information Services Program is responsible for the agency’s publications, website and feedback presence, network infrastructure and desktop operations, interactive mapping applications, and other programming applications in support of the agency’s projects.

### Public-Access Systems and Services:

- **Website**

The following were added to the Survey’s website, [www.wvges.org](http://www.wvges.org), during FY2019:

- Production Data: 2018 oil and gas wells.
- Scientific Posters:
  - ◆ *From the Tuscarora Sandstone to the Bubbles in Your Beverage: Naturally-Occurring CO<sub>2</sub> in the Indian Creek Field, Kanawha County, WV*, Jessica Pierson Moore, Philip A. Dinterman, Ronald R. McDowell, Joel R. Sminchak, and Gary W. Daft; poster presented at the Eastern Section, American Association of Petroleum Geologists (ES-AAPG) Meeting, October 2018.
  - ◆ *An Overview of the Midwest Regional Carbon Sequestration Partnership (MRCSP) Petroleum Fields 2019 Database*, J. Eric Lewis, Kristin Carter, Philip A. Dinterman, William Harrison, Cristian Medina, Jessica P. Moore, Richard Ortt, Brian Slater, Michael Solis, and Thomas Sparks; poster presented at the Geological Society of America Annual Meeting, May 2019.
- Research Reports: 2017 Marcellus Shale and Utica-Point Pleasant Production Summary, by Philip A. Dinterman.
- Website page updates:
  - ◆ Earthquakes/Seismicity,
  - ◆ STATEMAP Geologic Mapping,
  - ◆ Geologic Maps of West Virginia,
  - ◆ Maps and Map Files,
  - ◆ Oil/Gas Well Data DVD,
  - ◆ Marcellus/Devonian Shale,
  - ◆ Summary Data,
  - ◆ Geoscience Education Resources,
  - ◆ Visiting Geologists at State Parks,
  - ◆ News,
  - ◆ Job Openings, and
  - ◆ Mini-Museum.



*Information Services, FY2019  
By the Numbers:*

*Website:*

- *Over 3,000 static and dynamic web pages*
- *1,179,085 website visits*
- *41,855,731 page views*

*Service Requests:*

- *Agency staff responded to more than 6,200 requests for information.*



Reynolds Limestone, Pocahontas County

- **Web services**

The following web services provide data to the public:

- Oil and gas well “**pipeline**” and “**Pipeline-Plus**” services,
- Daily update of Excel spreadsheets for Marcellus shale wells and horizontal wells,
- Scanned Well Logs,
- Mine Information Database System (MIDS),
- Coal Bed Mapping Project, and
- Scanned Mine Maps.

- **Web-based interactive mapping applications**

Interactive mapping added or updated during FY2019 include the following:

- Middle and Upper Devonian Shales,
- WV Oil and Natural Gas Wells,
- Geology of the Marcellus Shale, and
- The Coal Bed Mapping Project (85 maps updated).
- Other interactive mapping applications on the WVGES website include: All (Coal) Mining Map, Appalachian Storage Hub (ASH) Project, Appalachian Basin Tight Gas Plays, Utica Shale Play, Regional Geology of the Ordovician Trenton-Black River Formations, WV Geothermal Map, Broadband Mapping Project (2014), A Geologic Transect across West Virginia, and the Topographic Map Index.

- **Facebook page:** total posts – 53; total reach – 19,219 people; total clicks on the posts – 2,201; total page “engagement” – 2,883.

### **New Publications in FY2019**

**AR-2018 – Annual Report: Fiscal Year 2018**

**RI-34 – Stratigraphic Geochemical Database for Portions of West Virginia and Adjacent Virginia Counties**, by R.R. McDowell (compiler); 2018 supplement added

**OF-1801 – Bedrock Geologic Map of the Hillsboro 7.5’ Quadrangle, West Virginia**, by J.W. Perkins, J.K. Tudek, J.S. Chapman, G.R. Dasher; Digital Cartography by S.E. Gooding

**OF-1802 – Bedrock Geologic Map of the Edray 7.5’ Quadrangle, West Virginia**, by P.J. Hunt, M.S. Burns, J.K. Tudek, J.W. Perkins, S.R. Brown, P.A. Dinterman, R.R. McDowell; Digital Cartography by S.E. Gooding

### **Publications Updated in FY2019**

**DDS-5 – WVGES Oil and Gas Well Data for West Virginia**, April 2019



*Close up of the state gemstone (fossil coral) Lithostrotonella*

### **IT Support and Professional Development:**

- Staff expanded programming to develop and enhance project applications, databases, interactive mapping applications, and management of network infrastructure. After several years of working on details and obtaining State permissions, a 100MB private fiber data circuit was finally installed to the Survey's Mont Chateau offices.
- Geologist/GIS Programmer-Analyst Susan Pool co-authored presentations on the lithostratigraphy of Middle and Upper Devonian organic-rich shales at meetings of the Appalachian Geological Society and the Eastern Section of the American Association of Petroleum Geologists.
- Services to Agencies: Staff prepared customized data-analysis files requested by the WV Department of Environmental Protection - Division of Air Quality for their use in the preparation of reports to federal agencies.
- Staff analyzed and processed data for a database and interactive applications for the Broadband Enhancement Council, with special processing of FCC Form 477 data. We participated in an Appalachian Regional Commission POWER Grant to the West Virginia Development Office ascertaining broadband access (especially fiber-optic technologies) for ten southern coalfield counties, in conjunction and cooperation with the Broadband Enhancement Council, the Development Office, and the Division of Highways. Our data analysis and mapping work aided in the development of a web-based hub for broadband-expansion resources in West Virginia. Broadband can help the economic revitalization of these "coal-impacted" counties.
- Program staff serve on the following committees: the State Information Technology Council (representing the Department of Commerce), the WV GIS Steering Committee, and the WV Association of Geospatial Professionals -- Communications Committee and Board of Directors.
- Staff helped coordinate the 2019 "WV GIS Day at the Legislature," and designed and staffed the agency's display booth.



Come see the Pteranodon, one of our latest acquisitions.

## WVGES MINI-MUSEUM

The Survey's Mini-Museum in our office lobby and its associated web pages continue to be an important part of our outreach and educational programs. Museum displays continue to inspire and educate teachers, students, and visitors. The Mini-Museum is open to the public from 8:00 am until 5:00 pm Monday through Friday (except State holidays). While no appointment is needed to visit the museum, organizations, groups, or classes may request a guided tour in advance of their visit. The Mini-Museum on the website can be found at: <http://www.wvgs.wvnet.edu/www/museum/museum.htm>.



Al and the others await your visit

- The museum was expanded this fiscal year by realigning display cases in order of geologic time. The records area near the main lobby was rearranged to make space for additional display cases and specimen exhibits.
- Our museum displays a variety of fossils and minerals native to West Virginia, as well as larger dinosaur skeletons, models, and reproductions from around the country. Children and adults alike enjoy seeing reproductions of *Tyrannosaurus rex*, *Pteranodon*, *Allosaurus*, *Triceratops*, a sauropod, and many other smaller specimens. We also have reproductions of a giant ground sloth (*Megalonyx jeffersoni*) and *Dunkleosteus sp.* (a massive Devonian fish), both native to West Virginia.

- We currently have the only authentic dinosaur skeleton in the state – *Edmontosaurus sp.* – collected in South Dakota.
- Our museum also has a display of historic industrial tools and products from the oil and gas industry.
- Using free and open-source software and “out of the box” hardware, staff created an “augmented reality sandbox” – a 3D, interactive, dynamic educational tool to help teach the concepts of elevation and topography. See discussion elsewhere in this report about its use.



Dimetrodon skeleton replica – this one actually used to live in what is now West Virginia



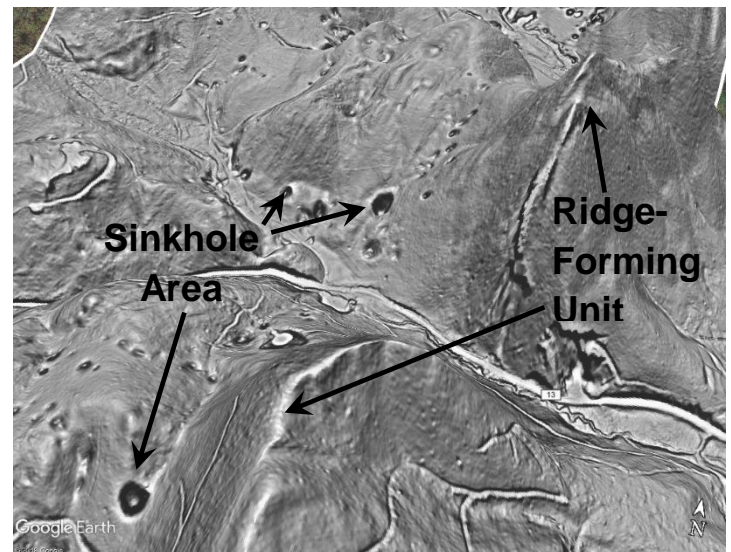
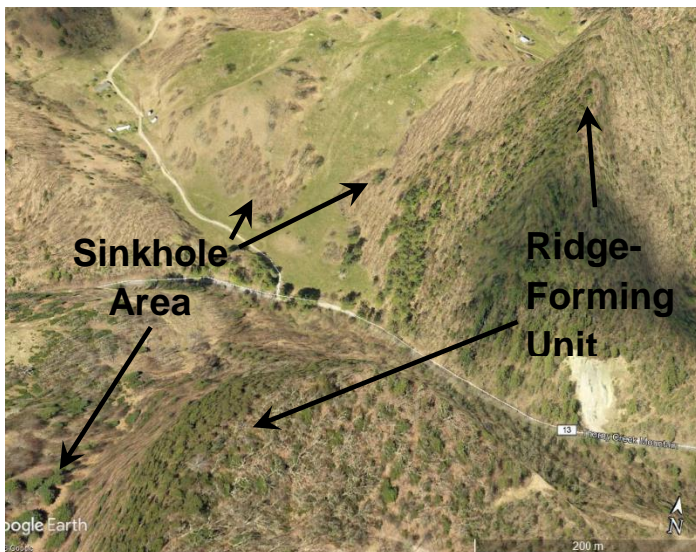
## **GEOGRAPHIC INFORMATION SYSTEM PROGRAM**

This program is responsible for planning, organizing, coordinating, and delivering high-level Geographic Information Systems (GIS) advice to agencies in state government; it is headed by the State GIS Coordinator, based in Charleston.

- The program continues to make headway in a number of critical areas: promoting data sharing among agencies; providing technical assistance to state, county, and local government and the public; and fostering the efficient and effective use of the state's geospatial capabilities.
- During FY2019, the GIS Policy Council (GISPC) convened and authorized the development of a statewide GIS Strategic Plan. The GISPC also authorized developing a geospatial certification for high school students in partnership with the state Department of Education. In addition, the GIS Coordinator, in partnership with the Secretary of State's Office, participated in a National States Geographic Information Council (NSGIC)-sponsored GeoEnabled Election Pilot Study.
- Together with WVGES GIS staff, the State GIS Coordinator continued to provide technical assistance to the Broadband Enhancement Council regarding broadband coverage and mapping issues and is assisting in the design and development of an interactive broadband map. The GIS Coordinator also provided GIS support to the Development Office, the Division of Homeland Security, Department of Environmental Protection, the Department of Education, the Water Development Authority, Infrastructure and Jobs Development Council, the National Guard, the WV Intelligence Fusion Center - Hazard Mitigation Section, and other state, regional, and local agencies in their search for GIS contract services, funding, and GIS-application development.
- The GIS Coordinator continues to provide general administrative oversight of the Mineral Lands Mapping Program in collaboration with the Survey's Coal Bed Mapping Project and the State Tax Department - Property Tax Division. During FY2019, the GIS Coordinator assisted in the development of the Property Tax Division's Statewide GIS Cadastral platform.
- The GIS Coordinator participated in the NSGIC NextGen 911, Addresses, and GeoEnabled workgroups. Documents developed by these groups outline the strengths and challenges of the state's spatial data infrastructure needed for NextGen 911, Addressing, and fair elections. The GIS Coordinator assisted the Federal Emergency Management Administration (FEMA) in the acquisition of LiDAR coverage in areas not covered in previous flights.



- Data-exchange protocols enhancing data sharing among state and local agencies established in previous years continue to be successful and this year state and locally produced datasets were added to the GIS Clearinghouse maintained by the WV GIS Technical Center (WVGISTC) in Morgantown.
- GIS workshops developed and presented in collaboration with the WV Association of Geospatial Professionals, WVGISTC, County Assessors, and 911 directors continue to be popular among GIS professionals. These workshops are designed to inform, train, and advise county and local government officials that have GIS programs in the latest technology, and at the same time, educate those officials that have not yet embraced GIS technology in their own organizations. The workshops emphasize interagency collaboration and are given at different locations throughout the state.



*Features not apparent on traditional aerial imagery (left) are visible on recently acquired high-resolution LiDAR (right)*

- The GIS Coordinator attended sessions and gave presentations at the NSGIC and the West Virginia Association of Geospatial Professionals midyear and annual meetings. The Coordinator participated in sessions of the Geographical Information Systems Certification Institute Board of Directors, NSGIC Leadership Group, WV Information Technology Council, WV Broadband Enhancement Council, E911 Council, and the WV Association of Professional Surveyors.





# West Virginia State Tax Department Property Tax Division

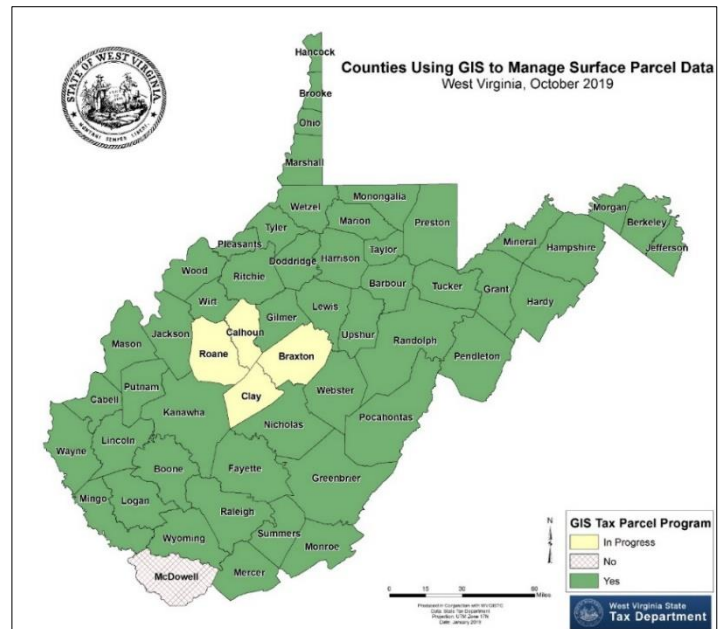
## WV STATE TAX DEPARTMENT, PROPERTY TAX DIVISION - MINED MINERALS/GIS UNIT

### Purpose

Per WV Code 11-6K, the State Tax Commissioner is to value the Natural Resources Properties in the state. Coal and other mined minerals are valued, per the law, by the Mined Minerals/GIS (MM/GIS) unit of the Property Tax Division of the West Virginia State Tax Department. The unit's primary goal is to accurately and equitably value mined and unmined minerals in West Virginia and to provide those values to the counties for taxation. The MM/GIS unit updates and maintains the geological, economic, infrastructure, and environmental mapping required by the West Virginia Legislature to value minerals in West Virginia. It is also an invaluable asset for locating properties for the valuation of coal, oil and gas, and managed timberland throughout the state. Annually, the unit performs digital geospatial analysis for managed timberland, the WVGES Coal Bed Mapping Project, coal quality, and economic and environmental impact of the mining and severance of natural resources.

### Geographic Information Systems (GIS)

GIS is a vital part of the natural-resource valuation process and the work of the GIS Section is essential to the entire unit because much of the valuation process is based on extensive geospatial analysis. The MM/GIS unit aims to map and/or ensure the mapping of all properties with mineral rights in the state, to provide accurate GIS data for the tax valuation of natural resources, and to make GIS data freely available. The GIS Section provides coal-occurrence maps, coal-contour maps, and other mapped natural resource features to the unit's geologists and tax analysts.



Counties using digital parcel data

### Geology

Geologists in the MM/GIS unit perform a wide range of geological work including the correlation and evaluation of mining, quarrying, and environmental preservation or impact. They provide quality control on geological work from outside sources and in-house mapping. Annually, the unit supplies WVGES with core hole and drilling data gathered from the Annual Appraisal to produce coal returns. This information is vital to WVGES' Coal Bed Mapping Project (CBMP) since it provides new data-control points for resource mapping. Because the CBMP is critical to property valuation, the MM/GIS unit closely reviews the information provided by CBMP, adding an extra layer of quality control for WVGES.



# West Virginia State Tax Department Property Tax Division

## Map Updates

The MM/GIS unit has updated 83 resource contours for coal beds, performed 258 individual resource analyses on request, and collected mining information for WVGES for over 800 active and idle mines. The unit operates on an ESRI GIS software platform and has an inventory of the surface maps for all 55 counties in West Virginia. Estimates indicate that the master datasets have over 1.3 million parcels mapped out of a possible 1.9 million parcels, which includes both surface and minerals. While most of the surface has been mapped, some mineral parcels still need to be located and mapped. Utilizing field mappers would be the most efficient manner to complete this.

The unit uses GIS analysis to locate deficiencies in areas that need to be mapped. In the last year, nearly 7,000 parcels were mapped resulting in a net increase of 4,000 parcels with coal reserves. The MM/GIS unit contracted the West Virginia GIS Technical Center to map mineral parcels using oil and gas well survey plats. Between January and August 2019, this experimental project mapped a total of 3,157 parcels.

## Map Distribution

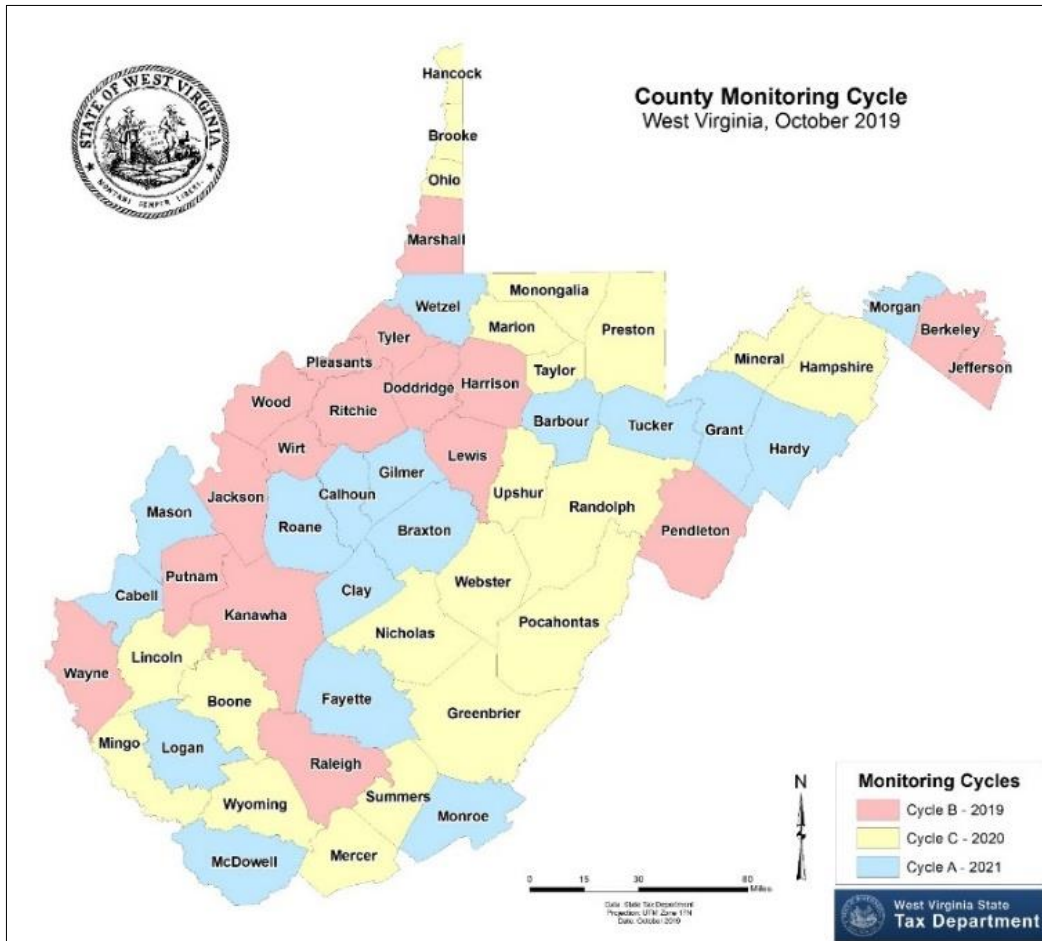
As the result of a change in the law, the MM/GIS unit transformed the way it distributes county tax maps and GIS shapefiles to the public and other government agencies. Thanks to a cooperative effort with the West Virginia GIS Technical Center, this significant change now allows anyone with Internet access to download county parcel maps at <http://wvgis.wvu.edu/data/dataset.php?ID=371>. In addition, anyone can view and print a map in our office using a digital kiosk specifically provided for this purpose.

## Mapping Maintenance for the Counties

The MM/GIS unit works closely with county tax assessors and their mapping personnel to ensure their compliance with the regulations set forth by the Property Valuation Training and Procedures Commission. The unit receives maps and shapefiles (if available) from all West Virginia counties every year. To further ensure compliance with the mapping regulations, the unit monitors all 55 counties' tax maps and their map changes on a 3-year cycle. MM/GIS also oversees manual mapping updates completed for the counties by mapping contractors and maintains Mylar and linen maps for the manual counties, if needed. During this past year, 17 counties have been monitored for map design, content, maintenance, and digital parcel submission (if applicable). These counties include Marshall, Tyler, Doddridge, Harrison, Lewis, Pleasants, Ritchie, Wood, Wirt, Jackson, Berkeley, Jefferson, Pendleton, Putnam, Kanawha, Raleigh, and Wayne.



# West Virginia State Tax Department Property Tax Division



County mapping maintenance cycles

## Recent Achievements and Future Goals

Our achievements during this past year include filling a management position, beginning the process of restoring basic and advanced licensing, creating and implementing more efficient procedures for processing new mineral mapping for real-time property changes, and developing new integration methods for county data conversion. In the future we plan to expand statewide mineral mapping, continue to work closely with other agencies and the industry on annual production filings, develop and implement a compressive staff training plan, create an intern position, hire a GIS professional with a programming background, and continue work with the WV GIS Technical Center to digitize tax maps in the remaining non-digital counties.

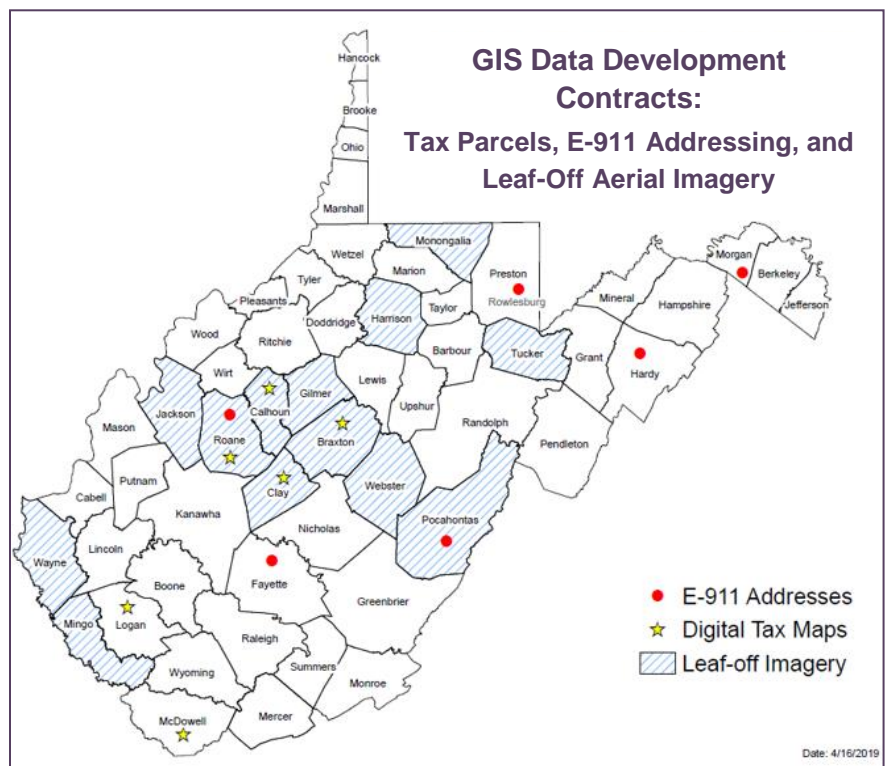


## WV GIS TECHNICAL CENTER

The West Virginia GIS Technical Center (WVGISTC), located in the Department of Geology and Geography at West Virginia University, provides focus, direction, statewide coordination, and leadership to users of geographic information systems (GIS), digital mapping, and remote sensing within the State of West Virginia. The Center was established by Executive Order 4-93 to provide coordination and technical support in the development and operation of GIS for the State. Statewide geospatial activities are coordinated through the WV Office of GIS Coordination at WVGES. Below are selected highlights for FY2019 GIS Data Development, GIS Map Applications, Web Portals, and GIS Services at WVGISTC.

### GIS Data Development

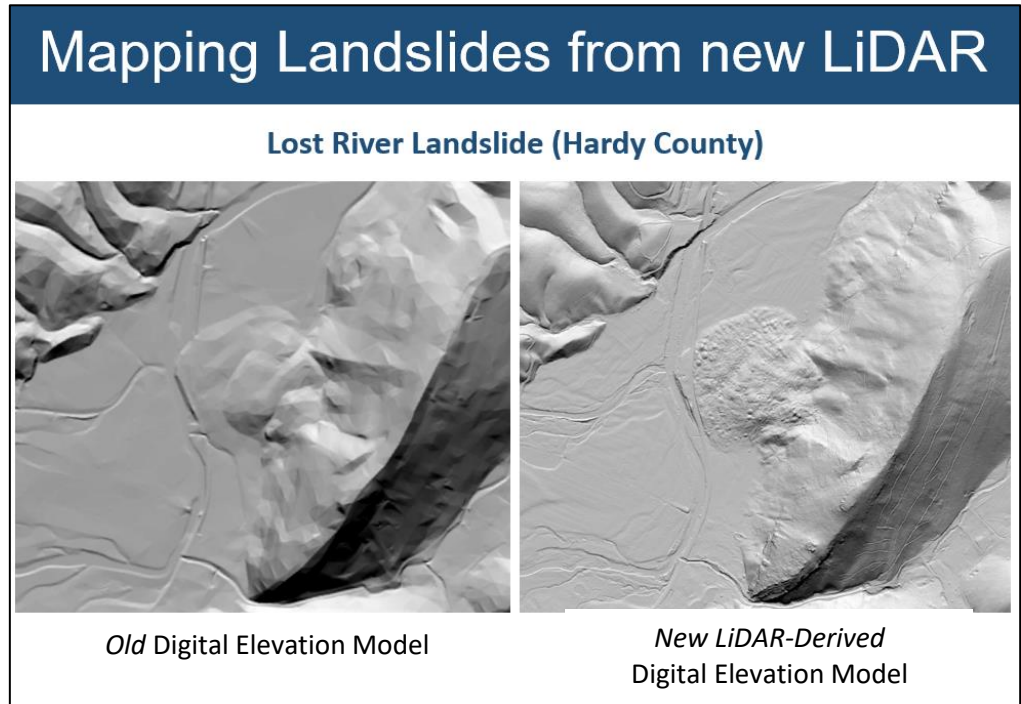
WVGISTC plays a crucial role in not only serving critical spatial data to state users but also in updating and integrating local geospatial data within state and national geospatial databases. These data layers are utilized by state agencies, communities, and the general public for applications including emergency response, risk assessment, economic development, energy resource exploration and management, transportation, natural resources, community planning, tax assessments, and health studies. This past year the Center focused on the development of the geospatial data layers listed below to enhance the State's Spatial Data Infrastructure. The continued development and publishing of GIS layers through the state clearinghouse node hosted by WVGISTC supports the Mineral Lands Mapping Program and other vital programs in the State that depend on current and accurate mapping layers.



*Two statewide GIS contracts currently support digital tax parcel, E-911 address, and leaf-off aerial imagery data development for multiple communities*

- **Mineral Parcel Mapping:** The Mineral Parcels Map Project, a collaborative effort with the WV Property Tax Division and WVGES, mapped 4,672 mineral records for Brooke, Monongalia, Ohio, and Wirt counties.

- **E-911 Addresses and Digital Parcels:** A major state contract was awarded to a GIS professional services company to assist six communities in correcting deficiencies with their E-911 addresses and to convert six counties from paper to digital tax maps.
- **Aerial Imagery:** Another state contract allowed for 11 counties to capture spring 2019 leaf-off imagery at four-inch resolution.
- **Elevation:** During the fiscal year, WVGISTC quality checked and organized FEMA-purchased QL2 LiDAR-derived elevation products for eastern West Virginia and reported errors to FEMA Region III to be corrected by the contractor. Staff created new statewide elevation and hillshade grids from the best-available elevation data sources.
- **Landslides:** Staff digitized over 100,000 landslide features from landslide studies and maps. In addition, staff mapped over 9,000 landslides from LiDAR-derived DEMs to be used as inputs for predicting landslide hazards.
- **Flood-Risk Buildings:** Staff inventoried and mapped over 10,000 at-risk structures in flood hazard areas.
- **Highway Plans:** WVGISTC personnel scanned more than 7,000 highway plan sets for an ongoing project with the WV Department of Transportation.



*The new FEMA LiDAR has many applications including landslide mapping ([www.mapwv.gov/landslide](http://www.mapwv.gov/landslide)) as well as editing and maintaining local address data required for E-911 dispatching, address matching services, and hazard risk assessments.*

### GIS Map Applications

WVGISTC provided continued application and web programming

assistance for state and federal agencies in support of West Virginia and its citizens. These applications support multiple state agencies via e-governance solutions to meet their regulatory and information exchange requirements (see Table). This past year, WVGISTC partnered with the Watershed Assessment Branch of the Department of Environmental Protection (WVDEP) to complete an online tool for rapidly assessing some of the important natural functions of all types of wetlands present in West Virginia. Additionally, during this fiscal year WVGISTC modernized online web applications for the WV Flood Tool, State Historic Preservation Office Viewer, and WV Elevation and LiDAR Download Tool. The Center also



supported federal initiatives for the Marcellus Shale Energy and Environment Laboratory ([www.mseel.org](http://www.mseel.org)) and terrestrial biosphere carbon ([www.carbonscapes.org](http://www.carbonscapes.org)). In July 2018, ESRI presented the Center with a Special Achievement in GIS Award for our innovative web map applications.

APPLICATION	PURPOSE	SPONSOR
<b>WV Elevation &amp; LiDAR Download Tool</b>	Download LiDAR, digital elevation models, and contours ( <a href="http://www.mapwv.gov/lidar">www.mapwv.gov/lidar</a> )	WVVIEW
<b>WV Flood Tool</b>	Flood hazard determinations, building permits, flood risk layers ( <a href="http://www.mapwv.gov/flood">www.mapwv.gov/flood</a> )	WVDHSEM, FEMA
<b>SHPO Map Viewer</b>	Conduct Cultural Resource Section 106 reviews ( <a href="http://www.mapwv.gov/SHPO">www.mapwv.gov/SHPO</a> )	SHPO
<b>Statewide Addressing &amp; Mapping System (SAMS)</b>	Update address sites and road centerlines required for emergency response ( <a href="http://www.mapwv.gov/address">www.mapwv.gov/address</a> )	WVDHSEM, E-911 Address Coordinators
<b>Hunting and Fishing</b>	Search and identify hunting and fishing adventures ( <a href="http://www.mapwv.gov/huntfish">http://www.mapwv.gov/huntfish</a> )	WVDNR
<b>WV Trail Inventory</b>	View publicly accessible recreational trails in the State ( <a href="http://www.mapwv.gov/trails">http://www.mapwv.gov/trails</a> )	WVDOT
<b>Highway Plans Locator</b>	View and download archival highway plans ( <a href="http://www.mapwv.gov/dotplans">http://www.mapwv.gov/dotplans</a> )	WVDOT
<b>Conservation Planning Interagency Tool</b>	Determine conservation planning measures for endangered species in support of environmental site evaluations ( <a href="http://www.mapwv.gov/ICT">www.mapwv.gov/ICT</a> )	WVDNR, NRCS
<b>WV Property Viewer &amp; Property Record Search</b>	Search and display property information for all 55 counties in West Virginia ( <a href="http://www.mapwv.gov/parcel">www.mapwv.gov/parcel</a> and <a href="http://www.mapwv.gov/assessment">www.mapwv.gov/assessment</a> )	WV Tax, WV State Auditor
<b>Wetlands Functional Assessment</b>	A standardized tool for assessing wetlands ( <a href="https://mapwv.gov/wetlands">https://mapwv.gov/wetlands</a> )	WVDEP

Statewide map applications supported by WVGISTC

### Web Portals

WVGISTC maintains two major web portals to distribute spatial data and information in the State. The WV GIS Clearinghouse (<http://wvgis.wvu.edu>) catalogs over 300 unique datasets and 120 web services valued at more than \$60 million dollars, while MapWV.gov (<http://mapwv.gov>) provides a public gateway to online mapping resources in the Mountain State. These geospatial services are distributed through new virtualized servers and storage devices with a storage capability of 150 TB,



WV Flood Tool ([www.mapwv.gov/Flood](http://www.mapwv.gov/Flood)) web traffic growth since 2010



continuously tuned and configured to attain high-availability performance.

Web-usage statistics reveal that [MapWV.gov](http://MapWV.gov) had a noteworthy increase in traffic for FY19. Average Page Views per day surpassed 50,000 for the first time since its creation, for a total of 4.6 million page views for the year. The [MapWV.gov](http://MapWV.gov) and [WV GIS Data Clearinghouse](http://WV GIS Data Clearinghouse) were accessed by over 300,000 and 94,000 unique visitors, respectively in FY2019. The newly released WV Property Viewer and Assessment Search Tool have grown in popularity and now are used by many organizations performing multi-county property-record searches.

## Services

This past fiscal year WVGISTC continued to assist the West Virginia geospatial community with advisory, training, and outreach services. These services are organized by the WV Office of GIS Coordination and WV Association of Geospatial Professionals.

- WVGISTC provided GIS Foundations training at the WVU Morgantown campus and WVU Tech campus in Beckley. ArcGIS Online, ArcGIS Pro Migration, and Geostatistical Analysis courses were also taught.
- Staff provided training and outreach services on numerous occasions in support of the WV Flood Tool, an important web application used by floodplain managers and FEMA personnel.
- WVGISTC trained E-911 addressing coordinators in support of the Statewide Addressing and Mapping System.
- WVGISTC continued technical support for statewide multi-hazard risk assessments for 287 community hazard-mitigation plans.
- Staff gave presentations on geospatial activities and projects at regional and state conferences.

**WV Property Application**

**Web Visits**

Year/Quarter	Flood Tool	Property Viewer
2017, Q4	~28,000	~0
2018, Q1	~32,000	~0
2018, Q2	~35,000	~0
2018, Q3	~38,000	~0
2018, Q4	~30,000	~15,000
2019, Q1	~32,000	~40,000
2019, Q2	~30,000	~50,000
2019, Q3	~30,000	~65,000

**Detailed Property Report**

**Property Viewer**

**Property Search Tool**

Search Options:  Hide  Basic  Appraisal/Sales  Advanced (Hover over input fields to view help)

County:  District:  Full Parcel ID:

Owner Name:  Map Number:  Property Class:

Street Name:  Parcel:  Tax Class:

Sub-Parcel:  Land Use:

Search  Lines per page:

**WV Property Viewer**  
[www.mapwv.gov/parcel](http://www.mapwv.gov/parcel)

**WV Property Search**  
[www.mapwv.gov/assessment](http://www.mapwv.gov/assessment)

The popular WV Property Application allows for searching and locating property records ([www.mapwv.gov/assessment](http://www.mapwv.gov/assessment))

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## Principal Staff Directory and Points of Contact as of June 2019

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### West Virginia Geological and Economic Survey

Mont Chateau Research Center

1 Mont Chateau Road • Morgantown, WV 26508-8079

304.594.2331 • fax: 304.594.2575

[www.wvges.org](http://www.wvges.org) • [info@geosrv.wvnet.edu](mailto:info@geosrv.wvnet.edu)

39°39'30" N, 79°50'57" W

Hours: 8 a.m. to 5 p.m. Monday through Friday (*closed holidays*)

*Back cover image: Bedrock geology of Germany Valley, Pendleton County draped over a hillshade produced from LiDAR imagery (Map Legend below)*

### Legend

<p><b>Bedding Symbol</b></p> <p>┆ Inclined</p> <p>⊕ Horizontal</p> <p>┆ Vertical</p> <p>┆ Overturned</p> <p><b>Structure Symbol</b></p> <p>↕ Anticline</p> <p>↘ Syncline</p> <p>→ Plunging</p>	<p><b>Geologic Units</b></p> <p>Pcg - Conemaugh Group, undifferentiated</p> <p>Pcc - Conemaugh Group, Casselman Fm</p> <p>Pm - Monongahela Group</p> <p>Pc - Casselman Formation</p> <p>Pg - Glenshaw Formation</p> <p>Pa - Allegheny Formation</p> <p>Pknr - Kanawha - New River Formations</p> <p>PPv - Pottsville Group, undifferentiated</p> <p>Mmc - Mauch Chunk Group</p> <p>Mg - Greenbrier Group</p> <p>Mp - Price Formation</p> <p>Dhs - Hampshire Formation</p> <p>Dgg - Greenland Gap Group</p> <p>Scherr Fm</p> <p>Db - Brallier Formation</p>	<p>Dh - Harrell Shale</p> <p>Dmt - Mahantango Fm</p> <p>Dmtmn - Mahatango - Millboro - Needmore Fms.</p> <p>Do - Oriskany Sandstone</p> <p>Dhl - Helderberg Group</p> <p>Stowc - Tonoloway - Wills Creek Formations</p> <p>Sto - Tonoloway LS</p> <p>Swc - Wills Creek Fm</p> <p>Swmc - Williamsport - McKenzie Formations</p> <p>Swp - Williamsport Sandstone</p> <p>Smc - McKenzie Fm</p> <p>Skrh - Keefer SS- Rose Hill Formations</p> <p>Sk - Keefer SS</p> <p>Srh - Rose Hill Fm</p> <p>St - Tuscarora Sandstone</p> <p>Oj - Juniata Formation</p>
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# Bedrock Geology of Germany Valley, WV

