West Virginia University
BRIDGE INITIATIVE FOR SCIENCE & TECHNOLOGY
POLICY, LEADERSHIP, AND COMMUNICATIONS

THE WATERS OF WEST VIRGINIA

A Science & Technology Policy Perspective

This policymaker's guide is a product of West Virginia University's Bridge Initiative for Science and Technology Policy, Leadership, and Communications. The Bridge Initiative identifies challenges and opportunities facing West Virginia and provides a bridge between the science and technology expertise of WVU faculty and staff and West Virginia's national, state, and local policymakers. In our work, we gather the views of stakeholders throughout the state to ensure we are making recommendations that serve the needs of West Virginians. This work supports WVU's critical land-grant mission to lead "transformation in West Virginia and the world through local, state and global engagement."

Although the Bridge Initiative coordinated the development of this policymaker guide, the true authors are the West Virginia University faculty, staff, and students who provided their expertise for the content of the guide. The Bridge Initiative would like to thank these individuals for their dedication, collegiality, and hard work. We recognize that they have demanding responsibilities outside of this study, and we thank them for their time and commitment to this project.

To read the full policymaker's guide, please visit:
http://scitechpolicy.wvu.edu

Wake up to the full potential and challenges of West Virginia's abundant waters to support its people, business, industry, and job creation opportunities.

Advance West Virginia's water-related infrastructure so it is better prepared for ever-increasing extreme precipitation events to reduce flooding, which threatens human and economic health.

Together, West Virginians will work to provide access to clean and affordable water to protect and enhance public health.

Engage West Virginia communities to coordinate efforts to enhance the potential of water resources--which flow across political boundaries--to provide prosperity and well-being to all.

Revitalize West Virginia's water resources, and increase the state's resilience to meet the societal and economic needs of today's West Virginians and their future generations.

Showcase West Virginia's natural water resources by marketing their beauty and developing river-related recreation opportunities that increase tourism and recruit new businesses and residents.

PARTICIPATING WEST VIRGINIA UNIVERSITY FACULTY, STAFF, AND STUDENTS

This policymaker's guide was developed by the WVU faculty, staff, and students listed below under the Bridge Initiative for Science and Technology Policy, Leadership, and Communications, directed by Joan Centrella. John Deskins, Jennifer Hause, and Nicolas Zegre led the working groups that developed the content for this guide. Deborah Stine was the study director as a consultant to WVU, and Jay Cole was the Study Advisor.

WATERS OF WEST VIRGINIA COMMITTEE MEMBERS

Jorge Atiles - Dean, Extension and Engagement; Director, WVU Extension Service

Robert Burns - Director, Division of Forestry and Natural Resources; Professor of Recreation, Parks & Tourism Resources

Peter Butler - Director, School of Design and Community Development; Associate Professor of Landscape Architecture; Landscape Architecture Extension Specialist

Greg Corio - Assistant Vice President, The Brad and Alys Smith Outdoor Economic Development Collaborative

John Deskins - Director, Bureau of Business and Economic Research (BBER); Assistant Dean for Outreach and Engagement, John Chambers College of Business and Economics; Associate Professor of Economics

Michael Dougherty - Professor and Extension Specialist, Community Resources and Economic Development

Timothy Driscoll - Associate Professor of Biology

Emily Garner - Assistant Professor of Civil and Environmental Engineering

Jennifer Hause - Program Manager, WVU Energy Institute, National Environmental Services Center

Ronnie Helmondollar - Program Director, Agriculture & Natural Resources, WVU Extension Service

Leslie Hopkinson - Associate Professor of Civil and Environmental Engineering

Jason Hubbart - Director, Institute for Water Security and Science; Professor of Hydrology and Water Quality

Charlene Kelly - Teaching Assistant Professor of Forest Resources Management and Plant and Soil Sciences

Tony Michael - Program Director, Family & Community Development, WVU Extension Service

Christopher Plein - Professor of Public Administration, Eberly Family Professor for Outstanding Public Service; Adjunct Extension Specialist, Family and Community Development

John Quaranta - Associate Professor of Civil and Environmental Engineering

Javier Reyes - Vice President, Start-Up West Virginia; Dean, John Chambers College of Business and Economics

Shikha Sharma - Professor of Geology; Director, IsoBioGeM Laboratory

Jamie Shinn - Assistant Professor of Geography

Hema Siriwardane - Professor and Chair, Civil and Environmental Engineering

Samuel Taylor - Assistant Director, WVU Energy Institute

Danny Twilley - Assistant Dean, The Brad and Alys Smith Outdoor Economic Development Collaborative

Nicolas Zégre - Associate Professor of Forest Hydrology; Director, Mountain Hydrology Lab

STUDY STAFF

Joan Centrella - Director, Bridge Initiative for Science and Technology Policy, Leadership, and Communications

Deborah Stine - Study Director, Consultant to WVU

Jay Cole - Study Advisor

April McGinnis - Editor

Samuel Wilkinson - Project Manager

POLICY ANALYSIS ASSISTANTS:

Ph.D. Students:
Brooke Eastman
Luis Andres Guillén
Michael Jones
Rachel Hostetler
Rachel Yesenchak

Master's Students:
Scott Lopez
Bryan Phillips
Eric Sjöstedt

Undergraduate Students:
Payton Seats
Wilson McNeil

Volunteer:
Jasmine Gonlin

EXECUTIVE SUMMARY

The waters of West Virginia are essential to the state's economy. From the water we drink to the rivers where we play to businesses and industries that provide our income, clean water is an essential element for West Virginia's future economic success. West Virginia's water resources are also precious to the nation. The headwaters of the Potomac and Ohio Rivers, which eventually reach 9% of the U.S. population, include waters that originate in West Virginia. These resources provide for quality of life, community development and resiliency, and economic opportunity.

Although West Virginia's water resources are the envy of others, we stand on a historical threshold where we must address the legacy of industrial and other activities that have compromised water quality and health in some of our rivers and streams, and also anticipate future challenges posed by climate change and an increased demand for water.

West Virginia is poised to stake its claim as the urban-rural nexus of the Washington-Baltimore, DC-MD-VA-WV Consolidated Metropolitan Statistical Area (CMSA) and the Pittsburgh-New Castle-Weirton, PA-OH-WV CMSA. As a result, West Virginia can emerge as a nationwide draw for "amenity migration," where people move to places with a higher quality of natural environment to improve their quality of life.

People are increasingly drawn to West Virginia's unique Appalachian Mountain setting and superior natural amenities. The United States Department of Agriculture's (USDA) new broadband initiative could provide the technical resources necessary for amenity migrators. A new emphasis on West Virginia's natural resource amenities (whitewater rafting, mountain biking, rock climbing, caving, etc.) will enhance West Virginia's visibility as a prime location for remote work, encouraging the migration of new residents and retaining existing residents. However, water-related amenities, such as clean drinking, surface and groundwater, quality wastewater management systems, flood prevention measures, and recreation infrastructure installation, are critical for this economic development plan to succeed.

The West Virginia University (WVU) Bridge Initiative for Science and Technology Policy, Leadership, and Communications worked with faculty and staff from across the university to examine the current state of West Virginia's water resources. This analysis incorporated the challenges and opportunities outlined above as well as the potential impact of changing climate conditions. WVU faculty and Bridge Initiative staff developed policy options based on these findings. Next, the Bridge Initiative hosted five topical roundtables to gather feedback on those options. Roundtable participants included key stakeholders interested in the waters of West Virginia from business and industry, government, and non-governmental organizations. Each roundtable was asked to review the policy options and then prioritize them based on the criteria of effectiveness (likelihood of meeting the societal goal), efficiency ("best bang for the buck"), equity (winners and losers), and ease of political acceptability (the degree to which key policymakers and stakeholders might oppose or support the policy).

Based on this work, the WVU faculty and staff who developed this policymaker guide propose that West Virginia national, state, and local policymakers take actions that support the following principles:

W ake up to the full potential and challenges of West Virginia's abundant waters to support its people, business, industry, and job creation opportunities.

A dvance West Virginia's water-related infrastructure so it is better prepared for ever-increasing extreme precipitation events to reduce flooding, which threatens human and economic health.

T ogether, West Virginians will work to provide access to clean and affordable water to protect and enhance public health.

E ngage West Virginia communities to coordinate efforts to enhance the potential of water resources--which flow across political boundaries--to provide prosperity and well-being to all.

R evitalize West Virginia's water resources, and increase the state's resilience to meet the societal and economic needs of today's West Virginians and their future generations.

S howcase West Virginia's natural water resources by marketing their beauty and developing river-related recreation opportunities that increase tourism and recruit new businesses and residents.

The following table provides the top recommendations for each of these principles and illustrations detailing why each action is important for West Virginia.

Table 1: West Virginia University Bridge Initiative Waters of West Virginia Recommendations

ACTION	RECOMMENDATION	ILLUSTRATIONS OF WHY ACTION IS IMPORTANT TODAY
Wake up to the full potential and challenges of West Virginia's abundant waters to support its people, business, industry, and job creation opportunities.	West Virginia's policymakers should take actions to establish or review (and, if necessary, reorganize) intercounty/ intercommunity councils to strengthen coordination and consistency, thus reducing the economic burden on local communities and enhancing their economic development.	West Virginia has 32 major watersheds--all of which cross political boundaries, such as county lines. Understanding watersheds is important because adverse conditions (such as pollution) that occur in one area of the watershed may flow to other parts of the watershed, impacting water quality and, consequently, drinking water and ecology. Because of this, water quality is not an isolated problem of any one water management system but is rather a concern of the region as a whole. West Virginia's county and municipal power and taxing authorities are limited and would benefit from reorganization and reconsideration of their authority. West Virginia's population is decreasing. This trend will continue unless West Virginia policymakers develop employment and economic initiatives, increase the availability of essential water-related services, and recruit a remote workforce to retain and increase West Virginia's population.
	West Virginia's policymakers should take action so that the state becomes an innovation leader in addressing challenges and opportunities related to water. This action should include institutional and financial support for technological innovations in wastewater systems that work for rural communities, underground pumped hydropower that utilizes abandoned coal mines, and testbeds to see if treated acid mine drainage (AMD) residue can be sold for commercial use.	Expansion of pumped hydropower energy storage in West Virginia could support both fossil and renewable energy sources by enhancing resiliency for West Virginia's energy utility system. Construction of such facilities could also provide an economic boost to rural development, generating jobs, economic growth, and tax revenue. These possibilities are especially promising for coal communities, where abandoned mines could be used for energy storage. Utilization of AMD sludge could both solve a current challenge related to storing the cleaned sludge and provide a potential revenue source to pay for AMD operations and management through use of the sludge as an economic resource. For example, the annual management cost of the Omega site near Morgantown is $90,000 - $100,000. The primary cost challenge is not the treatment of the water but rather the resulting sludge. If engineering methods could be found that provide beneficial uses for this sludge, then the costs of finding a home for the sludge would decrease and might even turn a profit that could help pay for AMD treatment.

ACTION	RECOMMENDATION	ILLUSTRATIONS OF WHY ACTION IS IMPORTANT TODAY
Advance West Virginia's water-related infrastructure so it is better prepared for ever-increasing extreme precipitation events to reduce flooding, which threatens human and economic health.	West Virginia policymakers should facilitate coordination of regional approaches that bring together water and wastewater management organizations in multiple counties to improve economies of scale and reduce the cost of services to residents. Policymakers should also provide a pool of funding for the matching funds that are needed to apply for federal grants. These regional collaborations should write proposals for federal funding, manage and prioritize the allocation of the available matching funds, encourage brownfield development, and support investment on behalf of rural and disenfranchised counties and communities in their regions.	West Virginia's small, rural communities often lack the financial, management, and technical staff to operate their current infrastructure and apply for grants and other support to improve their infrastructure. » These small, rural communities often pay a higher cost for basic drinking water and wastewater services due to the smaller population from which to draw the revenue needed to build and maintain these facilities, or because they need to purchase their water and wastewater services from another entity. » Often, community members do not recognize the cost involved to produce clean drinking water, nor do rates cover the true cost of producing and transporting treated water. According to the West Virginia Public Service Commission (WVPSC), the cost for these sewer utility services can range from $8 to $92 for the same services, depending on location and circumstances specific to each system. Functional drinking water and wastewater systems are important in making a good first impression on new visitors and businesses to West Virginia. For example, West Virginia's New River Gorge National Park is called a "haven for hiking, climbing, and rafting" by *National Geographic*. The area surrounding it, however, can emit foul odors due to an insufficient wastewater management system. Similarly, Thurmond is a small, historical town with rave reviews on TripAdvisor and interest from new businesses and the National Park Service in commercial property and housing. The challenge for those interested? A lack of wastewater infrastructure. Without access to this vital infrastructure, development that would bring jobs to the region is at a standstill.

ACTION	RECOMMENDATION	ILLUSTRATIONS OF WHY ACTION IS IMPORTANT TODAY
Together, West Virginians will work to provide access to clean and affordable water to protect and enhance public health.	West Virginia policymakers should require that West Virginia Parks and Recreation take actions to educate and protect West Virginians and tourists from vector-borne diseases, such as Lyme's Disease, that are likely to become more prevalent due to increased extreme precipitation and heat. They should also require that the Department of Health and Human Services (DHHR) increase its surveillance and reporting; develop physician, healthcare provider, and public education materials; and implement a long-term Wastewater-Based Epidemiology (WBE) system to provide early warning of potential infectious disease outbreaks.	According to the Centers for Disease Control, the changing climate is likely to increase the presence of ticks and other vectors, thereby increasing the prevalence of vector-borne diseases: From 2000-2014, there were over 1,283 reported cases of Lyme Disease in West Virginia. According to the DHHR, "The number of counties reporting Lyme disease cases has increased in recent years." This reflects a nation-wide trend. According to the Environmental Protection Agency (EPA), "The incidence of Lyme disease in the United States has nearly doubled since 1991, from 3.74 reported cases per 100,000 people to 7.21 reported cases per 100,000 people in 2018. The EPA states the same conclusion: "Studies provide evidence that climate change has contributed to the expanded range of ticks."

ACTION	RECOMMENDATION	ILLUSTRATIONS OF WHY ACTION IS IMPORTANT TODAY
Engage West Virginia communities to coordinate efforts to enhance the potential of water resources--which flow across political boundaries--to provide prosperity and well-being to all.	West Virginia policymakers should take action to establish a grant program for communities to support outdoor recreation initiatives and a "bridge" bill to facilitate public access to West Virginia waterways.	Volunteers throughout West Virginia work together to develop and maintain the waterways in their regions through volunteer organizations such as Mon River Towns and the Elk River Trail Foundation. These organizations, however, need financial resources to undertake their work, which provides vitality, stability, sustainability, and prosperity to the surrounding region. This financial support is particularly important in currently distressed regions so these communities can attract new businesses and jobs. In Utah, for example, every dollar in state money spent to support outdoor recreation opportunities resulted in an additional seven dollars coming to communities from private sources. The result: 700 outdoor jobs were supported, primarily in rural Utah, over five years.
	West Virginia policymakers should propose that the USDA-funded Cooperative Extension Service and the Appalachian Community Technical Assistance and Training (ACTAT) programs support and educate rural communities on water-related economic development opportunities; provide guidance on the management of drinking water and wastewater; identify water recreation opportunities to enhance economic development; augment the water-focused curriculum in K-12 education; and work with community colleges to train staff for work in drinking water, waste water, and recreational water jobs.	The ACTAT team has provided training to over 163 small water and wastewater utilities from West Virginia, Kentucky, and Tennessee, positively impacting over 513,050 citizens. Training focuses on helping utility staff develop sustainable management practices in areas such as infrastructure stability, employee and leadership development, and financial viability. ACTAT works with small water systems from across West Virginia and other Appalachian states to advance the implementation of sustainable best management practices. For example, many small utilities lack a digital record of the location and condition of buried water and wastewater infrastructure and must rely on paper records or institutional knowledge to maintain this critical information. The ACTAT team works with utilities to digitize these records to improve system operation, using methods such as hydraulic modeling, which can support identification of leaks or other operational issues. ACTAT also supports utilities in conducting water audits and reducing the amount of water lost due to pipeline leaks. Less water loss means a more efficient and less costly water utility system.

ACTION	RECOMMENDATION	ILLUSTRATIONS OF WHY ACTION IS IMPORTANT TODAY
Revitalize West Virginia's water resources, and increase the state's resilience to meet the societal and economic needs of today's West Virginians and their future generations.	West Virginia policymakers should request that the USDA fund a 5-year study led by an independent party, such as a university, that would bring together stakeholders to identify, assess, and prioritize corrective water management infrastructure and flood inundation mapping actions in response to the changing climate. This study should include an assessment to determine whether West Virginia employs a sufficient number of engineers with the expertise to inspect dams. Policymakers should encourage the Federal Emergency Management Agency (FEMA) to prioritize remapping West Virginia's flood plains given the state's propensity for catastrophic flooding. Federal and state agencies should work together to take action on water-related infrastructure, particularly dams, drainage, culvert systems, and green infrastructure. In addition, the West Virginia Emergency Management agency should review its flood early warning system (FEWS) to ensure that it incorporates the most up-to-date "internet of things" (IOT) technology and that it monitors not only large rivers but small rivers as well.	According to West Virginia's 2018 Statewide Standard Hazard Mitigation Plan Update 2018, "All counties in West Virginia were ranked as having a high level of risk for flooding." Yet only 16% of particularly vulnerable structures are covered by flood insurance. FEMA's flood plain maps are often inadequate and inaccurate for West Virginia. This deficiency puts homeowners and businesses at risk, as not all homeowners who need insurance know that they could obtain it. When flood insurance is purchased, it is often insufficient to meet the purchaser's needs. Renters' properties are not covered by FEMA flood insurance or a typical renter's policy. West Virginia's June 2016 "extreme rainfall" flood, in which 8-10 inches fell in twelve hours, led to a state of emergency in 44 of West Virginia's 55 counties. Twenty-three lives were lost, over 2,300 people stayed overnight in shelters, and 1,700 families requested long-term help. West Virginia's 30 federal dams are now more than 50 years old. These dams were designed for last century's climate and are potentially undersized for current and future predicted precipitation regimes. Most dams in West Virginia (278) are privately owned, and many (203) are owned by local governments. The West Virginia state government has only three engineers to monitor the safety of all the dams in the state. Two West Virginia communities, Martinsburg (where 30% of the city lacks stormwater infrastructure) and Huntington (an area prone to flash-flooding), have demonstrated green infrastructure projects that could serve as models for other communities. As indicated by the Huntington project leader, "Uncertainties around flooding can make companies and private investors wary of spending on improvements that might be washed away in the next flood."
Showcase West Virginia's natural water resources by marketing their beauty and developing river-related recreation opportunities that increase tourism and recruit new businesses and residents.	West Virginia policymakers should introduce a "West Virginia Headwaters Legacy Act" that would provide a federal-designation and protect West Virginia's scenic rivers to ensure water quality is maintained or enhance a river's special values.	West Virginia has the greatest density of whitewater runs in the country, some of the best climbing in the eastern U.S., and thousands of miles of trails for hiking, trail running, backpacking, nature watching, and mountain biking. However, in 2019, outdoor recreation contributed only 1.9% to the state's overall state GDP, compared to rates of 4.7% in Montana, 3.3% in Utah, and 3.1% in Colorado.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AMD	acid mine drainage
ASDSO	Association of State Dam Safety Officials
CCR	Consumer Confidence Report
CDC	Centers for Disease Control
CRSCI	Climate-Ready States and Cities Initiative
CSO	combined sewer overflow
DHHR	Department of Health and Human Resources
EAP	emergency action plan
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FEWS	flood early warning system
HUD	Housing and Urban Development Association
NCRS	National Conservation Resource Service
NOAA	National Oceanic and Atmospheric Administration
NRDC	Natural Resources Defense Council
ORB	Ohio River Basin
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WBE	wastewater-based epidemiology
WVDEP	West Virginia Department of Environmental Protection
WVPSC	West Virginia Public Service Commission
WVU	West Virginia University

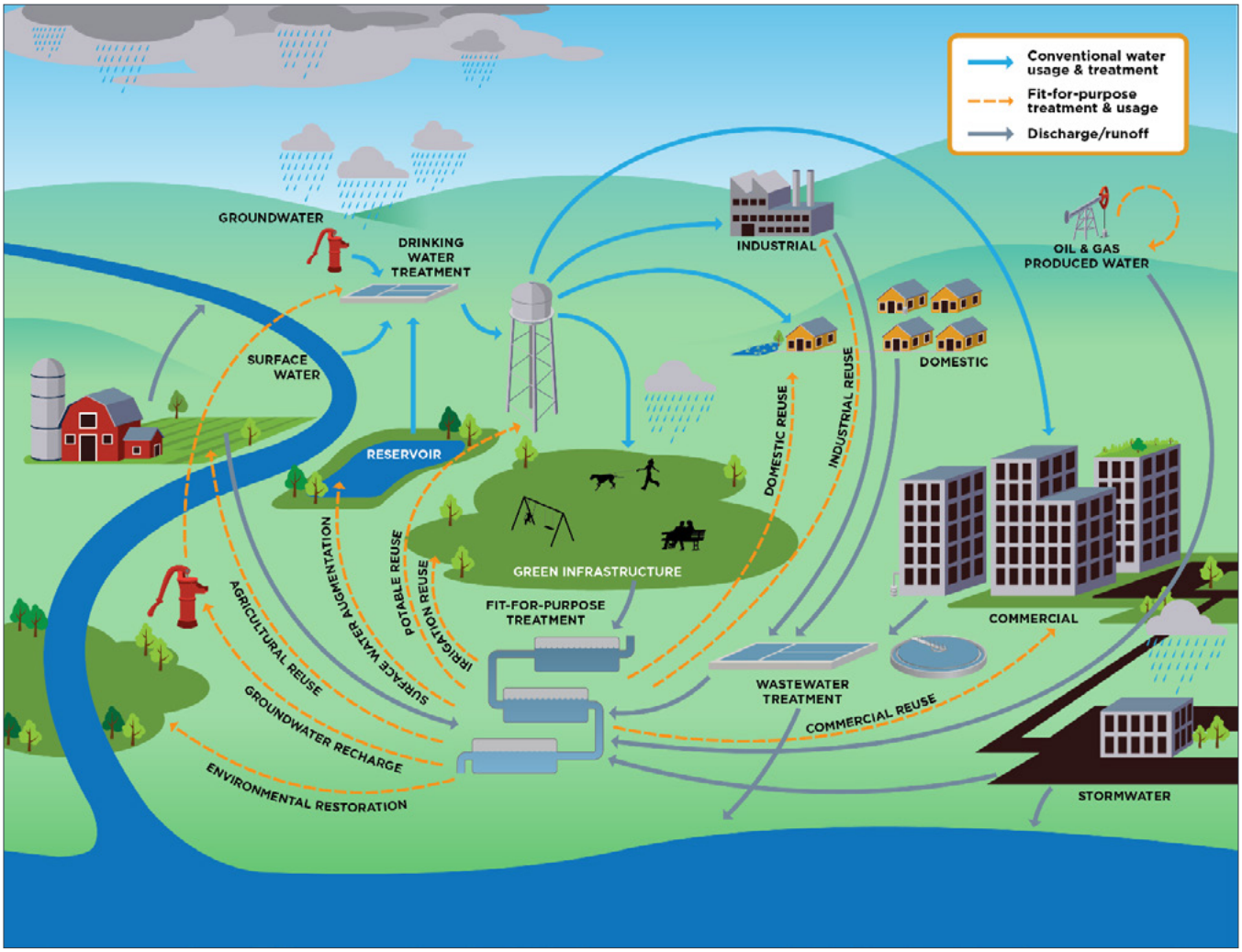


Figure 1. The Water Cycle. (U.S. Environmental Protection Agency) (2021)

WEST VIRGINIA'S WATER CYCLE

An important principle to understand about water is that it is part of a "water cycle"--that is, there is a finite amount of water in West Virginia. This water is constantly flowing, changing form from liquid to gas ("vapor") to solid ("ice") as it moves through use, reuse, and treatment (Figure 1). The implication of this is that someone else's wastewater may, after treatment, become your drinking water. Another consideration is that the wastewater from oil and gas operations removes water from the water cycle when it is disposed of in underground injection wells. As a result, policymakers and the public need to consider the whole water cycle system (as opposed to focusing on only one part of that cycle) when developing policy.

Another important aspect to understand about water is that it crosses state, county, and local jurisdiction lines as it moves through watersheds. A watershed is "a land area that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean."

West Virginia has 32 major watersheds, as illustrated in Figure 2. Understanding watersheds is important because adverse conditions (such as pollution) that occur in one area of the watershed may flow to other parts of the watershed, thereby altering water quality and the related drinking water and ecology. As a result, water quality is not solely the problem of any one water management system, but is rather a concern of the state and region as a whole.

In addition, the quality of West Virginia's waters affects not only West Virginia residents but 9% of the U.S. population.

Some of West Virginia's waterways are headwaters (upland sources of streams and rivers). For example, the Potomac River begins its journey in West Virginia, but the Potomac Water Basin includes Pennsylvania, Maryland, the District of Columbia, Virginia, and the Chesapeake Bay. The physical, biological, and chemical nature of the headwaters can impact those downstream across state lines. Similarly, the Ohio River begins its journey in Pittsburgh, Pennsylvania, but West Virginia rivers and streams also form part of the Ohio River headwaters. During its 981-mile journey ending in the Mississippi River, it flows through or borders four more states (Illinois, Indiana, Kentucky, and Ohio), providing drinking water for three million residents. West Virginia participates in a number of interstate basin organizations whose membership often includes a combination of local, state, and federal agencies, industry, academia, and not-for-profit organizations. These organizations typically focus on activities such as water management, watershed improvements, pollution reduction, data collection on water quality and aquatic life, and public education and engagement. Examples include the Ohio River Valley Water Sanitation Commission, the Ohio River Basin (ORB) Alliance, the Interstate Commission on the Potomac River Basin, and the Chesapeake Bay Watershed Initiative.

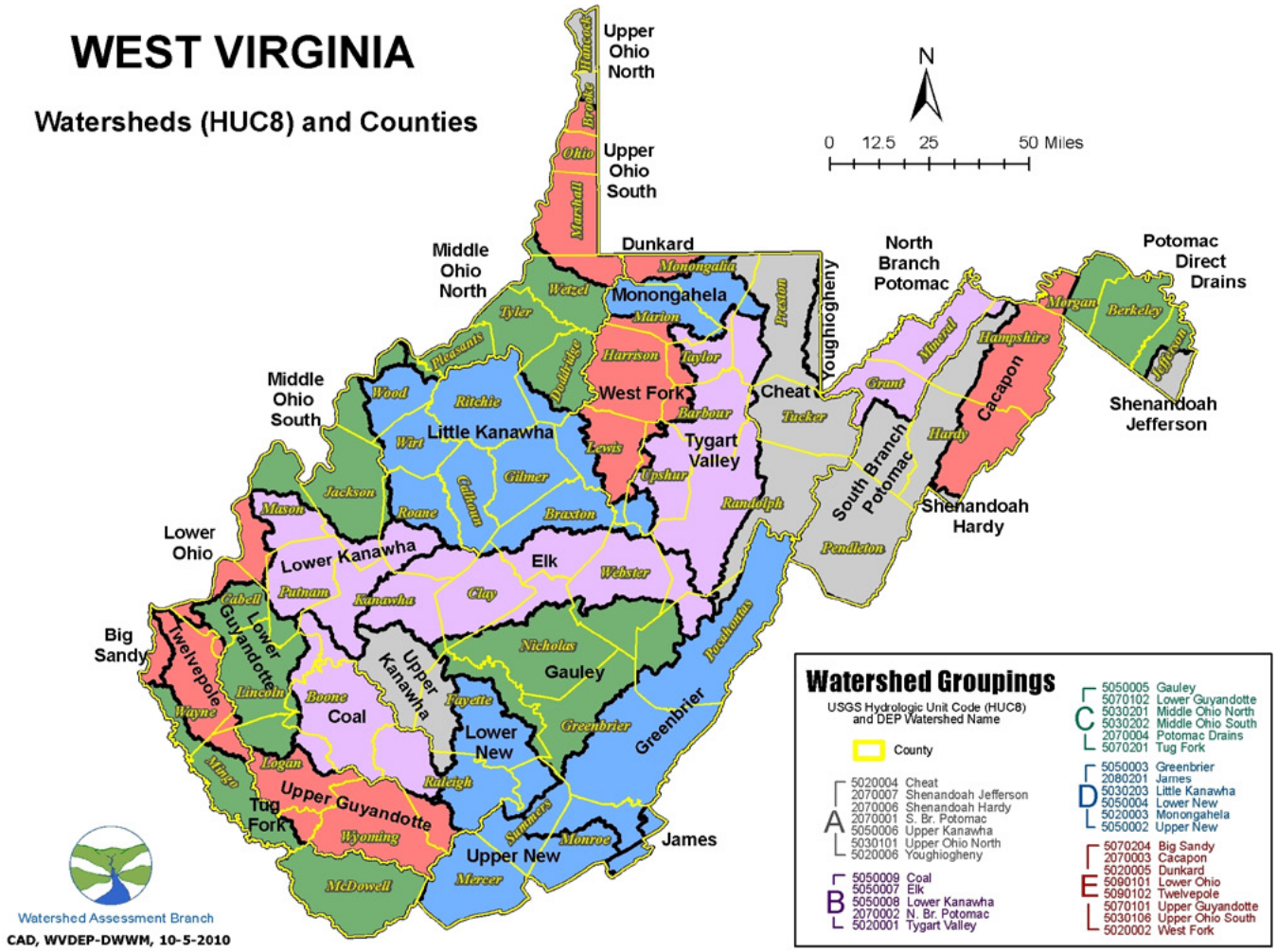


Figure 2. Watersheds of West Virginia. (West Virginia Department of Environmental Protection) (2021)

REGIONALIZATION AND RURAL COMMUNITY SUPPORT

West Virginia is largely a rural state characterized by small communities and dispersed populations. The state's rural population is decreasing, however: between 2000 and 2016, this population reduced from 45.6% to 38%. Such changes result in a smaller financial base for drinking water and wastewater services, which is particularly challenging for West Virginia's financially-disadvantaged communities.

This trend will continue unless the rural population has opportunities to develop employment and economic initiatives, increase the availability of essential water-related services, and recruit a remote workforce to increase population from within and outside of West Virginia.

Until that occurs, these small communities often lack the financial, management, and technical staff to operate their current infrastructure and apply for grants and other support to improve their infrastructure. As a result, these communities often pay a higher cost for basic drinking water and wastewater services due to the smaller population from which to draw the revenue needed to build and maintain these facilities, or because they need to purchase their water and wastewater services from another entity (as approved by the West Virginia Public Service Commission (WVPSC)). According to the WVPSC, the cost for these sewer utility services can range from $8 to $92 per 3,400 gallons for the same services, depending on location and circumstances specific to each system.

Another challenge is the major increase in special purpose government organizations that do not have the same geographical boundaries. From the 1950s to the early 21st century, West Virginia increased its special purpose governments, such as those managing water and sewer systems, from 57 to 342. As noted in the 2017 West Virginia University (WVU) report A Roadmap on Maximizing Local Government Effectiveness in West Virginia, "many different interests and perspectives are converging on a common desire to improve the coordination and delivery of essential services in our state and to create regional and cooperative platforms to develop plans and strategies that help West Virginia move forward."

WHAT IS RURAL ANYWAY?

"There are many ways of defining the word 'rural,' but it is clear that large chunks of West Virginia would fit into most of them. In popular culture, rural has been defined as a place that has more people in a parade than watching it.

"According to the U.S. Census Bureau, it is defined as any population, housing, or territory outside urban areas. It defines urbanized areas as those with 50,000 or more people and urban clusters as areas of at least 2,500 but less than 50,000 people. The Office of Management and Budget defines rural as all the places outside of a metro area with a core urban population of 50,000 or more.

"Such definitions do not often mesh with the lived experience of West Virginians. It is easy to find areas that would pass as rural to most observers only a short drive away from urban cores.

"The characteristics of West Virginia's terrain only enhances the feeling of its rurality. It is classified as the third most forested state, trailing only Maine and New Hampshire, with forests covering 78 percent of the state's rugged and mountainous 24,038 square miles. According to the West Virginia Department of Health and Human Resources (DHHR), the state is also ranked as the third most rural by the Census Bureau. In the 2010 census, 34 of West Virginia's 55 counties were considered rural, according to the Office of Rural Health Policy."

Source: What is Rural Anyway? (West Virginia Center on Budget & Policy) (2018)

WEST VIRGINIA CHALLENGES TO REACHING ITS POTENTIAL:

- Limited power and taxing authority of counties and municipalities
- Inconsistent boundaries for the increasing number of special purpose governments
- Decreasing rural population straining the financial ability of small communities (particularly those that are already economically disadvantaged) to support traditional water and wastewater management systems

POLICY OPTIONS FOR DISCUSSION:

West Virginia policymakers could propose a national network, enhance an existing network, support and educate rural communities on water-related economic development opportunities, and provide guidance on the management of drinking water, wastewater, and water recreational opportunities to enhance economic development opportunities. This may include developing proposals on behalf of rural communities to fund organizations and bring together communities to jointly propose initiatives such as unified drinking water and wastewater testing and treatment services. Implementation options include the following:

- Expanding the economic development activities of the current U.S. Department of Agriculture (USDA)-supported Cooperative Extension Service (part of the National Institute of Food and Agriculture) and the U.S. Department of Commerce Economic Development Administration.
- Developing a new program modeled after the Manufacturing Extension Partnership, which is a public-private partnership managed independently of the federal government with branches in each state.
- Establishing or enhancing existing interstate activities, given that water basins cross state lines. One example is the Appalachian Community Technical Assistance and Training program, funded by the USDA, where West Virginia works with Kentucky and Tennessee to provide customized face-to-face training and technical assistance to small Appalachian communities with inadequate water services.
- Enhancing or initiating water-related economic development activities of interstate basin groups such as the Ohio River Valley Water Sanitation Commission, the ORB Alliance, the Interstate Commission on the Potomac River Basin, and the Chesapeake Bay Watershed Initiative. A recent U.S. Army Corps of Engineers (USACE) Ohio River Basin report, for example, discusses economic development issues generally but not explicitly enough to provide guidance for policymaker action.

West Virginia policymakers could take actions to establish or review (and, if necessary, reorganize) intercounty/intercommunity councils to strengthen coordination and consistency, thus reducing the economic burden on local communities and enhancing their economic development. In particular, counties with limited resources may wish to consider pooling their resources for purchasing, constructing, and coordinating water-related services, public safety, management, and economic development activities. Examples include water-related tourism, workforce development, and drinking water, wastewater, and watershed management. A related issue is that there may be too many of these councils (19 in total) rather than an overall coordinated effort. According to a WVU report examining these 19 councils, “it is apparent that many different interests and perspectives are converging on a common desire to improve the coordination and delivery of essential services in our state and to create regional and cooperative platforms to develop plans and strategies that help West Virginia move forward.”

COMMUNITY BUILDING AND ECONOMIC DEVELOPMENT AROUND RECREATION

Outdoor recreation (Figure 3) is already a mainstay of the West Virginia economy, and water is a key element of that recreation. There are, of course, direct water-related activities such as fishing and water sports, but there are also indirect water-related activities such as wildlife viewing, hunting, trail sports, and snow sports.

West Virginia has the potential to be a national leader in the outdoor recreation economy. It has the greatest density of whitewater runs in the country, some of the best climbing in the Eastern U.S., and thousands of miles of trails for hiking, trail running, backpacking, nature watching, and mountain biking.

This is true not only for those areas of the state commonly recognized as outdoor destinations but for all of the state. For example, on this whitewater river density map (Figure 4), the dark pink color indicates a high degree of river density across most of West Virginia. The economic potential of these opportunities and resources can be further developed through collaboration and coordination among the state's stakeholders.

Yet, state outdoor recreation data from the Bureau of Economic Analysis (Figure 5) suggests that this potential is currently going untapped. According to their report, in 2019, outdoor recreation contributed only 1.9% to the overall state GDP in West Virginia, compared to rates of 4.7% in Montana, 3.3% in Utah, and 3.1% in Colorado. What lessons can West Virginia learn from these states?

Figure 3. Outdoor Recreation Activities. (Outdoor Industry Association) (2017)

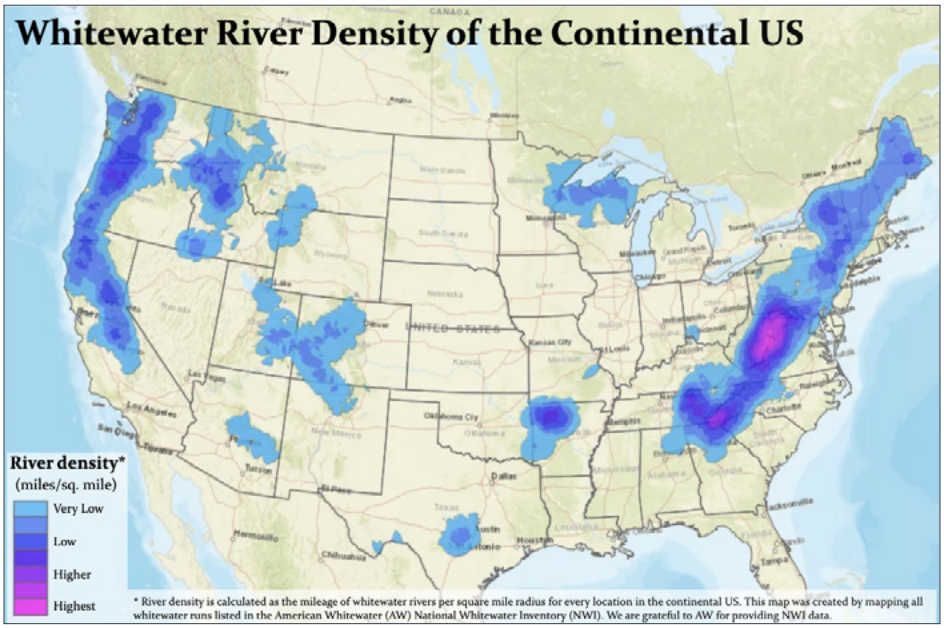


Figure 4. Whitewater River Density of the Continental US. West Virginia has the highest density of white water in the country.. (Morgantown Magazine) (2021)

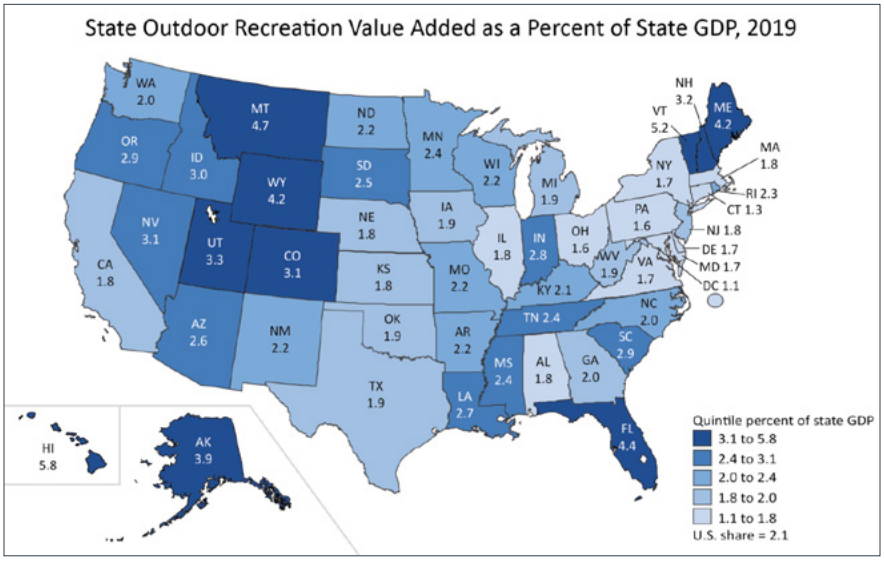


Figure 5. Outdoor Recreation Value as a Percent of State GDP.
(Bureau of Economic Analysis) (2019)

Figure 6. King Shoals River Access along the Elk River Trail.
(Elk River Trail Foundation) (2021)

A number of West Virginia non-profit volunteer organizations are currently taking action to improve access to the state's rivers. These efforts include action by the Elk River Trail Foundation, within the Elk River watershed, which is focusing on community development along that corridor through a "rail-to-trail" initiative. For example, the King Shoals initiative access point (Figure 6) includes a concrete ramp for small boats, concrete steps along the ramp, and a boat pad to ease entry to and exit from the river. Water trails are also in development within the Guyandotte, Coal, and Cacapon watersheds, among others.

In 2020, the West Virginia legislature passed Senate Bill 738, which formed a new Flatwater Trail Commission. The commission members, appointed in February 2021, will "standardize procedures, programs, research, and support for the development of flatwater trails" and advise the West Virginia Department of Commerce on the "development of activities and programs of beneficial interest to water recreation and flatwater trails."

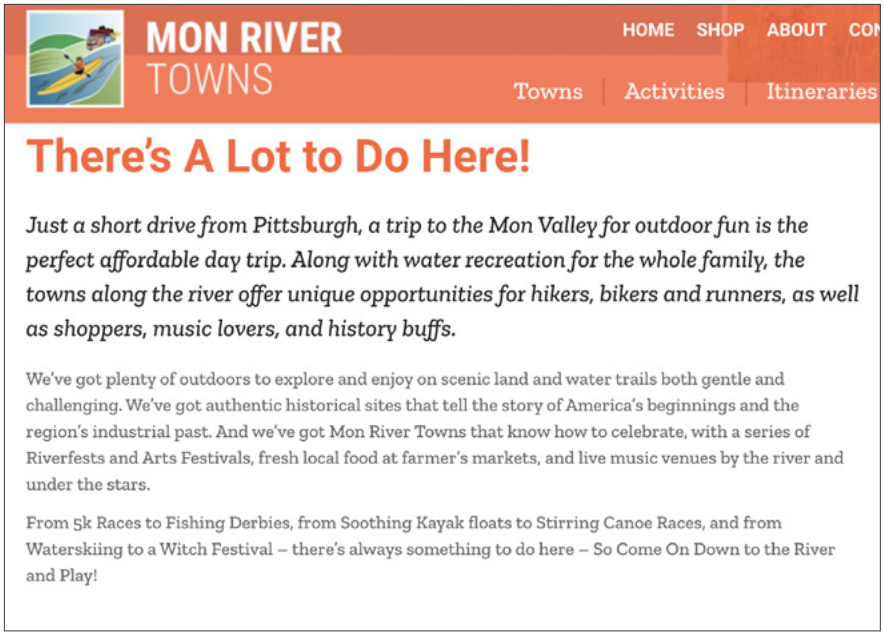


Figure 7. Mon River Activities Overview. (Mon River Towns) (2021)

Mon River Towns helps communities in West Virginia and Pennsylvania recognize the potential benefits of their rivers as an asset for community and economic development (Figure 7). Since its inception in 2011, the number of participating communities has increased from 5 to 25. The effort, initiated by the Pennsylvania Environmental Council, has leveraged $2.8 million. This investment has supported 18 public art projects, 5 boat launches, 4 park clearings, and 13 wayfinding and gateway signs; it has also increased the number of river festival celebrations from 3 to 11. This major investment to increase tourism in the region required many small towns working together with funding partners as described in their 5-year strategic plan.

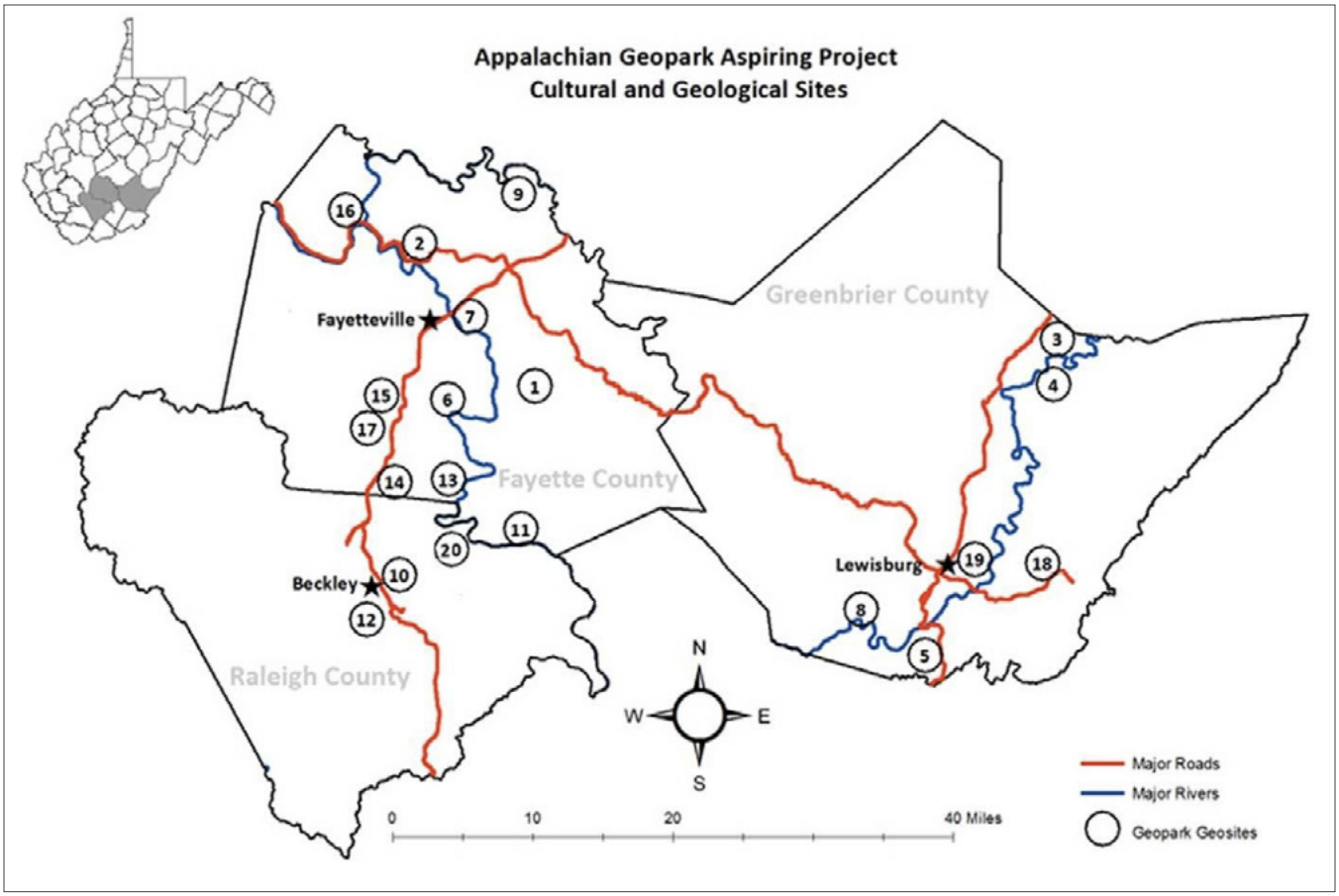


Figure 8. Cultural and Geological Sites in the Appalachian Geopark. (West Virginia University: Appalachian Geopark) (2021)

The proposed Appalachian Geopark (Figure 8) elevates and celebrates the state's geology, coal heritage, rail heritage, caverns and caves, springs, historical monuments, and protected areas. The goals of geoparks are to protect geological sites of international significance through proper planning, management and legislation, and to encourage sustainable geo-site public education activities. Geopark status does not imply restrictions on any economic activity inside a geopark where that activity complies with indigenous, local, regional, and/or federal legislation. Expected outcomes include an increase in both domestic and international visitors and the accompanying economic benefits. Geoparks are in many places around the world, but as of now there are none in the United States. In addition to West Virginia, geoparks are also proposed in Colorado and Michigan. The National Academies of Sciences, Engineering, and Medicine recently held a workshop to discuss the current state of geoparks in the United States and the opportunities such parks can bring to a community.

These water-focused natural amenities encourage visitors to the region. As illustrated in Figure 9, amenities such as these can lead not only to short-term economic benefits from tourists but also to long-term economic benefits from individuals who become enchanted with the region and proceed from repeat visits to renting and then purchasing second homes to full migration to the community.

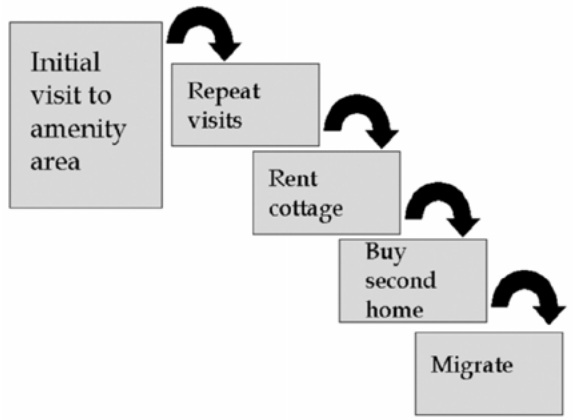


Figure 9. Increasing Levels of Commitment to a Place.
(U.S. Department of Agriculture) (2009)

WEST VIRGINIA CHALLENGES TO REACHING ITS POTENTIAL:

- Insufficient infrastructure for water-focused activities, including access for physically-challenged populations
- Insufficient right-of-way and public access to waterways (e.g., roads to waterway bank; waterway bank to river center)
- Low-head water dams that limit year-round recreational water opportunities
- Seasonal variations that limit white water recreational opportunities
- Insufficient employment and recreational opportunities to grow rural communities
- A decrease in West Virginia's overall population and an increase in the average age of its residents

POLICY OPTIONS FOR DISCUSSION:

West Virginia's policymakers could introduce a "West Virginia Headwaters Legacy Act" that would designate and protect West Virginia's scenic rivers. This act could be modeled after the proposed Montana Headwaters Legacy Act. In Montana, the outdoor economy industry supports 71,000 jobs and $7.5 billion in spending--more than its mining and utility sectors. The proposed act, scheduled for introduction by U.S. Senator Jon Tester in 2021, would designate and protect 336 miles of Montana rivers as scenic rivers, ensuring that water quality is maintained or enhanced to maintain a river's special values. In West Virginia's case, such an act would benefit not only West Virginians but the states that are downstream of its headwaters--about 9% of the U.S. population.

West Virginia's policymakers could introduce a West Virginia "bridge" bill to facilitate public access to West Virginia waterways. A West Virginia bridge bill would provide public access to streams and rivers from county roads and bridge rights-of-way, improving access for recreational activities. This could include working with private land and railroad companies. This act could be modeled after the Montana Bridge Bill.

West Virginia's policymakers could request that the West Virginia Conservation Agency utilize federal wetlands and stream restoration credits for removing low-head dams and Federal Emergency Management Agency (FEMA) funding for establishing nature-based resilient communities. By removing low-head dams, when feasible, the state would qualify for federal wetland and stream restoration credits. Efforts to assist nature-based resilient communities, such as integrating recreation into floodplain management practices, could be supported by FEMA funding.

West Virginia's policymakers could provide seed funding to build natural and artificial whitewater parks to provide year-round recreational opportunities and employment. One model program is in Bend, Oregon, a former log-mining area, where a combination of bonds, private donations, property taxes, and user fees led to the construction of a $10-million whitewater park that now provides a net benefit of $65-95 million annually. An artificial water park in Buena Vista, Colorado (population 2,700), heated by geothermal springs, provides off-season recreation opportunities.

West Virginia's policymakers could take action to retain West Virginia rural residents through water-related community building (e.g., river trails). This could include supporting the effort of existing non-profit groups such as the Elk River Trail Foundation, Mon River Towns, and Appalachian Geoparks. These could then serve as model programs for new activities that could be supported and advanced in West Virginia. Another option that could be explored is financial incentives to develop post-industrial brownfields as water-based recreational facilities.

West Virginia's policymakers could take action to establish a grant program for communities to support outdoor recreation initiatives. For example, the Utah Governor's Office of Economic Development, working with the legislature, provides Outdoor Recreation Grants that support communities interested in building tourism in their region by matching funds for the construction and expansion of outdoor recreation amenities. As illustrated in Figure 10, for every dollar spent in state money, an additional seven dollars was received by communities from private sources. As a result, 700 jobs were supported, primarily in rural Utah, over five years.

Figure 10. Outdoor Recreation Activities Provided by State Funding 2015-2020 (Utah). (Utah Office of Outdoor Recreation) (2020)

CONGRESSIONAL ACTIVITIES

In the Consolidated Appropriations ("Omnibus") bill passed by Congress in December 2020 for the federal Fiscal Year 2021 (ending September 30, 2021), a number of actions were taken regarding some of the issues in this policymaker guide. The following is a summary of the actions that specifically pertain to West Virginia's water, energy, infrastructure, and economic development activities.

- **Energy Storage**: Technical and planning assistance grants will be established to help smaller utilities and electric cooperatives deploy energy storage.
- **Southern WV Economic Development:** The USACE, the Appalachian Regional Commission (ARC), and other relevant federal agencies are required to work together to identify potential improvements to USACE facilities for recreation, economic development, and hydropower in the Appalachian region. This includes USACE evaluation of USACE projects to facilitate non-federal hydropower projects if requested by a relevant non-federal interest.
- **WV Water Infrastructure:** Maximum funding for the Central and Southern West Virginia Environmental Restoration programs will be expanded by $80 million each ($160 million total) to provide clean water and sanitary waste systems to West Virginia communities.
- **Bluestone Dam:** The USACE will continue to support the Bluestone Dam Safety Assurance Mega-Project in Hinton, WV. According to the USACE, "Bluestone Dam's primary purpose is to reduce flood risks throughout the New, Kanawha, and Ohio River valleys. It has reduced flood damages in excess of $5.9 billion during its life."
- **Clean Drinking Water:** Nearly $2.74 billion will go toward supporting water infrastructure.
- **Economic Development:** $115 million will be provided for the Interior Department's Office of Surface Mining Reclamation and Enforcement AML (Abandoned Mine Land) Economic Development Grants, $50 million for the Appalachian Regional Commission's POWER (Partnerships for Opportunity and Workforce and Economic Revitalization) Grants, and $33.5 million for the Economic Development Administration's Assistance to Coal Communities for Appalachia.
- **Inland Waterways:** The cost-share for construction of navigation projects on inland waterways will be changed to potentially increase funding and expedited construction of locks and dams on those waterways.
- **Local Levee Certification:** Federal agencies are to consider establishing one uniform federal standard for certifying levees as opposed to the two that are in place today, enabling communities to maintain, rather than lose, their federal certification.

Source: Adapted from West Virginia Senator Manchin Press Release (2020) and Senator Capito Press Release (2020)

Note: At the time of this writing, additional financial support is proposed by President Biden's Infrastructure proposal, called the America Jobs Plan, for some of the policy options proposed for consideration in this policymaker guide.

INDUSTRIAL USES OF WATER

West Virginia's industrial sector relies on water and power for its operations. Figure 11 illustrates the very complicated relationship between water, land, and energy--and the impact of climate variability and change on that relationship. This situation leads to both challenges and opportunities for business, industry, and the utilities that serve them and the general public.

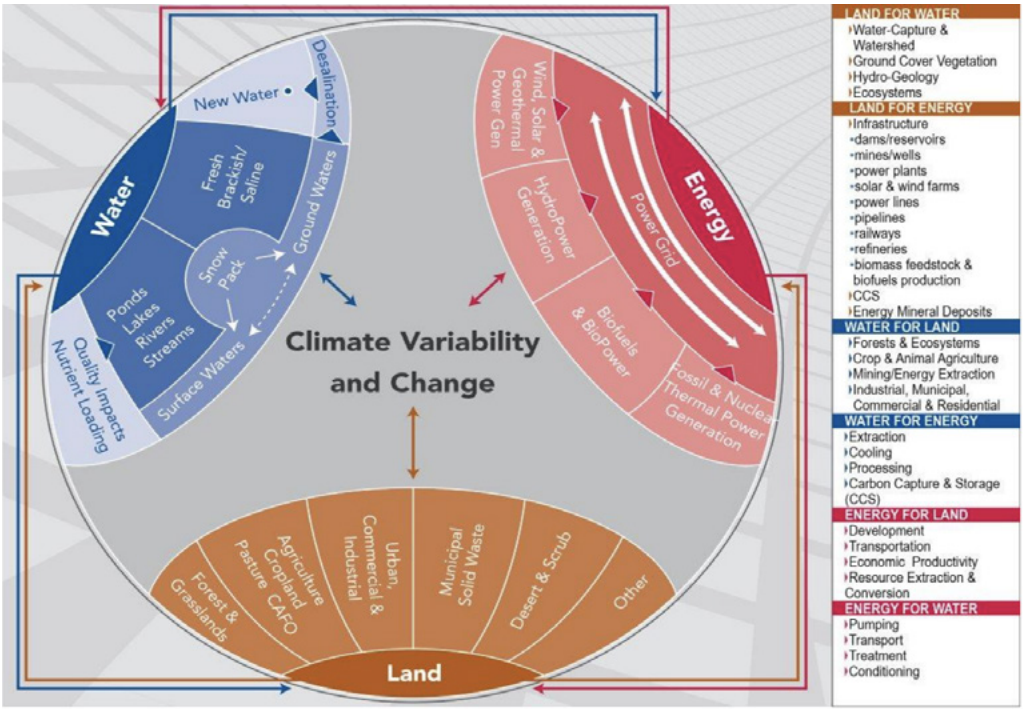


Figure 11. The Water, Land, and Energy Nexus. (U.S. Department of Energy) (2012)

Among the many possible topics, we focus in this section on two potential opportunities:

1. expansion of pumped hydropower energy storage that could support both fossil and renewable energy sources by enhancing resiliency for West Virginia's energy utility system

2. utilization of acid mine drainage (AMD) (i.e., mine-influenced water) sludge both to solve a current challenge related to storing the cleaned sludge and as the potential revenue source to pay for AMD operations and management through use of the sludge as an economic resource.

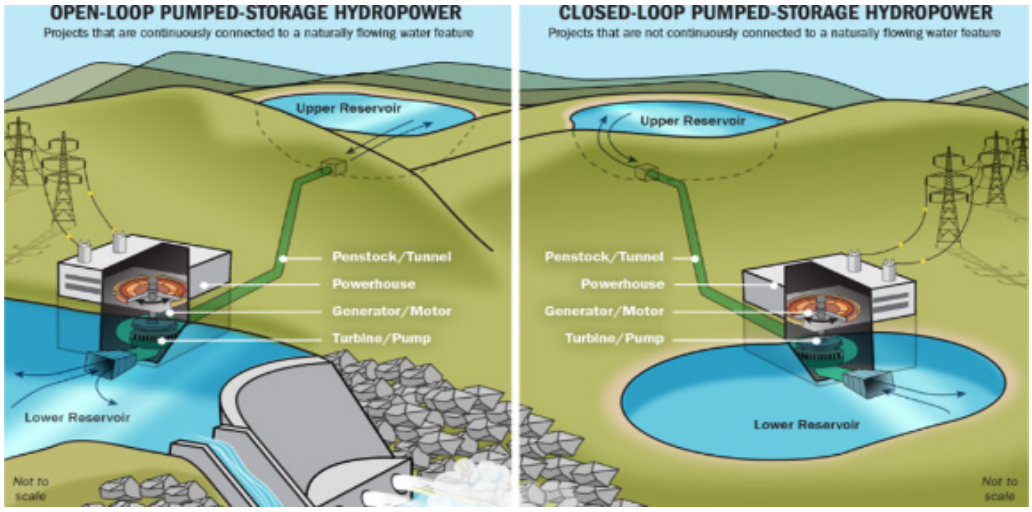


Figure 12. Open-Loop and Closed-Loop Pumped-Storage Hydropower.
(U.S. Energy Information Center) (2019)

Pumped Hydropower Energy Storage

Other options for West Virginia are circular dam pumped hydropower energy storage (Figure 12) as well as mine pumped hydropower storage. Energy storage is important for all sources of electricity. For example, a coal or natural gas plant might not need to "cycle" (that is change how much power it is generating) if it could store its energy for use when demand is higher. Storing energy could reduce the cost of running a fossil fuel power plant by 3-7%, support smaller modular fossil fuel facilities, and make these plants more resilient as they compete with renewable energy sources. For intermittent energy sources like wind and solar that depend on wind speed and solar intensity, energy storage is a critical element for them to become a significant contributor to baseload electricity supplies.

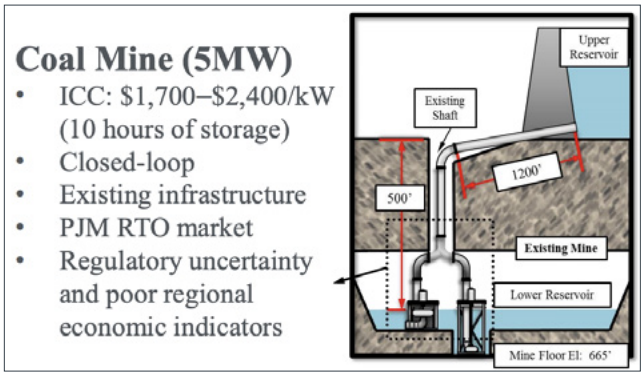


Figure 13. Modular Pumped Storage in Existing Mine.
(U.S. Department of Energy) (2017)

Not only is the generation and storage of energy important, but construction of such facilities can also provide an economic boost to rural development, creating jobs, economic growth, and tax revenue. This may be particularly true for coal communities, where abandoned mines could be used for energy storage instead. Several of these facilities are currently under study in Illinois and Maine, and there have been additional environmental and economic studies. The results of these studies (see Figure 13, which proposes consideration of decommissioned coal mines for energy storage), as well as a hearing of the Federal Energy Regulatory Commission, indicate the need for additional studies as well as site-specific analysis.

On the West Virginia/Virginia border is one of the largest facilities in the country: the Bath County Pumped Energy Storage Station. It is one of the world's most powerful pumped storage generating stations. The facility generates 3,000 MW of power and 24,000 MWh of storage--enough for 750,000 homes. As with run-of-river dams, the power comes from the movement of water from a higher-level to a low-level, which could work well given West Virginia's elevated areas. The facility also includes recreational opportunities including fishing, non-power boating, picnicking, swimming, hiking, and camping.

This facility, however, like most in the United States, was built long ago (1977) and was designed for a different energy world. One question that could be useful to address today is whether smaller facilities are more relevant for the 21st century. The U.S. Department of Energy recently conducted a competition to develop alternative, smaller, modular designs (Figure 14) that could be useful today. Building on this work, techno-economic analysis--incorporating community input--could be used to identify potential locations and their economic and environmental feasibility. Recent attempts to build such a facility in West Virginia's Grant and Tucker counties, however, resulted in significant public opposition and a 2019 U.S. Forest Service report expressing concerns about the effect on the ecology in the region. The concerns about this proposal will need to be fully understood and overcome for these projects to be successful.

Utilization of Acid Mine Drainage Treatment Residues

One legacy of West Virginia's industrial heritage is AMD at several mine sites statewide. AMD is also called "mine-influenced water" because water from mining areas can include not only acid but also other pollutants such as

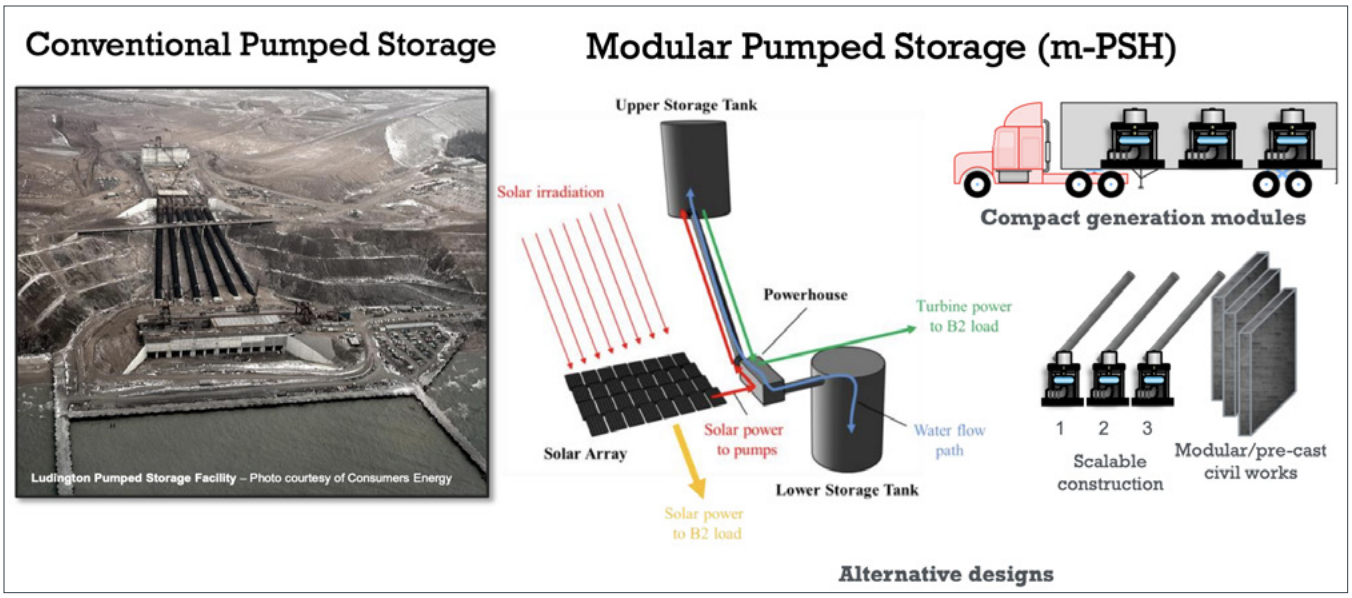


Figure 14. Modular Pumped Storage Options, Compared to Conventional Pumped Storage. (U.S. Department of Energy) (2017)

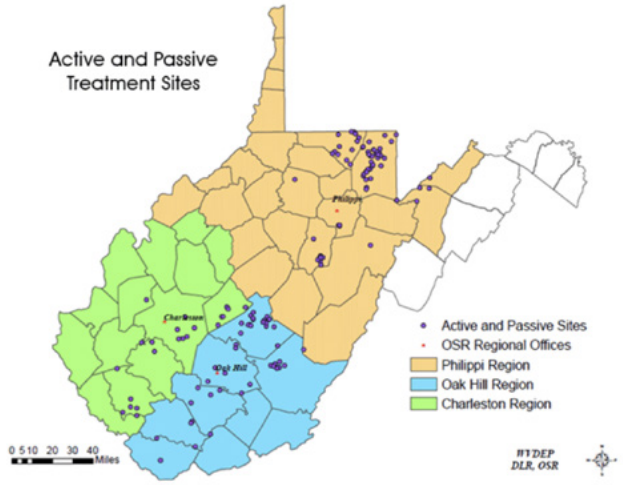


Figure 15. Active and Passive Treatment Sites for Acid Mine Drainage. (West Virginia Department of Environmental Protection) (2021)

iron, manganese, and aluminum. Mine drainage can be benign, but a number of sites throughout the state require treatment (Figure 15).

These treatment sites are managed by either the mining industry or the West Virginia Department of Environmental Protection (WVDEP) Office of Special Reclamation, which manages AMD treatment when the state has revoked mining permits and the company's surety bonds are forfeited. These bonds are typically not sufficient to cover the actual cost of reclamation or the environmental liability, so bonds are supplemented by a Special Reclamation Fund.

The water that drains from some mine sites is acidic, which compromises its uses downstream. Because of exposure to metal compounds within or near the coal seam, the water is contaminated with metals such as iron, aluminum, and manganese and is a threat to aquatic life. Active and legacy mine operations must take measures to prevent problematic mine drainage from forming or treat it before discharge to receiving streams. Active treatment with neutralizing chemicals such as lime liberates the metals compounds from the drainage and generates large volumes of "sludge." Often, properly disposing of these precipitates is more costly than the initial neutralizing treatment.

This WVDEP video about the Omega site near Morgantown explains how the AMD is managed and details the related economic and management challenges. For example, the annual management cost is $90,000-$100,000 at just the Omega site. The primary cost challenge, according to the WVDEP officials interviewed in the video, is not the treatment of the water but rather the management of the resulting sludge. Developing engineering methods to find a beneficial use for this sludge could help pay these costs.

WEST VIRGINIA CHALLENGES TO REACHING ITS POTENTIAL:

- Insufficient recognition of the potential for energy storage as an enabler of both fossil and renewable energy
- Lack of siting guidelines that take into consideration the potential impact of pumped hydro on nearby communities and the environment
- Conflicts with recreation and current use of public lands with the potential for pumped hydropower sites
- Engineering and economic feasibility being location-specific
- Limited access to renewable energy, which is important to attract companies, particularly those from Silicon Valley, that have sustainability goals; energy storage availability will help support that goal by providing an option to store electricity from renewable sources

POLICY OPTIONS FOR DISCUSSION:

West Virginia's policymakers could request that the U.S. Department of Energy, working with the Appalachian Regional Commission, relevant federal land agencies, and the USACE, develop siting guidelines for above ground and underground pumped hydropower sites in Appalachia. These guidelines could then be used to examine the potential engineering, economic, ecological, environmental, and funding impacts and potential for such sites. This work could build on previous efforts of these federal organizations as well as private organizations with a focus on site-specific situations. In all cases, public officials will likely need to meet with local communities and environmental advocates to discuss each potential project to identify and discuss their ideas and concerns as part of this analysis.

Figure 16. Conventional Acid Mine Drainage Sludge Treatment.
(West Virginia Department of Environmental Protection) (2021)

Figure 17. New Method of Acid Mine Drainage Sludge Treatment.
(Professor John Quaranta) (2021)

As shown in the photo above (Figure 16), in the traditional sludge management process, water is pumped from the mine and treated then enters a settling pond. Following this treatment, contaminants precipitate from the water and form a sludge, which is transferred to "geotubes" (tubes made of a specialized engineered textile that enhances dewatering). The water leaves the geotubes through the holes in the fabric and the solids remain inside. Geotubes are used for many purposes, including coastal and beach erosion. Once the dewatering and solid consolidation process is completed, the sludge-filled geotubes are typically stored back in the mine from which the AMD came.

Newer processes bypass the settling pond and go directly into the geotubes. As you can see in the photo of the Omega Mining Site near Morgantown (Figure 17), these geotubes are quite large, and AMD sludge management is a continuing concern as the amount generated continues to increase.

Overall, the AMD treatment process is essential yet expensive, and it poses a long-term management problem for the state in terms of where to store the processed sludge. The minerals inside the sludge, however, make it a valuable resource that can be utilized or sold. The WVDEP and others are evaluating methods to not only economically capture and store these byproducts but actually reuse them. Researchers at WVU have joined others in exploring the potential to reclaim rare earth elements from the sludge, and the work has progressed to a full-scale processing facility now under construction near Mount Storm. Another alternative that may be worth exploring is to utilize the now environmentally-safe sludge for land reclamation (Figure 18).

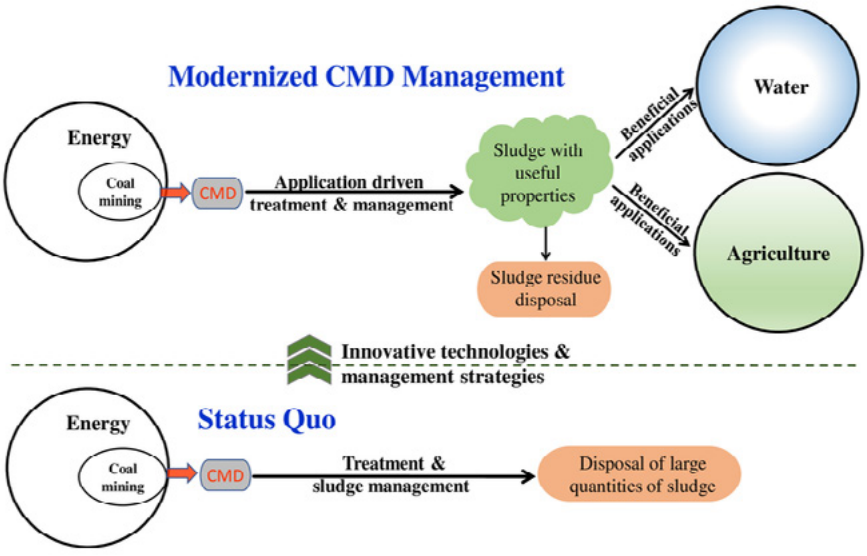


Figure 18. Beneficial Applications of ADM Sludge after Using Modern Treatment Methods. (Professor Lian-Shin Lin) (2021)

Although more techno-economic analyses are needed, these alternative uses could potentially defray costs, improve efficiency of coal mining and reclamation activities, and generate a new revenue stream for West Virginia. For example, the post-processed environmentally-safe sludge could potentially be used for

1. pollution control for removal of arsenic, selenium, and chloride
2. innovative energy-efficient wastewater treatment
3. mitigation of surface water runoff pollution at agricultural feedlot sites
4. mitigation of stormwater runoff impacts and combined sewer overflow (CSO)
5. nutrient management for crop production

This concept is at the preliminary stage but may be worth exploring and prioritizing for the potential financial benefits given this ever-increasing challenge. Beyond the technical issues, there are also marketing issues that would need to be explored, such as developing a market, perhaps through regulatory pull mechanisms, and understanding the potential and allowable uses for the reclaimed material.

Another possibility for funding such efforts is the RECLAIM Act, a bipartisan proposal in Congress that would "accelerate the release of $1 billion from the remaining, unappropriated balance in the Abandoned Mine Reclamation Fund to revitalize coal communities impacted by abandoned mine lands and the recent decrease in coal mining."

WEST VIRGINIA CHALLENGES TO REACHING ITS POTENTIAL:

- Lack of supply chain for reclaimed materials
- Lack of knowledge of reclaimed materials and their potential uses
- Insufficient regulatory pull to encourage reclaimed material use
- Insufficient economic analysis to understand the potential market
- Potential Environmental Protection Agency (EPA) wastewater management regulatory barriers on the horizon

POLICY OPTIONS FOR DISCUSSION:

West Virginia's policymakers could request that the U.S. Department of Energy and the U.S. Department of Interior Office of Surface Mining, Reclamation, and Enforcement work with the WVDEP to develop and fund an AMD treatment residues utilization test bed and commercialization study. The study could analyze the engineering resources, economic potential, marketability, and supply chain to determine if this is a viable option that will both solve an existing challenge of storing this residue and provide an economic stream to fund these efforts--and perhaps create a new source of economic development and jobs for communities with AMD challenges.

INFRASTRUCTURE AND WATER

Economic development relies on a solid infrastructure of roads, bridges, dams, power, drinking water, and wastewater management. Unfortunately, West Virginia, like much of the nation, has a crumbling infrastructure that often deters economic development of the state's most vulnerable communities. And the lack of reliable potable (i.e., safe to drink) water has led some West Virginians to not only leave their homes but also leave the state altogether.

INFRASTRUCTURE AND ADAPTATION TO EXTREME PRECIPITATION EVENTS

The West Virginia chapter of the American Society of Civil Engineers (WVASCE) 2020 Infrastructure report card provides an overview of the situation for bridges, dams, drinking water, roads, and wastewater. The overall grade is D, defined as "POOR: AT RISK":

> The infrastructure is in poor to fair condition and mostly below standard, with many elements approaching the end of their service life. A large portion of the system exhibits significant deterioration. Condition and capacity are of significant concern with strong risk of failure.

The WVASCE report provides many recommendations for how to respond to the state's infrastructure challenges.

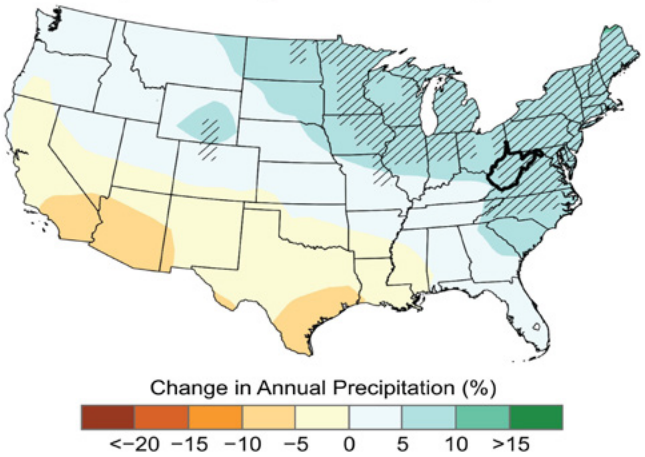


Figure 19. Projected Change in Annual Rainfall by 2050.
(National Oceanic and Atmospheric Administration) (2018)

The WVU analysis presented here supplements the WVASCE recommendations on the current state of the infrastructure with a focus on issues related to the expected impact of climate change, which will affect the future status of this infrastructure.

Today, according to the National Oceanic and Atmospheric Administration (NOAA), the number of extreme precipitation events in West Virginia over a 5-year period began increasing as of 2010 and is expected to increase even more in the future. As the map shows, West Virginia is expected to show a significant increase in annual precipitation (Figure 19).

CASE STUDY:
WASTEWATER MANAGEMENT NEEDED TO BRING A GHOST TOWN BACK TO LIFE

A case study that illustrates the economic impact of insufficient infrastructure is the "ghost town" of Thurmond, West Virginia, located on the New River Gorge with Amtrak access. Thurmond is a small, historical town of less than 10 residents with an additional 17 property owners who are eager to develop their properties. The potential for business and job creation related to recreational opportunities is high given the new National Park Service designation and the rave reviews on TripAdvisor. The National Park Service itself is interested in revitalizing and refurbishing their buildings to provide commercial services as well as seasonal housing for their employees. The challenge for those interested is a lack of wastewater infrastructure. Without access to this infrastructure, development of this town that would bring jobs to the region is at a standstill.

According to NOAA, this map provides the "projected changes in annual precipitation (%) for the middle of the 21st century relative to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. West Virginia is part of a large area of projected increases in the Northeast."

In addition, projections suggest that West Virginia will experience more frequent dry periods and droughts and extreme events such as flooding, heat waves, and tornados, all stimulated by a temperature increase of up to 10 degrees Fahrenheit throughout this century.

Of particular concern are the state's aging dams, typically owned by the federal government, some of which are over 50 years old and are "high hazard." A high hazard dam is not one that necessarily poses an immediate risk but rather is located where a failure could lead to adverse consequences on nearby populations. Provided in Figure 20 are excerpts from West Virginia's Dam Safety Report, developed by the Association of State Dam Safety Officials

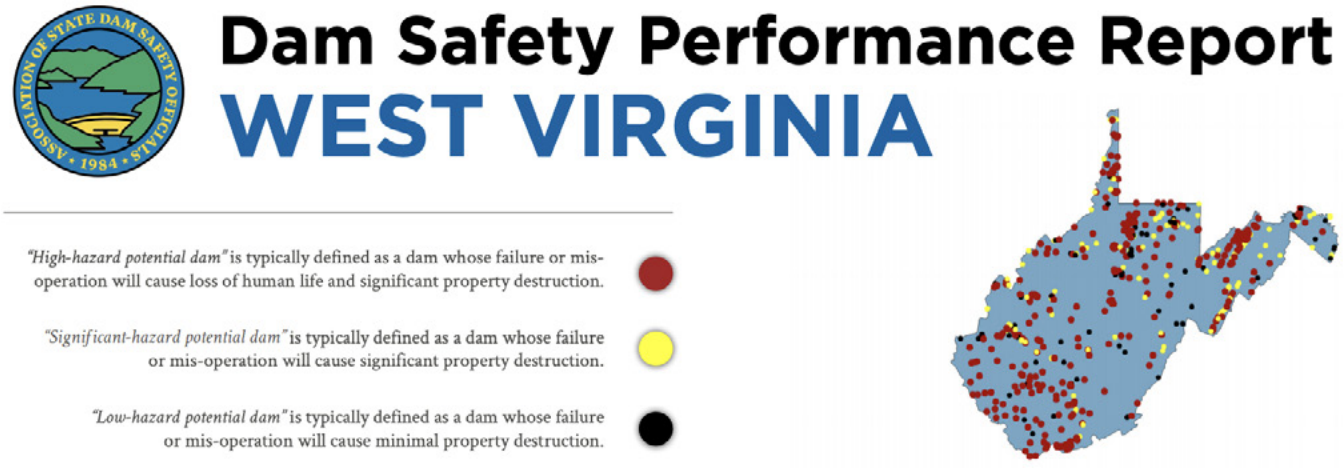


Figure 20. Dam Safety Ratings and Potential Damage Report for West Virginia. (Association of State Dam Safety Officials) (2018)

HOW IS WEST VIRGINIA DOING ON DAM SAFETY COMPARED TO THE NATIONAL BENCHMARK?

"The National Dam Safety Program, in cooperation with ASDSO, developed a benchmark called the Model State Dam Safety Program to assist state officials in initiating or improving their state programs. The model outlines the key components of an effective dam safety program and provides guidance on the development of more effective and sustainable state programs to reduce the risks created by unsafe dams. It contains chapters on Legislative Authorities, Permitting, Inspection, Enforcement, Emergency Action Planning and Response, Education and Training, and Public Relations.

"The tables here present the state's response to a series of yes/no questions on the authorities for each chapter and an overall weighted percentage for the program. The tables also show how the state's weighted averages compare to the national averages over time. Higher percentages indicate greater alignment of the state program with the model and lower percentages can be indicative of needed improvement in authority. The areas are weighted by importance (listed in order with weightings indicated in parentheses) for the overall percentage. Areas of concern where additional state authorities may be needed are highlighted."

Source: West Virginia State Staffing and Budgets for Dam Safety. (Association of State Dam Safety Officials) (2018)

Overall Weighted Percentage

1989	1998	2010	2018	
62%	78%	89%	90%	**West Virginia**
59%	66%	77%	79%	**National Average**

2018 State Weighted Percentage

Legislation (5)	**91%**
Inspection (4)	**92%**
Enforcement (4)	**100%**
EAP & Response (4)	**83%**
Permitting (3)	**92%**
Education & Training (3)	**89%**
Public Relations (1)	**50%**
Weighted Percentage	**90%**

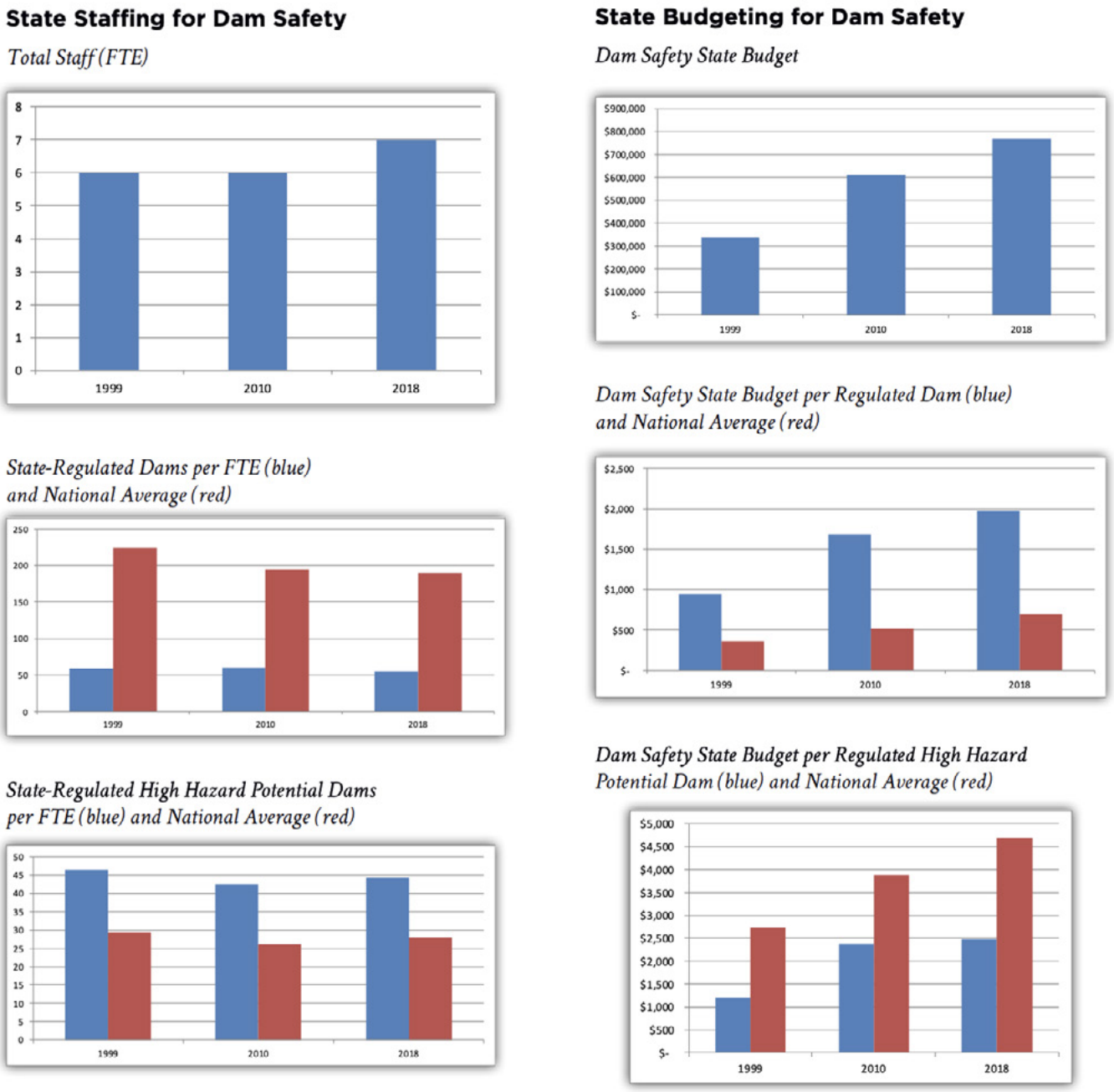


Figure 21. West Virginia State Staffing and Budgets for Dam Safety. (Association of State Dam Safety Officials) (2018)

(ASDSO), which provides information on dams that are in the National Inventory of Dams and state-regulated dams.

The accompanying map identifies and describes the number of high-hazard, significant hazard, and low-hazard dams in West Virginia.

The data on the previous page indicates how well West Virginia is doing compared to the national average in overall performance, legislation, inspections, enforcement, emergency action plans, permitting, education and training, and public relations. Note the low score for public relations.

The data above provides information on how well West Virginia is staffing its dam safety information (Figure 21). Although the total staff identified for dam safety is 6-7, additional discussions WVU had with the program staff indicated that only three of these staff members are engineers capable of doing safety inspections. This is particularly concerning given that the state regulated dams per FTE for West Virginia is well below the national average even looking at the total program staff number, much less the number of engineers. On state budgeting, the dam safety budget per regulated high hazard dam (lower right) is also below the national average. When you consider the

number of state engineers and the location throughout the state of all the high hazard dams (red dots) in the map above, this is an area of concern. Three engineers seem to be an insufficient number to travel and inspect all the dams in West Virginia on a regular basis.

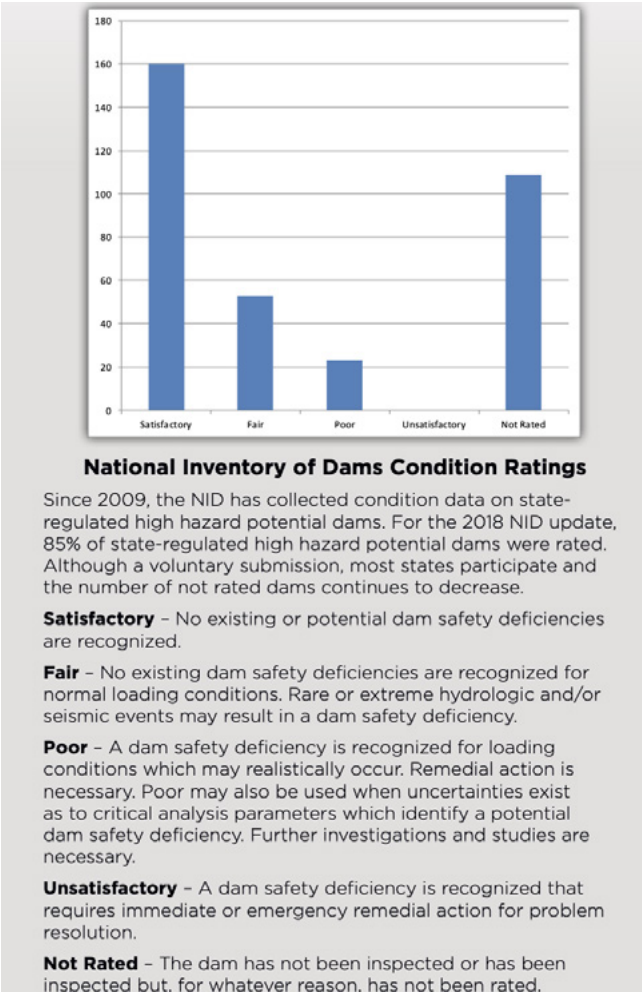


Figure 22. Condition of West Virginia High Hazard Potential Dams. (Association of State Dam Safety Officials) (2018)

Figure 22 provides information on the condition of state-regulated high hazard potential dams in West Virginia. Note that the total number of fair, poor, and "not rated" (not inspected or not rated) dams, when combined, is higher than the number of satisfactory dams. This may be related to the dam safety engineer staffing challenges described above.

In a May 2017 report by the USACE in partnership with the ORB Alliance, the West Virginia National Conservation Resource Service (NCRS), under the USDA, provided the following response to a question about the importance of developing a climate change response plan for West Virginia:

NCRS is interested in working with the Corps and other partners to integrate systems within the ORB for several reasons:

PL 566/534 Dams;

- Are critical infrastructure that communities depend upon for flood protection & water supply
- More people are at risk living downstream from the dams than ever before
- Dams are getting older and do not meet current safety standards
- Climate change will increase precipitation intensity, will produce larger and more frequent floods, will increase drought severity, will dangerously reduce critical water supplies, and more result in more frequent and widespread wildfires.
- Limited funds are available for maintenance and rehabilitation to keep the dams safe
- Fewer experienced people are available to address operation and maintenance issues and effectively respond to emergency conditions.

Very few plans are in place to deal with any of the items listed above. Any exposure to the benefits of the dams, the issues faced when dealing with the aging infrastructure of the dams, impacts on climate change to the structures would benefit communities across the Commonwealth.

Dams are just one element of a complex system that can prevent flooding, which can also include levees, weirs, detention basins, and flood bypasses (Figure 23).

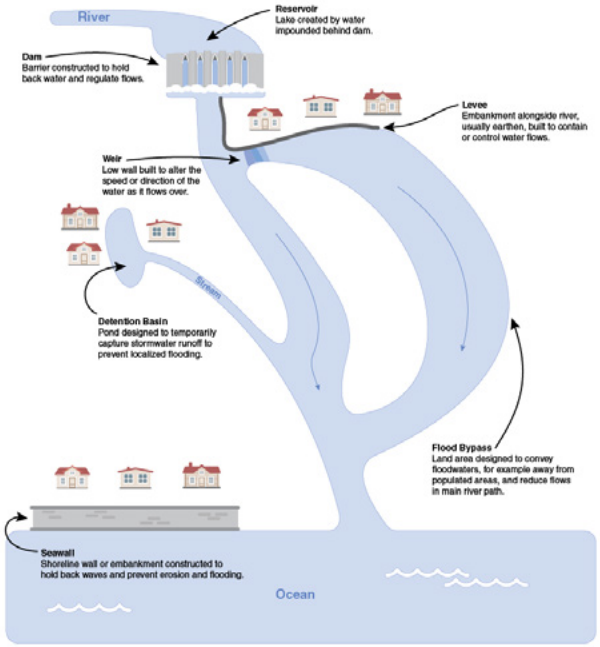


Figure 23. Key Flood Infrastructure Components.

("Managing Floods in California" Legislative Analyst's Office) (2017)

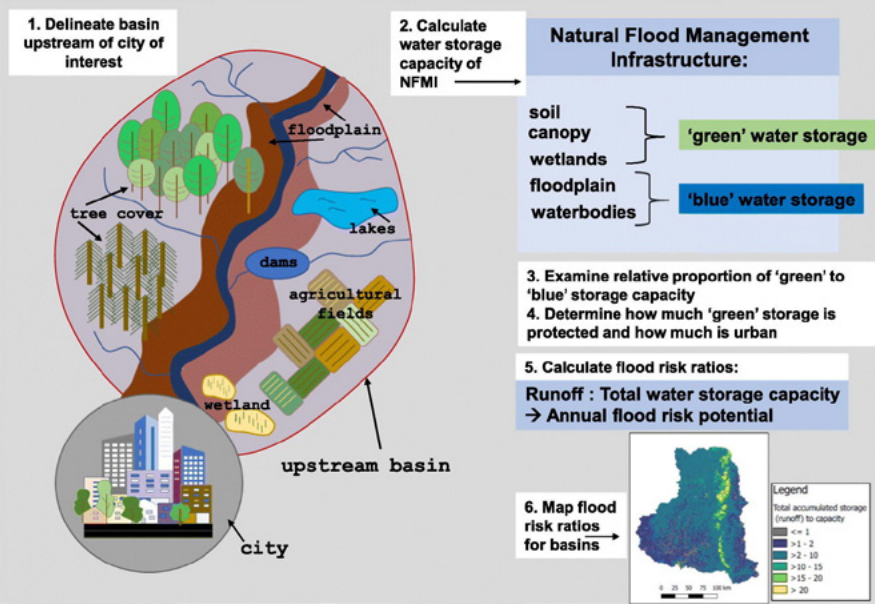


Figure 24. Natural Infrastructure Methods to Enhance Water Storage and Prevent Flooding. (Gunnell, et al.) (2019)

Figure 25. Project Timeline: Puyallup River Flood Protection at Orville Road.

(Pierce County, WA) (accessed October 2021)

In addition, there are natural infrastructure methods where wetlands, reefs, dunes, floodplains, and forests are restored to enhance their ability to store water and prevent flooding. Figure 24 describes how to assess the potential of natural infrastructure.

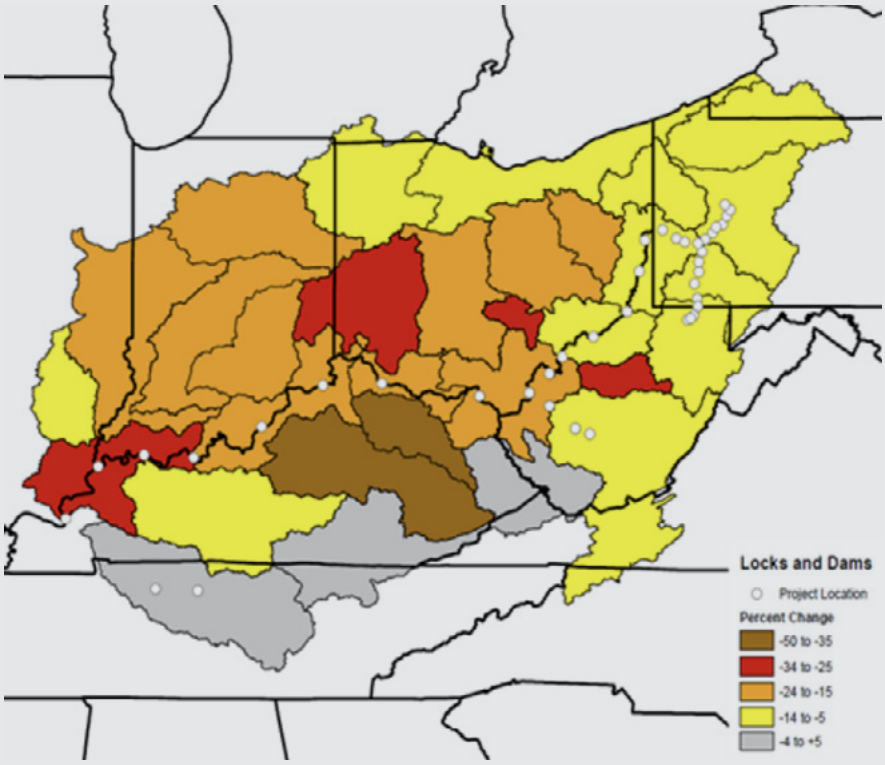
The USACE's Engineering with Nature project focuses on the development of green infrastructure, which they define as the "intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaborative processes." The USACE has collected case studies from the Puyallup River in Washington state that illustrate the possibilities of an Engineering with Nature approach. Case studies such as these can be a starting point for discussions in West Virginia. As described by FEMA,

> In 1996, a flood on the Puyallup damaged several homes along the river a few miles upstream from the city of Orting, damaged or destroyed several hundred feet of a levee, and threatened Orville Road, an important local roadway. That event triggered efforts by the U.S. Army Corps of Engineers (USACE), in close cooperation with Pierce County, the Washington Department of Fish and Wildlife (WDFW), and the Puyallup Tribe of Indians to develop a plan to address the flood damages and lessen the risk of future damages along the river. . . The reconnection of the Puyallup River with about 125 acres of its natural floodplain had two positive consequences. First, it allowed the river more room to spread out and dissipate energy during future flood flows. Since completion of the project in 1997, the levees have worked as designed. In fact, during the floods 2003 and 2006, they greatly mitigated the flood impact to the area protected by the project. . . The project also restored the access to salmon of approximately 2,000 feet of the channel of a tributary to the Puyallup, and within a few days of completion of the work, chum salmon were seen entering the small stream for the first time in many years.

The timeline above (Figure 25) shows how long the project took and the investment needed for this operation.

Additional methods include elevating homes (FEMA supports 100-year flood risk plus at least one foot) or relocating homes to a new area that is further away from the potential flood zone.

NAVIGATION LOCKS AND DAMS



"The USACE operates a system of locks and dams that supports commercial navigation on the Ohio River and its major tributaries. Altogether, there are 40 operating navigation dams in the system. Figure 8-14 shows the location [and forecasted change in water flow discharge] of these structures on the Ohio River and its major tributaries and Table B-18 of Appendix B identifies each by name and river location.

"These facilities are authorized to maintain a specific draft for commercial barge traffic through maintenance of relatively stable, linear pools. These pools are similar in operation to reservoirs that maintain a permanent pool, but navigation dams generally have no flood control purpose. The locks allow passage by tows (tow boats and commercial barges) and recreation craft between pools. Navigation dams control river flow through multiple gates that can be operated independently. Navigation dams with associated hydropower stations can control navigation pool depths through cooperative operation of hydropower plant flow alone. Under high river flow conditions, navigation dam gates are opened to allow passage of high flows without any consideration for storage of flows to address downstream damages; tributary flood damage reduction dams and LPPs fulfill that flood damage reduction responsibility within the system.

"Byproducts of this navigation purpose are stable pools for water-based recreation, M&I water supply, hydropower, commercial fishing, effluent attenuation, marine-related businesses (i.e., floating dry docks), and sustaining aquatic habitat for federally protected and non-protected species.

"A significant drop in river flow that dewaters municipal, industrial, or corporate water intakes can result in serious economic losses and emergency water supply conditions. ORSANCO data indicates that more than 5 million people depend upon Ohio River mainstem flow alone for potable water supply. Withdrawals for cooling facilities at thermoelectric power plants along the Ohio River and its major tributaries can be sharply reduced in drought conditions, resulting in plant shutdowns and loss of regional energy supplies. Likewise, increased water temperatures can adversely impact the efficiency of 'once through' thermoelectric power plants. Both 'cool-water' and 'cold-water' aquatic resources can be adversely affected by rising water temperatures. Forecasted lower flows could impact the capability of rivers to dilute/assimilate permitted effluent discharges under Total Maximum Daily Load (TMDL) guidelines.

"Past episodes of persistent drought have jeopardized agencies' ability to maintain authorized draft of several navigation pools, thereby ceasing navigation on the river system. As the Ohio River navigation system feeds commercial traffic into the Mississippi River, any losses could translate into that lower system as well. Some flow relief can be provided by upstream reservoirs, but long term attenuation of a navigation pool loss comes at the concurrent loss of economic benefits at basin reservoirs. Other options are available, such as channel dredging to maintain authorized draft for navigation, but that solution is limited by the water depth over the sill elevation of the lock."

Source: OHIO RIVER BASIN: Formulating Climate Change Mitigation/Adaptation Strategies through Regional Collaboration with the ORB Alliance. (U.S. Army Corps of Engineers and Ohio River Basin Alliance) (2017)

INFRASTRUCTURE AND ADAPTATION TO DROUGHT EVENTS

West Virginia's 30 federal dams, most built with the help of Senator Byrd following flooding incidents in the 1960s, are now more than 50 years old and were designed for last century's climate (based on predictions of expected precipitation at the time); these dams are potentially undersized for current and future predicted precipitation regimes--specifically an increase in extreme precipitation events due to climate change.

Climate change may also lead to drought in other parts of West Virginia. In fact, many federal dams are approved for flow augmentation in addition to flood control. Such dual concerns are addressed in the USACE's ORB report. The excerpt (see box above) illustrates how drought conditions due to climate change may reduce the flow of navigable waters, thereby jeopardizing commercial activities. The report further shows that the quality of drinking water decreases as the concentration of pollutants increases due to the lack of Ohio river flow. As stated in the report, "a significant drop in river flow that dewaters municipal, industrial, or corporate water intakes can result in serious economic losses and emergency water supply conditions."

Adaptation Themes	Basin Purposes Supported							
	Flood Risk Management	Wastewater Management	Water Supply	Navigation	Hydropower	Recreation	Aquatic Ecosystem	Land Ecosystem
Restore Wetlands	X	X				X	X	X
Reconnect Floodplains	X					X	X	X
Reduce Consumptive Uses of Water			X	X	X	X	X	X
Water Harvesting	X		X					
Drought Planning			X	X	X	X	X	
Increase Nutrient and AMD Management		X	X			X	X	
Thermoelectric Power Plant Cooling Changes[22]		X	X				X	
Nonstructural Flood Risk Management	X	X	X			X	X	X
More Water Quality and Discharge Monitoring	X	X	X	X	X	X	X	X
Land Use Management	X	X	X			X	X	X
Reservoir Operation and Structure Modifications	X	X	X	X	X	X	X	X
Managing Ecosystem Stress	X	X	X	X	X	X	X	X

Table 1. Adaptation Themes. (U.S. Army Corps of Engineers) (2017)

Adaptation Options	
Ecosystem Resources and Services	**Operating Infrastructure**
Reconnect floodplains to river channels where opportunities exist to remove or realign impediments	Investigate options to modify fall/winter drawdown for additional seasonal storage at three reservoir sites on the New, Gauley, and Elk rivers
Restore wetlands by targeting the 10,232 occurrences where existing wetlands intersect hydric soils	Encourage transition of cooling systems at four once-through power plants to use re-circulating methods
Reduce stressors on aquatic ecosystems through water quality improvements	Implement nonstructural measures through multiple programs to reduce flood damages
Increase emphasis on nutrient and AMD management programs	Consider increased discharges from storage reservoirs to support navigation in future drought situations on the Kanawha River and Ohio River
Modify release schedules at storage reservoirs to meet seasonal aquatic needs during high flow periods	Ensure that flood control dams showing poor or unsatisfactory performance are rehabilitated before increased flows are forecasted
Encourage more wise use and development of floodplains and land resources including use of LID concepts	Consider relocation of flood sensitive infrastructure from high hazard floodplains
Install additional water quality and quantity monitoring stations	

Table 2. Adaptation Options for the Kanawha River Sub-basin.
(U.S. Army Corps of Engineers) (2017)

The USACE report identified a number of adaptation strategies that policy leaders in the Ohio River Basin can take now to mitigate the potential impacts of climate change. Table 1 summarizes the predicted societal and economic outcomes. For example, actions taken now to plan for future droughts can help support water basin activities such as water supply, navigation (see excerpt above), hydropower, recreation, and aquatic ecosystem.

Table 2 provides examples of how those strategies might be applied to the Kanawha sub-basin of the Ohio basin. Possible strategies include reconnecting floodplains, restoring wetlands, encouraging power plants to recycle water rather than using it only once, and increasing water discharges to support navigation.

Another challenge is that most dams in West Virginia are privately owned (278) and many are owned by local governments (203). Private dam owners are required to prepare an annual Emergency Action Plan (EAP), which is then reviewed by the WVDEP. These EAP plans are important in case an emergency response action becomes necessary. Developing these plans, however, is expensive due to the engineering documentation and emergency response details required. The EAPs may take several weeks to prepare and review. As a result, they are not updated very often, nor are they practiced with the relevant county and local first responders. A regular practice requirement could lead to improved plans and more aware first responders.

WEST VIRGINIA CHALLENGES TO REACHING ITS POTENTIAL:

- Expected increase in the frequency of extreme and isolated precipitation events, which may pose a concern for West Virginia's aging dams
- Insufficient practice by county and state first responders and other stakeholders well in advance of the potential need for implementation of an EAP

POLICY OPTIONS FOR DISCUSSION:

West Virginia's policymakers could request that the USDA fund a 5-year study led by an independent party, such as a university, that would bring together stakeholders to identify, assess, and prioritize corrective water management infrastructure and flood inundation mapping actions due to the changing climate. The taskforce developing the study could include the owners of federal dams in West Virginia (including the USDA and the USACE) as well as WVDEP dam safety section staff, West Virginia Conservation Agency Operation, Maintenance & Repair Program staff, engineering faculty from West Virginia universities, and others to review dam safety.

- This taskforce could, for example, conduct modeling exercises to develop a mitigation plan that would include updating flood inundation mapping throughout the state for intense precipitation events.
- That information could then be used to identify and prioritize adaptation of federal and state dams that are more than 50 years old.
- The study could also analyze the potential of green infrastructure designs such as removing dams and restoring floodplains instead.

Supported by the actions of West Virginia's policy-makers, this taskforce could then use the results of the above study to take action on West Virginia's infrastructure (particularly dams, drainage, and culvert systems) utilizing green infrastructure whenever possible.

West Virginia's policymakers could require regular table-top review exercises of private high- and significant-hazard dams using EAPs). FEMA-based table-top review exercises would provide "peer review" by independent engineers, owners, first responders, WVDEP dam safety staff, and other stakeholders. First responders would gain insight into the scope and significance of dam-related disaster planning and response in a non-critical environment. This effort might be supported by fees paid by private dam owners.

DRINKING AND WASTEWATER INFRASTRUCTURE

Safe drinking water in West Virginia has long been a concern as has the infrastructure used to provide that water and to manage wastewater. This infrastructure includes not only the treatment facilities but also the pipes used to convey drinking water to homes and businesses and the resulting wastewater from them.

Drinking Water Infrastructure

West Virginians get their drinking water from municipal water systems (sometimes managed by commercial organizations like American Water), privately owned water systems, privately-owned water wells, nonpublic sources (e.g., streams, ponds, or shallow wells) not intended for drinking, and commercial bottled water. In all of these cases (excluding commercial bottled water), the sources of the drinking water are the same: the lakes, rivers, streams, and groundwater in West Virginia. Yet, some West Virginia residents, particularly in McDowell County, lack access to running water and in some cases have no access to safe or potable water at all.

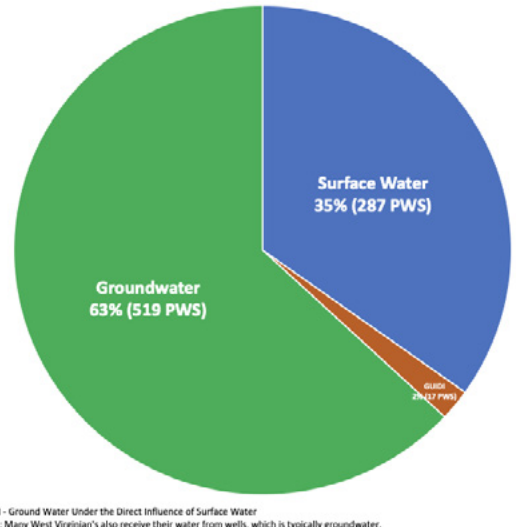


Figure 26. Source of Water for West Virginia's 823 Public Water Systems. (Personal Communication, West Virginia Department of Human and Health Services' Infrastructure and Capacity Development Program Staff to WVU Faculty) (2020)

As illustrated in Figure 26, most public water systems in West Virginia, along with homeowner wells, rely on groundwater. Typically, larger municipalities are more likely to use surface water and smaller communities and wells to rely on groundwater. In the United States as a whole, approximately 39% of public systems rely on groundwater.

In some communities, the public drinking water systems use water from former coal mines (Figure 27), which is processed

to remove contaminants before becoming drinking water. A WVDEP study on this topic obtained and compiled data for "underground-mine pool aquifers for the purpose of using existing mine-pool water-quality data as a reconnaissance tool in development of underground-mine-pools for public supply, industrial, and agricultural use." For example, one possible industry option is to develop West Virginia's aquaculture industry as illustrated by this research project in Leetown, West Virginia and supported by this legislation.

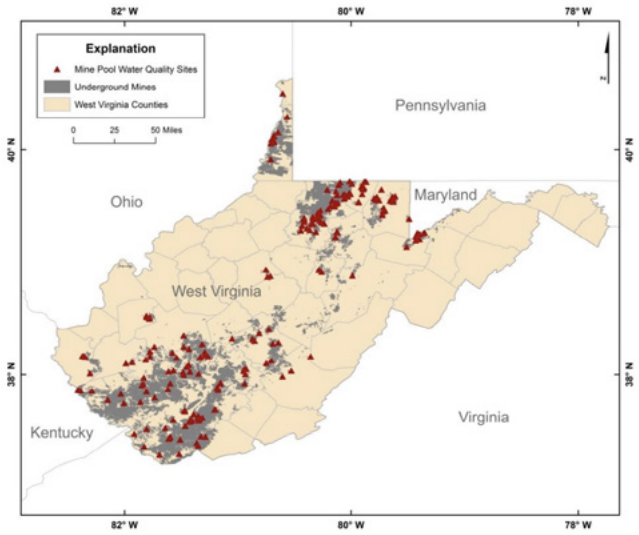


Figure 27. Assessment Locations for Public Water Systems Using Water Impacted by Active and Legacy Coal Mines. (West Virginia Department of Environmental Protection) (2018)

While drinking water from municipal water systems is regulated by the EPA, drinking water from wells is not. The U.S. Geological Survey (USGS) estimated that 23% of West Virginia's 2004 population relied on private wells or springs, compared to 13% nationwide.

Infrastructure also includes pipes that transport drinking water and wastewater within and outside the home. In West Virginia, about 0.5% of residents lack indoor plumbing. Figures 28 and 29 provide information on the percentage of West Virginians and McDowell County residents with "complete plumbing" (defined as the "presence of hot and cold running water, a bathtub or shower, a sink with a faucet").

Figure 28. Percent of West Virginia Households Lacking Complete Plumbing Facilities. (U.S. Census Bureau American Community Survey) (2020)

Figure 29. Percent of McDowell County, WV, Households Lacking Complete Plumbing Facilities. (U.S. Census Bureau American Communities Survey) (2020)

West Virginia is not alone in having households that lack access to piped (or "running") water, as illustrated in the map below (Figure 30). According to this study, published in the *Proceedings of the National Academy of Sciences*, "an estimated 1,121,100 people (±25,500 margin of error [MOE]) lacked a household piped water connection between 2013 and 2017."

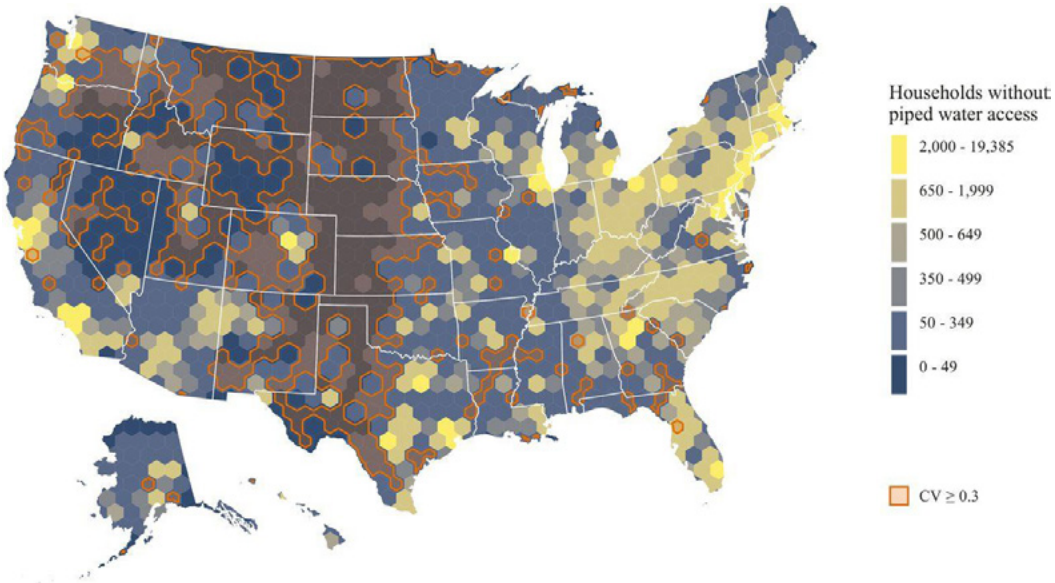


Figure 30. The Housing-Water Nexus: Households Without Piped Water Access. (Proceedings of the National Academy of Sciences of the United States of America) (2020)

Drinking Water Quality Assessment

As noted earlier, drinking water in West Virginia comes from both surface water and groundwater. Surface water quality in West Virginia is assessed every two years, providing under section 303(d) a list of impaired streams. This information provides a perspective on the quality of the water entering the state's water treatment systems with the goal of removing these contaminants. The West Virginia government, however, decided to provide a combined 2018/2020/2022 report, hence the information provided in this 2016 report (authored by the WVDEP and approved by the EPA) is the latest available.

According to this report, approximately 44% of West Virginia's streams are impaired and another 33% lacked sufficient data for assessment. This report also provides information on the causes of this impairment (Tables 3 and 4). The two pollutants affecting the largest number of miles of West Virginia streams are fecal coliform (from human and animal waste) and iron (from industrial activities including mining). Prioritizing actions to reduce these two pollutants could have a major effect on West Virginia's overall surface water quality, which may be the source of both drinking water and water used for other purposes such as industrial and recreational activities.

The WVDEP summarized its 2015 water quality analysis of its long-term monitoring stations as follows:

> Large areas of West Virginia have been impacted by coal mining practices. Stations in and downstream of the heavily mined areas of the state presently show some of the highest and most variable concentrations of alkalinity, hardness, total dissolved solids, specific conductivity, sodium, magnesium, and sulfates, and sometimes iron and aluminum. The affected stations often show significant long-term degrading (increasing) trends in these parameters as well. Coal, Tug Fork, West Fork, Dunkard, the Upper Monongahela are among the most notably affected sites.

The drinking water that exits the drinking water treatment system may or may not meet the EPA's standards by the time it reaches West Virginians' homes. Provided below are excerpts and data from the "2017 Report to the Governor: West Virginia Public Water System Capacity Development Program" (see Figure 31, Table 5, and the explanation of ranking from this report below). In addition, as noted in the report, "over the years, the assistance program has identified the following: In order for water systems to maintain viability, they must have an adequate customer base as well as effective, proactive management."

Type	Cause	Miles
Stream	Aluminum	1,318
Stream	Ammonia	6
Stream	Bacteria	243
Stream	Beryllium	17
Stream	Bio	6,837
Stream	Chloride	57
Stream	CNA-Algae	126
Stream	Dioxin	352
Stream	DO	67
Stream	Fecal Coliform	8,259
Stream	Iron	8,782
Stream	Low Flow Alterations	44
Stream	Manganese	116
Stream	PCBs	430
Stream	pH	1,354
Stream	Selenium	666
Stream	Temperature, water	2

Table 3. Summary of Impairment Causes for West Virginia Streams. (West Virginia Department of Environmental Protection) (2016)

Type	Cause	Acres
Lake	Chlorophyll-A	1,148
Lake	DO	4
Lake	Iron	54
Lake	Methylmercury	9,826
Lake	PCBs	630
Lake	Phosphorus	1,217
Lake	Sedimentation/Siltation	189
Lake	Trophic State Index	96

Table 4. Summary of Impairment Causes for West Virginia Lakes. (West Virginia Department of Environmental Protection) (2016)

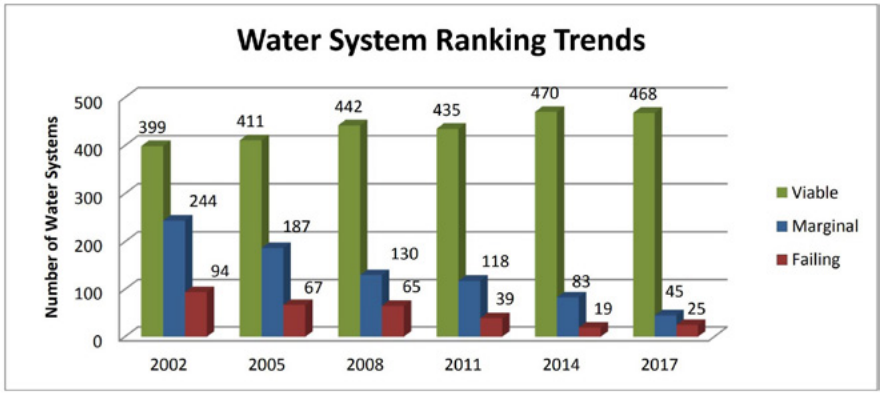


Figure 31. Water System Ranking Trends in West Virginia 2002-2017. (West Virginia Department of Health and Human Resources) (2017)

The drinking water that does meet EPA standards when it leaves the water treatment facility may not meet those standards by the time it exits faucets in West Virginia homes and businesses. That is because the pipes that bring it to these locations are often antiquated (more than fifty years old). As a result, pollutants from these pipes may contaminate the previously clean drinking water so that the drinking water quality may differ not just from one neighborhood to another but even between homes in the same neighborhood. Another concern is that disinfection byproducts can collect in the distribution system, as illustrated in this Kanawha Valley West Virginia American Water report.

According to a WVU analysis based on 2019 data from a West Virginia Public Service Commision report, approximately 23% of this clean water was lost due to leaks in these pipes. The WVDEP estimates that leaks and losses caused by burst pipes that occur during unusually cold winters range from 20-30%; this is higher than the 16% national average of water lost. According to the EPA, 75% of this lost water is recoverable. Sixteen of West Virginia's 55 counties have unaccounted water losses of more than 30%, and four of these have more than 40%. Replacing these antiquated pipes, therefore, would improve both the quality and quantity of clean drinking water available to West Virginians.

West Virginia Public Water Systems Identified as Failing (2017)		
County	**Average 2017 Score**	**System Name**
McDowell	0	OTOOLE WATER
Mercer	0	WEYANOKE GIATTO WATER SYSTEM
Mercer	0	HIAWATHA WATER
Wyoming	0	COAL MOUNTAIN WATER
Boone	1	PRENTER WATER COMPANY
Fayette	1	KANAWHA FALLS COMMUNITY WATER
Wyoming	2	HERNDON COMMUNITY WATER
Kanawha	10	REAMER HILL WATER ASSOC
Mason	10	J-2-Y-35 WATER
Mercer	10	MATOAKA WATER SYSTEM
Wyoming	10	GARWOOD COMMUNITY WATER
McDowell	15	KEYSTONE MUNICIPAL WATER
Wyoming	15	HERNDON HEIGHTS COMMUNITY WATER ASSOC
Clay	20	QUEEN SHOALS PSD
Mercer	30	POCAHONTAS WATER SYSTEM
McDowell	34	CRUMPLER COMMUNITY WATER
Roane	34	REEDY WATER SERVICE TOWN OF
Boone	35	BOONE RALEIGH P S D
Mercer	35	PINNACLE WATER ASSOCIATION
Lincoln	36	LINCOLN PSD - ROUTE 3
Kanawha	38	GLASGOW TOWN OF
Kanawha	39	EAST BANK WATER DEPT
Wayne	40	FORT GAY WATER WORKS
Wyoming	40	GREEN CAMP PSD
Wyoming	40	BRENTON PSD

Table 5. West Virginia Water Systems Rated as "Failing."

(WVU Bridge Initiative. Data Source: West Virginia Department of Health and Human Resources) (2017)

If West Virginians receive their drinking water through a public water system that serves more than 25 people, each June they will receive an annual report on the quality of that water for the prior year. This Consumer Confidence Report (CCR) is required by national law. The table below, from McDowell County's PSD Eckman 2020 CCR report, provides their 2019 testing results.

BASELINE RANKING OF WATER SYSTEMS

"Section 1420(c)(2)(D) of the Federal Safe Drinking Water Act requires all states to develop a baseline ranking of their water systems. The initial baseline conducted in 2002 ranked West Virginia's 737 CWS and NTNC water systems. Compiling the initial 2002 baseline and the updates of 2005, 2008, 2011, 2014 and 2017 involved gathering information via a voluntary questionnaire sent to the CWS and NTNC systems in addition to obtaining input from the Office of Environmental Health Service's Environmental Engineering Division District Engineers (district offices are located in Beckley, Kearneysville, Fairmont, St. Albans, and Wheeling).

"The systems are ranked (0% – 100%) and categorized as viable, marginal and failing based on responses to the questionnaire. For the data used in the 2017 baseline, West Virginia water systems submitted their questionnaire responses by either mail, fax, or online.

"Not all of the question responses are scored for each system. For example, some questions are informational data for CDP. However, all similar types of systems are scored by their responses to the same questions. Raw scores and data sets (questions/answers) are provided to the district office engineering staff who generally provide onsite technical assistance to the water systems frequently. The district engineers review the information and provide a score for the system. The raw score and the district engineer's score are averaged. Since submitting the questionnaire is voluntary, the district engineers assign a score used for any system not responding to the questionnaire. In 2017, 76% of CWS responded and 53% of NTNC systems responded. For those systems, the average score becomes the final baseline score for each system."

Source: 2017 Report to the Governor: West Virginia Public Water System Capacity Development Program. (West Virginia Department of Health and Human Resources) (2017)

Testing Results for: MCDOWELL COUNTY PSD ECKMAN

Microbiological	Result	MCL	MCLG	Typical Source
No Detected Results were Found in the Calendar Year of 2019				

Regulated Contaminants	Collection Date	Highest Value	Range (low/high)	Unit	MCL	MCLG	Typical Source
BARIUM	12/3/2019	0.0351	0.0351	ppm	2	2	Discharge of drilling wastes; Discharge from metal refineries; Erosion of natural deposits
FLUORIDE	12/3/2019	0.1	0.1	ppm	4	4	Erosion of natural deposits; Water additive which promotes strong teeth; Discharge from fertilizer and aluminum factories
NITRATE	6/19/2018	0.24	0.24	ppm	10	10	Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits
NITRATE-NITRITE	6/19/2018	0.24	0.24	ppm	10	10	Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits
SELENIUM	12/3/2019	6.3	6.3	ppb	50	50	Discharge from petroleum and metal refineries; Erosion of natural deposits; Discharge from mines

Lead and Copper	Monitoring Period	90th Percentile	Range (low/high)	Unit	AL	Sites Over AL	Typical Source
COPPER, FREE	2017 - 2019	0.0529	0.0089 - 0.0857	ppm	1.3	0	Corrosion of household plumbing systems; Erosion of natural deposits; Leaching from wood preservatives
LEAD	2017 - 2019	0.8	0.2 - 1	ppb	15	0	Corrosion of household plumbing systems; Erosion of natural deposits

Table 6. McDowell County, WV, Water Test Results 2019.

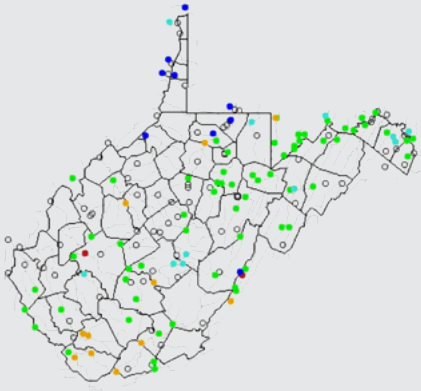
(McDowell County Public Service District) (2019)

Drinking water must be free of pathogenic microorganisms and disinfection to meet federal and state regulations. Filtration, to reduce turbidity and remove viruses and cysts, along with disinfection, is the most effective way to ensure drinking water quality reaches these standards. Private systems are not federally regulated, but the drinking water needs to be 'biologically' safe as well; thus, it is in the best interest of homeowners to ensure adequate home system treatment is in use.

These CCRs, however, do not necessarily provide data on the quality of drinking water coming from the taps in West Virginia's homes and businesses. Rather, each report provides water quality information at the stage where the water exits the water treatment system and enters water towers and then the water pipeline distribution system. The WVDEP has made a plea for more help on data collection in its past several reports to the West Virginia legislature and other state agencies (see excerpt below).

Further, although water quality is tested monthly, it is the responsibility of each water system to determine where they take samples as opposed to utilizing an independent third party testing process. On request, WVU does help small communities develop their CCRs and assist utilities with clean water education and customer service/communications. Still, many of these communities lack resources for more than a part-time staff member at their offices; this staff member must manage all billing, reporting, and other operations.

Another challenge is that the EPA does not regulate private water wells, so the drinking water quality of these systems is not assessed. A 2009 study showed that 20% of wells nationwide were contaminated.



The stream gauge network in West Virginia (USGS).

Source: 2020 Annual Water Resources Report. (West Virginia Department of Environmental Protection) (2020)

WATER RESOURCES PROGRAM NEEDS

"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 188 stream gauges and 18 groundwater level monitoring wells in the network managed by the U.S. Geological Survey. The Water Use Section is deeply reliant upon these federal resources. The Section uses stream gauges to generate thresholds for water management plans under the Horizonal 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 USGS does monitor groundwater quality in West Virginia, which is the primary water source for both wells and many rural water systems, as illustrated in the excerpt above. At one point, the WVDEP had a sentinel system that monitored groundwater quality, but that system ended in 2015.

Another source of information is the West Virginia Water Quality Impact Portal which provides public data for over 1.3 million surface and groundwater samples aggregated from federal, state, and local organizations in shale gas regions.

Drinking Water Quality Regulation Violations

The map below, developed by WVU, provides more in-depth information for West Virginia regarding the number of safe drinking water regulations by county in West Virginia. The darker the blue, the greater the number of calendar quarters with violations (Figure 32).

West Virginia, like other states, has an environmental justice issue when it comes to drinking water quality. The Natural Resources Defense Council's (NRDC) "Watered Down Justice" report found that "race, ethnicity, and language had the strongest relationship to slow and inadequate enforcement of the Safe Drinking Water Act. That means that water systems that serve the communities that are the most marginalized are more likely to be in violation of the law—and to stay in violation for longer periods of time" (see Figures 33 and 34).

Based on EPA data, the NRDC concluded that "drinking water systems that constantly violated the law for years were 40 percent more likely to occur in places with higher percentages of residents who were people of color." In addition, "small systems – those that serve less than 3,300 people – were responsible for more than 80 percent of all violations." Among its recommendations, the NRDC proposes that national law be improved "to measurably increase access to safe drinking water for communities of color, starting by identifying, engaging and funding water infrastructure projects."

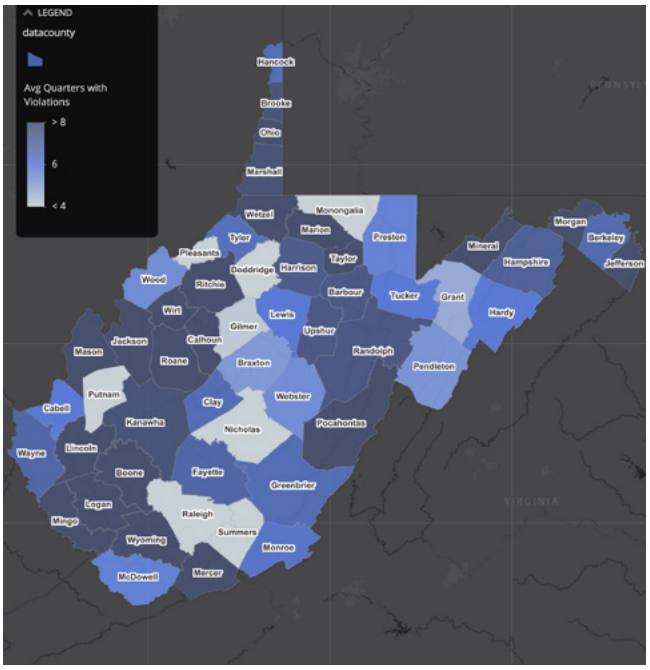


Figure 32. Number of Safe Drinking Water Act Violations, by County. (ArcGIS) (2016)

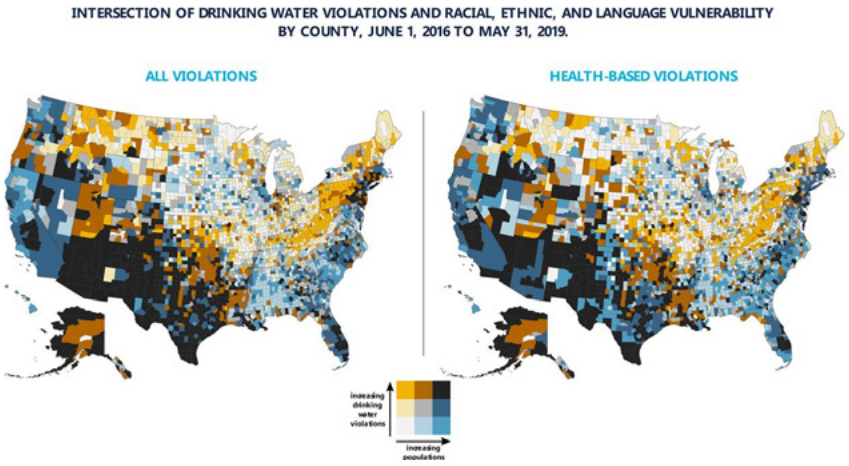


Figure 33. Intersection of Drinking Water Quality Violations and Racial, Ethnis, and Language Vulnerability. (Natural Resources Defense Council) (2019)

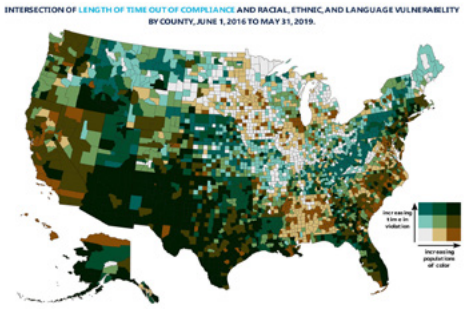


Figure 34. Intersection of Length of Time Not in Compliance and Racial, Ethnis, and Language Vulnerability. (Natural Resources Defense Council) (2019)

CASE STUDY:
ELKHORN CREEK WASTEWATER MANAGEMENT STUDY

Project Area	Total Estimated Project Cost	Customers	Construction Cost/Customer
Ashland	$1,300,000	64	$15,098
Crumpler	$3,200,000	125	$19,843
Northfork North	$3,300,000	96	$26,744
Maybeury	$5,700,000	163	$27,417
Northfork South	$8,200,000	232	$27,932
Kimball	$11,300,000	279	$32,004
Vivian	$2,900,000	58	$38,587
McDowell	$3,600,000	63	$45,219
Elkhorn	$4,100,000	71	$45,722
Lower Big Four	$2,500,000	41	$47,182
Kyle	$6,100,000	101	$47,834
Rolfe	$5,600,000	65	$67,494
Upper Big Four	$700,000	7	$76,627
Eckman	$2,400,000	23	$79,843
Upper Switchback	$2,100,000	20	$81,664
Lower Switchback	$1,100,000	9	$95,085
Landgraff	$700,000	5	$104,160

"The Elkhorn Creek Watershed consists of nearly 1,450 residences which currently utilize antiquated on-site treatment practices or direct discharges to one of the state's prime recreational fishing waterways. The PSD is currently planning and pursuing funding for a sewer collection and treatment system to provide service to the approximately 1,450 potential customers in the Elkhorn Creek area. The area is located in northeastern McDowell County. It begins along Elkhorn Creek, just outside the City of Welch in the community of Superior and continues east to the Mercer County line."

"**A. Health, Sanitation and Security** . . . Most of the proposed customers have failing sewer collection systems constructed by mining companies, failing on-site septic tanks on undersized lots, or direct discharges to Elkhorn Creek and its tributaries. These community sewer collection systems in the mining camps essentially convey the sewer downstream of the populated areas and discharge into Elkhorn Creek with no treatment. . . Septic systems installed after the mining companies shut down left the area are not adequate due in large part to the inadequate space available on the residential lots and also many of the dwellings along Elkhorn Creek are located in the flood plain.

B. Aging Infrastructure The existing community sewer collection systems constructed by the mining companies are in poor/failing condition and commonly run under houses are not suitable for use with a new sewer system. Therefore, a new sewer collection system will need to be installed in replacement of the substandard, outdated and unacceptable practices which have been utilized for a number of years."

Description and Evaluation of Alternatives considered: The following alternatives have been considered in the development of the project:

- Alternative 1: Gravity sewer collection system with lift stations to connect to the City of Welch's existing wastewater collection and treatment system
- Alternative 2: Centralized wastewater collection and treatment systems breaking the study area into seven centralized service areas having their own treatment systems
- Alternative 3: Centralized wastewater collection and treatment systems breaking the study area into eleven centralized service areas having their own treatment systems, as well as a small number of decentralized on-site treatment options for residences which cannot be feasibly served by conventional methods
- Alternative 4: Centralized wastewater collection and treatment systems breaking the study area into seventeen centralized service areas having their own treatment systems, as well as a number of decentralized on-site treatment options for residences which cannot be feasibly served by conventional methods
- Alternative 5: Conventional septic systems
- Alternative 6: Do Nothing Alternative

Conclusion: "As a result of this study it has been concluded that the Elkhorn Watershed located in McDowell County could benefit greatly from the installation of a public wastewater collection and treatment systems. Based on the facts and findings, it would be most feasible to provide wastewater collection and treatment to customers in the area by utilizing 'cluster' type systems consisting of small gravity collection systems and having their own wastewater treatment facility for each density of homes.

Through development of cost estimates, operation and maintenance evaluations for both the collection and treatment systems, the following prioritized list has been compiled showing the project areas, estimated project costs, estimated number of customers to be served and construction cost per customer in an order ranking from most feasible to least feasible."

Source: Elk Creek Clean Stream and Trout Habitat Initiative (E.L. Robinson Engineering) (2018)

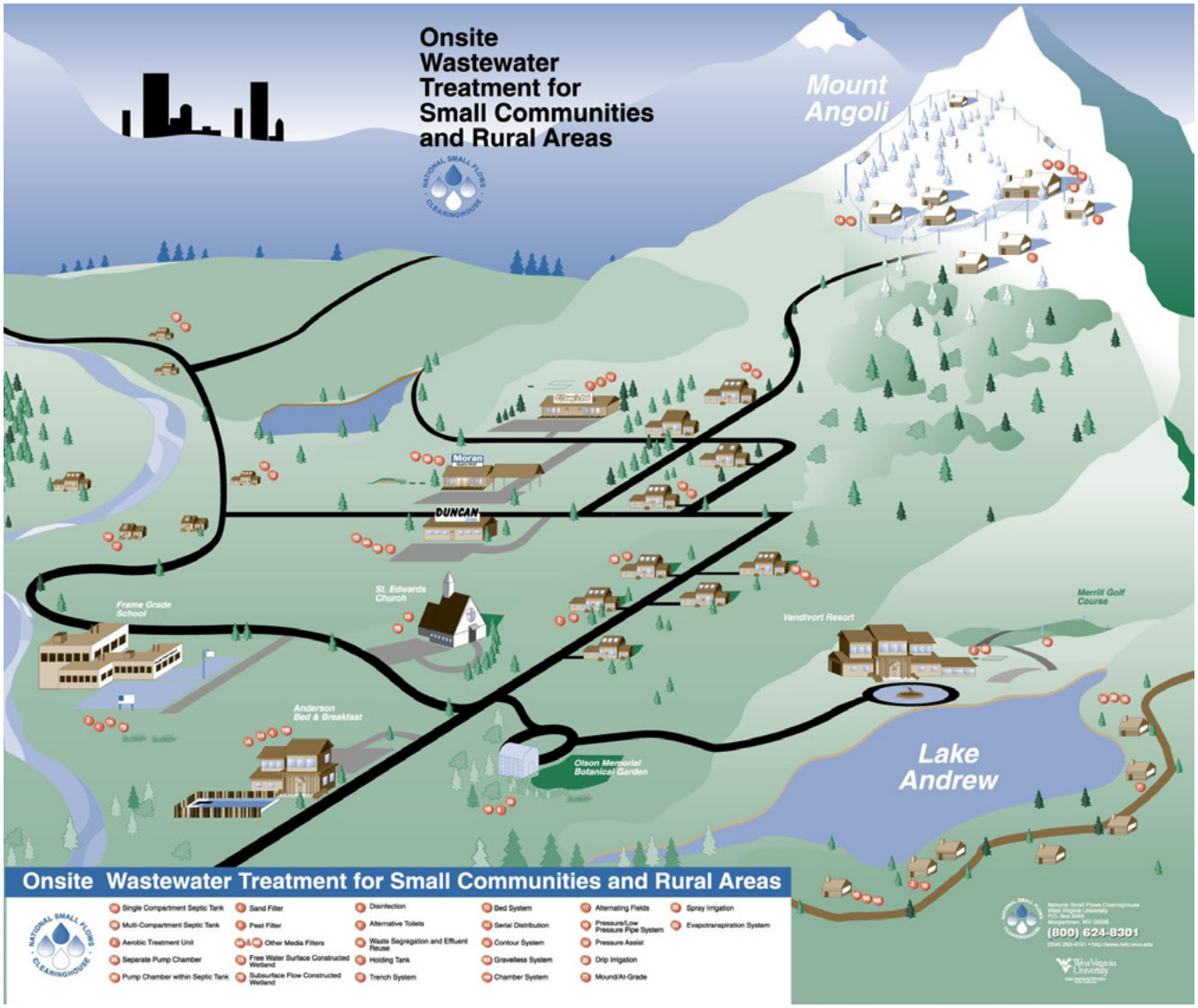


Figure 35. Onsite Wastewater Treatment for Small Communities and Rural Areas. (National Small Flows Clearinghouse) (undated)

Wastewater Management

The situation in rural areas is far more challenging and complex than in urban areas, which typically have municipal waste systems. Rural communities and individuals use a number of methods for wastewater management, including small community systems, septic tanks, and what is known as "straight pipes" or "straight piping," where waste goes directly into waterways (Figure 35).

Provided above is a case study from an engineering analysis on options for managing wastewater from a number of small communities in McDowell County along Elkhorn Creek. Several key lessons can be learned from this case study:

- The number of customers served is small, but their challenges are great when it comes to wastewater-management-related health, sanitation, security, and aging infrastructure.
- The infrastructure needs per household for the proposed methods may well be more than the value of the home in some situations.

A related issue is the potential of cybersecurity attacks on water treatment systems, as occurred in a Florida town in 2021.

Replacing straight piping with a septic system is challenging given both the initial capital costs (as illustrated

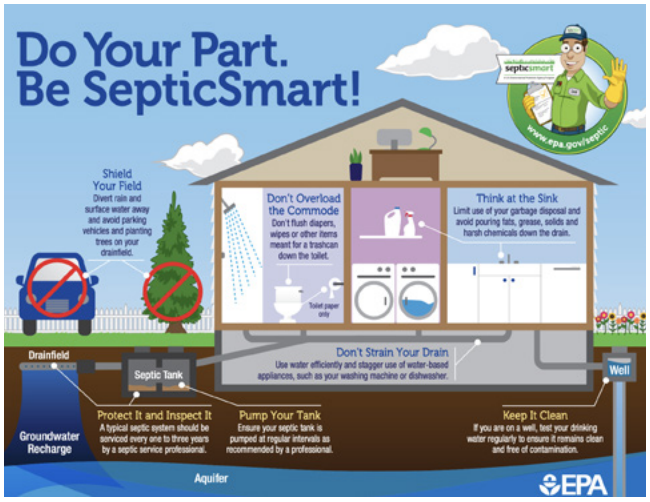


Figure 36. "SepticSmart" Practices for Septic Tank Users. (U.S. Environmental Protection Agency) (2018)

in the Elkhorn Creek case study) and the need for long-term maintenance to prevent these systems from getting clogged or drainage fields losing their absorption capacity (Figure 36). And even when septic systems are installed, they can be challenging for homeowners to manage and maintain--especially in disadvantaged communities, where many residents are financially challenged.

In addition, septic systems are not regulated by the EPA, and the authority for monitoring these systems has been delegated to states. In West Virginia, this authority goes to the DHHR's Office of Environmental Health Services. Although they have not been updated in some time, the regulations are sufficient. It is necessary to increase enforcement to ensure that homeowners follow these regulations. Often, homeowners do not take action on their septic systems unless there is a visible sewage problem. The challenge is that these problems affect not only the homeowner but the community as whole. One option might be to further delegate inspection authority to EPA-certified inspectors to reduce the burden on the state.

Drinking Water and Wastewater Management in Rural Communities

The management of community systems is a challenge in Appalachia as well. A number of issues increase the cost of water and wastewater management, specifically:

- Small- and medium-sized drinking water systems that serve less than 10,000 people cost more per user than larger systems as there is less of a population base to charge for the fixed costs. This can be seen in the case study above when looking at the construction cost per customer. This may be the case for up to 33% of Applachian systems compared to 20% nationwide.
- Drinking water systems that rely on surface water (18% in Appalachia versus 11% nationwide) cost more to operate than those that rely on groundwater.
- Wastewater systems that collect less than 10 million gallons per day make up about 70% of the systems in West Virginia compared to 50% nationwide, which also leads to higher per-person cost as they serve smaller populations.
- Costs for both water and wastewater systems can also be higher due to Appalachian geology. The hard rock subsystems make installation and maintenance of piping expensive, as does the location of groundwater in fractured rock rather than in aquifers. Steep, pervasive slopes can require pumps with higher capacity and more pumps than typical, and thin soils make onsite waste systems challenging. Innovative technologies that would overcome these obstacles require more technical understanding than small rural communities have available.
- Few Appalachian communities have sufficient financial resources or credit rating for the capital cost necessary for constructing new drinking water and wastewater systems. Communities can apply for government grants to help fund these systems, but in order to have sufficient funds they may need to cobble together several funding sources, which makes the process challenging to manage. Another challenge is the lack of management and technical staff with the capacity to apply for the resources that are available. Simply not understanding the opportunities available and how to apply to them prevents some communities from getting the help they need.

One option to respond to some of these concerns is to switch residents to decentralized wastewater treatment systems. As defined by the EPA, "decentralized wastewater treatment consists of a variety of approaches for collection, treatment, and dispersal/reuse of wastewater for individual dwellings, industrial or institutional facilities, clusters of homes or businesses, and entire communities." These systems, according to the EPA, can be cost-effective and economical, avoid large capital cost, reduce operation and maintenance costs, and promote business and job opportunities in addition to protecting community health, the environment, and water quality. There are a number of options for implementing them, as illustrated in Table 7.

SUMMARY

Clearly, the drinking and wastewater system in West Virginia is a challenging one. While some parts of the state will have extreme precipitation events, other areas will have droughts due to climate change. This leads to several concerns related to the provision of drinking water, including the possibility of inadequate water flow when the source water

at the surface is low. In the past, some West Virginia communities required emergency water supplies during droughts. In addition, the lower the flow of source water, the worse the water quality, which causes the drinking water of some West Virginia communities to fall short of national drinking water standards. In other words, although the amount of pollution in water does not change, the concentration of pollutants in a given water flow may. A related issue is the importance of protecting source water, as illustrated by the 2014 Elk River chemical spill, which affected the drinking water provided to thousands of West Virginia residents and businesses in Charleston and surrounding counties.

Typical applications	Program description	Benefits	Limitations
1. Homeowner Awareness: Local agency service reminders, educational information, and inventory			
• Areas of low environmental risk	• Systems sited and constructed according to prescribed criteria • Maintenance reminders • Inventory of all systems	• Ease of implementation • Inventory of systems that is useful for tracking and area-wide planning	• No compliance tracking or monitoring mechanism • Limitations on advanced treatment systems due to operation and maintenance (O&M) requirements
2. Maintenance Contract: State/local requirements that certain systems be professionally managed			
• Areas of low to moderate environmental risk where sites are marginally suitable for individual systems • Small clustered systems	• Use of advanced treatment options and clustered systems • Service contracts for system O&M • Tracking system for services provided • Inventory of all systems	• Previously unbuildable lots can be served • Prompt attention to treatment system problems • Lower risk of treatment system malfunctions	• Higher level of expertise and resources needed by regulatory agencies and system service providers • Requires compliance assurance mechanism
3. Operating Permit: Revocable/renewable state/local permit specifying operation/maintenance requirements			
• Areas of moderate to high environmental risk • Systems treating high-strength wastes, or cluster systems	• Renewable, revocable system operating permits • Performance and monitoring requirements	• Regulatory agency directly checks system operation and performance through permit issuance program	• Agency resource requirements are significant • Effluent monitoring can be expensive
4. Responsible Management Entity (RME) Operation & Maintenance (O&M): Professional, third-party O&M			
• Areas of moderate to high environmental risk • Clustered systems	• System operation, performance monitoring, and repair/replacement is handled by a third party • RME holds operating or NPDES permit; homeowner retains ownership	• Same as #2 above, but removes homeowner from responsibility role • Regulatory agency tracks fewer system managers	• May require code changes to allow RME to hold operating or NPDES permit • RME financial and payment assurance requirements
5. Responsible Management Entity (RME) Ownership: Ownership and O&M by third party entity			
• Areas of greatest environmental risk	• Same as #4 above, but RME also owns system infrastructure/property	• RME has full access to system and all components	• Same as #4 above

Table 7. Decentralized Wastewater System Management Models for Local Communities.

(U.S. Environmental Protection Agency) (2015)

The current drinking water/waste management system not only puts West Virginians' health at risk but results in economic and societal challenges that prevent our state from reaching its full economic and social potential, as a lack of adequate water treatment and wastewater infrastructure may deter new business investment in the state and discourage visitors and new residents from coming to the Mountain State.

To improve this infrastructure, drinking water and wastewater systems in West Virginia that serve small, rural communities need help with basic services including maintenance, testing throughout the system, consumer confidence reports, and other services. Although existing organizations such as the West Virginia Rural Water Association can provide assistance, small systems cannot always afford the fees required to join this organization to be assured of timely services. An alternative is the West Virginia Water/Wastewater Agency Response Network, which offers free membership--in exchange, members are required to help each other. The challenge with this program is insufficient information on the program and limited funding. In sum, the need is high, and resources are available but limited; more services could be offered if resources were more accessible.

Technological, economic, and management innovations, however, can possibly play a role in advancing West Virginia's drinking water and wastewater infrastructure. In September 2020, the EPA awarded $24.7 million to West Virginia for water quality improvement projects. This funding, combined with $4.9 million in state funding along with West Virginia's Clean Water State Revolving Fund (which offers low-interest loans for wastewater treatment facilities), provides an opportunity for major advancements if it is prioritized and used to support innovations rather than incremental improvements of the existing systems.

To support all of these goals, West Virginians need to be better informed about drinking water quality standards, wastewater treatment regulations, and the rights and responsibilities of citizens.

WEST VIRGINIA CHALLENGES TO REACHING ITS POTENTIAL:

- Insufficient planning and technical resources available for West Virginia's small and rural communities
- Difficult geography and geology
- Disruptive and expensive installation of new drinking and wastewater pipelines, which pose a barrier to infrastructure updates
- Lack of outreach, testing, and inspection for water/wastewater programs
- Reluctance of new businesses and residents to move to areas that need economic development to advance

POLICY OPTIONS FOR DISCUSSION:

West Virginia policymakers, working through the existing regional planning communities, could develop a plan that would bring together water and wastewater management organizations to improve economies of scale and reduce the cost of services to residents. Examples include expanding or increasing funding for the existing "circuit rider" technical assistance program to help small rural areas maintain their systems and provide training, or alternatively providing economic resources that would enable communities to participate in existing organizations.

West Virginia policymakers could provide economic incentives to support and promulgate innovative water technology approaches that are better suited for rural areas. These include drinking water, wastewater, and CSO management technologies. The primary barrier to implementation of these new technologies is lack of awareness and reluctance to implement unknown systems. For example, to support these programs, the governor could provide economic incentives to implement these new technologies when awarding the $24.7 million funding recently provided by the EPA to improve these systems.

West Virginia policymakers could require that, when contractors are digging trenches for broadband infrastructure, installations in rural areas include space for replacing antiquated community water pipeline technologies at the same time--resulting in cost savings and solving two societal challenges at once. In December 2020, Congress approved $7 billion nationwide for broadband as part of the COVID relief package, $3.2 billion of which is designated for low-income communities. These are the same communities that need help replacing water/wastewater distribution infrastructure that is more than 50 years old. The portion of these funds received by West Virginia could improve the economic efficiency of funds for two essential rural services: broadband and drinking water/wastewater pipelines.

West Virginia policymakers could work with state agencies to financially support an outreach/education, testing, and inspection program to facilitate positive changes in drinking water quality, wastewater treatment, and stakeholder education. Specifically, this outreach and education could support community discussions on the potential for implementing decentralized wastewater management systems in their region.

West Virginia policymakers could support the establishment of a "rural renewal" program (including brownfield redevelopment) similar to the "urban renewal" programs that occurred in the past. The goal of these programs would be to enhance the economic development of these regions.

- Among the efforts that could be included in such a program are buying out properties so the residents and businesses can relocate to more advantageous economic situations, using eminent domain to improve the overall community. In addition, West Virginia's universities and colleges could play a role by mobilizing students, engaging communities, and conducting interdisciplinary research (similar to this initiative in Oklahoma).

- This program could build on the existing federal rural renewal economic incentive program. The U.S. Internal Revenue Service indicates the following: "A rural renewal county is a county in a rural area that lost population during the 5-year periods 1990 through 1994 and 1995 through 1999." The following West Virginia programs are currently included: "The counties of Calhoun, Gilmer, Logan, McDowell, Mercer, Mingo, Summers, Tucker [see case study below], Webster, Wetzel, and Wyoming." This program, however, could be updated and expanded to include all rural regions, including those that have been successful in maintaining their populations.

- Care needs to be taken so that "rural renewal" programs do not repeat the mistakes of "urban renewal" programs, such as disrupting or isolating long-term economically-disadvantaged communities or gentrification (wealthier people displacing economically-disadvantaged people).

CASE STUDY:
TUCKER COUNTY BENEFITS FROM TOURISM AND RECREATION

"The numerous rural communities that are surrounded by the Monongahela National Forest (MNF) [including Tucker County] have long had their livelihoods tied to the coal and timber industries and wood products. Over the last few decades, these industries have waned and these communities are struggling to find a new path forward. Current capacity building, design, placemaking, and entrepreneurship efforts are helping to improve the capacity of gateway communities in the MNF to undertake recreation economy projects to support community and economic development that will improve the quality of life in their communities."

Using a participatory process managed by the WVU Extension Service, the Mon Forest Towns initiative identified which tourism opportunities should be developed based on resident and visitor opinion surveys. Both groups agreed on nature tourism as a high priority (Figure 37).

"Tucker County's tourism businesses generate an estimated $65 million in annual sales. These sales directly support 824 jobs in the county and more than $15 million in employee compensation and proprietors' income. The industry contributes an additional $19 million in taxes and property income for a combined $35 million value-added impact.

"Subsequent rounds of business-to-business spending (indirect effect) and employees' household spending (induced effect) stimulated by sales at tourism businesses generate additional economic impact in the local economy. The purchase of inputs and additional business-to-business spending supports 80 jobs and $2.3 million in employee compensation and proprietor's income. Household spending by local workers supports an additional 67 jobs and $1.8 million in employee compensation and proprietor's income. In total, the industry supports 970 local jobs and generates $44 million in income and taxes, including more than $19 million in local wages and proprietors' incomes.

"Response from local business owners suggests that tourism is and will continue to be strong in the coming years. Nearly three-quarters of respondents (73%) indicated that their business's sales have increased, and 70% anticipated their business's sales to increase in the coming year. As a result of the industry's positive momentum, half (52%) of businesses indicated that they would create new positions or add additional staff; an additional 33% indicated that staffing would remain the same in the next year."

Source: Economic and Quality of Life Indicators for Monongahela National Forest Communities (Daniel Eades and Doug Arbogast) (2019)

Figure 37. Tucker County, WV, Residents' and Visitors' Opinions on Tourism Development Opportunities. (WVU Extension Services) (2016)

COMMUNITY VULNERABILITIES TO EXTREME STORMS

In recent years, West Virginia has experienced an increase in extreme precipitation events (annual number of events with greater than 2 inches). A NOAA assessment of West Virginia (as illustrated by Figures 38 and 39) found the following:

- "Total precipitation amounts and the number of extreme precipitation events have been above average in the 21st century.
- Winter and spring precipitation amounts are projected to increase, as well as the number and intensity of extreme precipitation events, posing an increased risk of flooding.
- Flood-producing extreme precipitation over the rugged topography is the costliest and most severe natural hazard for the state."

FLOODING AND VULNERABLE COMMUNITIES

Flooding is a long-term challenge for West Virginia. That challenge is likely to increase in the future due to extreme precipitation. And when flooding events do occur, the financial, social, and human toll are significant.

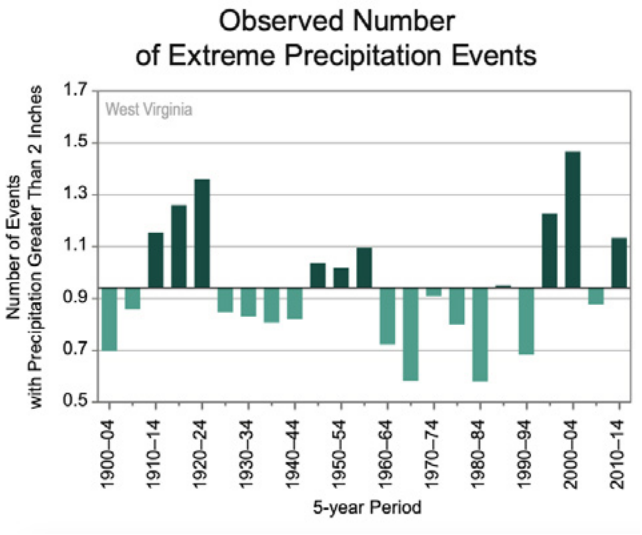


Figure 38 (above). "The observed number of extreme precipitation events (annual number of events with greater than 2 inches) for 1900–2014, averaged over 5-year periods; these values are averages from NCEI's version 2 climate division dataset. There is no long-term trend but the numbers have been generally above average over the most recent 20 years. The dark horizontal line is the long-term average (1900–2014) of 0.9 days with precipitation greater than 2 inches per year. Source: CICS-NC and NOAA NCEI." Observed Number of Extreme Participation Events 1900-2014.

(NOAA National Centers for Environmental Information) (2017)

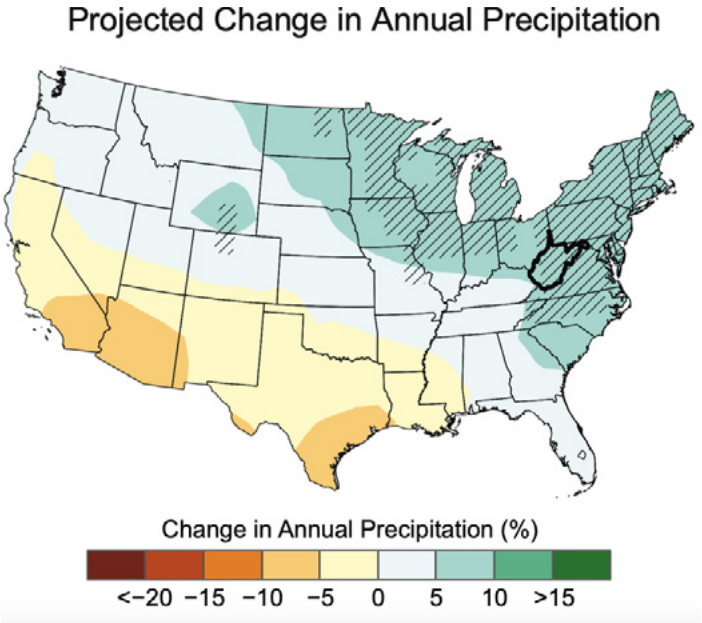


Figure 39 (at left). "Projected changes in annual precipitation (%) for the middle of the 21st century relative to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. West Virginia is part of a large area of projected increases in the Northeast. Source: CICS-NC, NOAA NCEI, and NEMAC." Projected Change in Annual Precipitation.

(NOAA National Centers for Environmental Information) (2017)

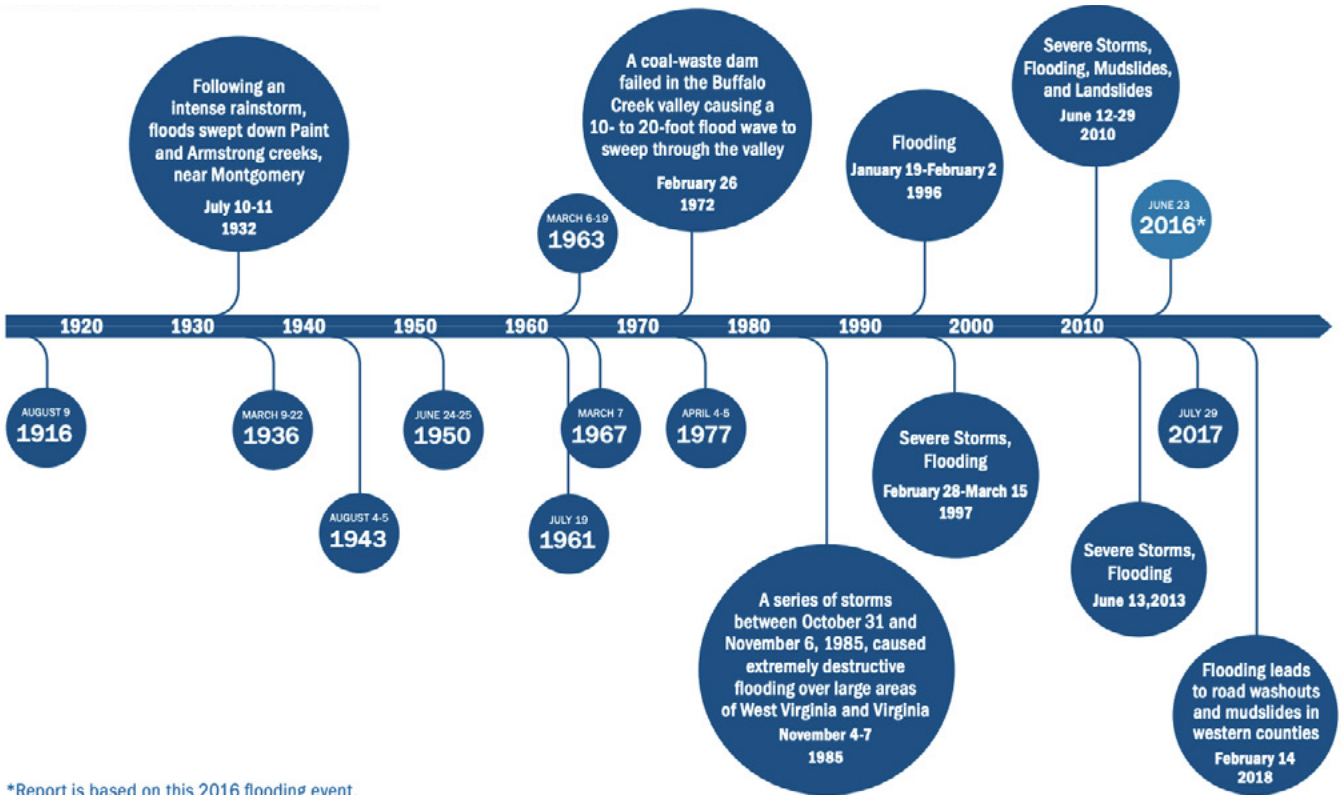


Figure 40. Timeline of Notable Flood Events in West Virginia 1916-2018. (Federal Emergency Management Agency) (2018)

Flood Hazard Mitigation Assessment

As illustrated in the timeline above (Figure 40), West Virginia has a long history of extreme rainfalls leading to flooding events. That risk has not diminished over time. According to West Virginia's 2018 Statewide Standard Hazard Mitigation Plan Update,

All counties in West Virginia were ranked as having a high level of risk for flooding.

The risk to West Virginians is evident in the map on the right (Figure 41), which is based on flood risk data from the First Street Foundation, a nonprofit research and technology group. In the map, you can clearly see that, unlike other U.S. States, almost the entire state is at risk. The risk from flooding in West Virginia is predicted to be as high as that in coastal areas. Furthermore, West Virginia's most vulnerable populations are the ones that are most likely to suffer the worst consequences (see the following excerpt).

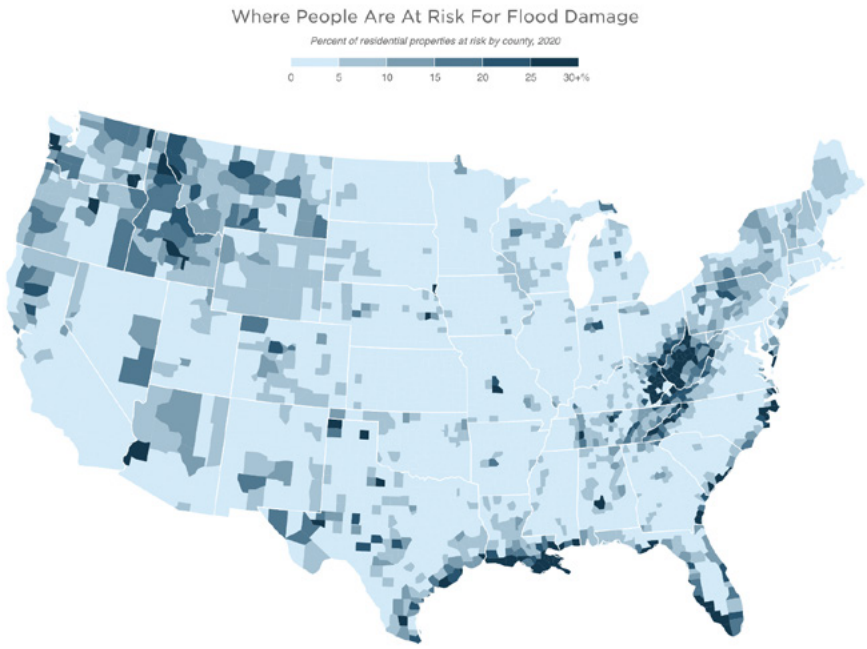


Figure 41. Percent of U.S. Residential Properties are at Risk, by County. (National Public Radio) (2021)

THE IMPACT OF THE 2016 FLOOD IN RAINELLE, WEST VIRGINIA

"Pastor Aaron Trigg was at home when the water arrived in Rainelle. It had been raining hard all day, filling the creeks and rivers that run through southern West Virginia. In the past, such intense downpours would last only a few hours, but this storm brought wave after wave of torrential rain.

"'You could hear the water up in the mountains just crashing trees,' Trigg remembers.

"Rainelle is a small town in a steep valley. When the creek near downtown jumped its banks on the evening of June 23, 2016, the water immediately flooded into every home on Trigg's block.

"Trigg's house was one-story tall, so there was nowhere to escape. He took shelter on the second floor of his neighbor's house and waited as the water kept rising. As it got dark, he could hear people screaming for help. He wondered if he would survive the night. 'I did a lot of praying that night,' he says. 'Not so much for myself, but for the people I could hear.'

"Trigg was rescued by boat the next morning. The home he and his wife lived in was destroyed, as were almost all of the other homes on their block. In all, at least 23 people died in the 2016 West Virginia floods, and an estimated 1,500 homes and businesses were ruined.

"Rainelle is one of hundreds of small towns where climate-driven flooding potentially poses an existential threat. . . When large numbers of people don't have insurance or savings after a disaster, the effects can ripple through the community. Towns like Rainelle are a bellwether for that future. Here, flood insurance is already unaffordable for many residents, and climate-driven flood damage has already exceeded local resources. About a third of Rainelle residents live below the poverty line, and the cost of repairing the 2016 flood damage was insurmountable for many families.

"Trigg's displaced congregants would call him, hopeless, in the months after the flood. 'A lot of people in Rainelle were poor, and they didn't have any insurance. They didn't have any way to have any backup plan,' he says.

"With no money for repairs, many people took what they could salvage and left Rainelle for good. 'It affected the spirit of the town,' Trigg says. Nearly five years later, a lot of homes are gone or only partially repaired. Trigg says all but one of the families on his block left. The city government saw a 10% decrease in water utility customers, a proxy for population loss. . .

"'It's shocking,' says John Wyatt, a member of the Rainelle City Council.

"Still, Wyatt is an optimist of sorts when it comes to the town's future. He's running for mayor, and he imagines Rainelle hosting an Appalachian music festival and attracting hiking tourists. 'This town has so much to offer,' he says. But if there's another big flood, he adds, 'I can't see our town surviving.'"

Source: A Looming Disaster: New Data Reveal Where Flood Damage Is An Existential Threat, National Public Radio (2021)

Rainelle is one indicator of a wide-spread challenge regarding insufficient flood insurance. As stated in the 2018 Statewide Standard Hazard Mitigation Plan Update,

> A [2006] study conducted by The Rand Corporation found the number of homes with flood insurance is significantly lower in rural communities with 500 or fewer homes in the Special Flood Hazard Area (SFHA), communities where less than 50% of the homes are in the SFHA, and communities that do not experience coastal flooding. West Virginia has 1,010,819 addressable structures and 101,928 non-addressable structures, for a total of 1,112,747 structures. Statewide, 9% of those structures are in the effective 100-year floodplains, and 14% are in both the 100-year and 500-year floodplains. Effectively, 99,520 to 159,804 structures are located in SFHAs.

Another important element is the number of structures that have flood insurance. As described below in another excerpt from the report, **only 16% of the 99,520 to 159,804 structures in Special Flood Hazard Areas have flood insurance:**

> There are 16,332 National Flood Insurance Program policies in effect in West Virginia, which is roughly 16% of the structures in the SFHA. The number of NFIP policies has decreased from approximately 21,000 (in 2013). This drop can be attributed to buyouts, elevating properties, and other mitigation efforts.

Vulnerable Communities

As illustrated in Figure 42, 100-year floodplains (represented by the red lines) occur throughout most of West Virginia. The counties with the most critical facilities

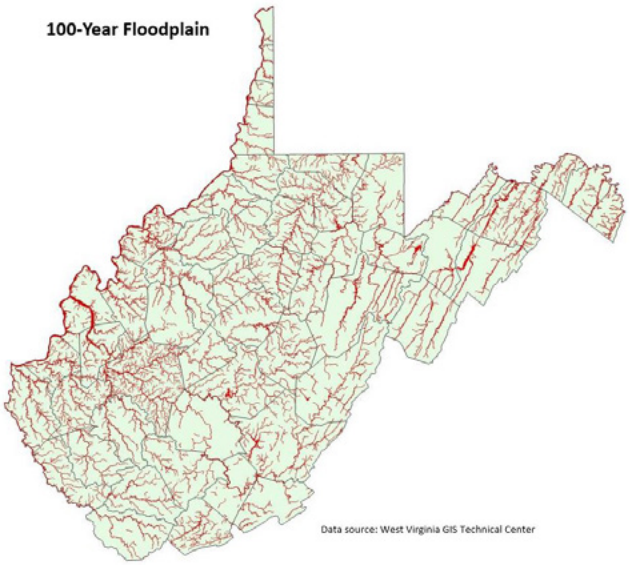


Figure 42. West Virginia 100 Year Floodplain.
(WVU Bridge Initiative. Data source: West Virginia GIS Technical Center) (2021)

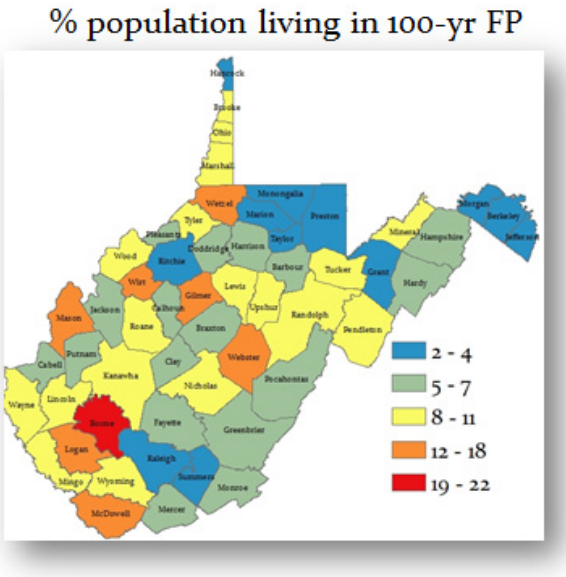


Figure 43. Percent of West Virginia Population Living in 100 Year Floodplain. (Professor Nicholas Zegre) (2021)

in 100-year floodplains are Kanawha (24), McDowell (20), Boone (13), and Wayne (11). (Note that FEMA is in the process of updating floodplain maps throughout the United States, so this map may change in the future.)

Floodplain maps, however, can be deceiving, as West Virginia's June 2016 flood was deemed afterwards to be a "1,000 year" extreme rainfall event (not a flood event according to FEMA) where 8-10 inches fell in 12 hours, leading the governor to declare a state of emergency in 44 of 55 counties. Twenty-three lives were lost, and over 2,300 people stayed overnight in 13 Red Cross shelters. On a long-term basis, 1,700 families and individuals requested help. In the end, FEMA concluded that many areas of West Virginia had "at least a 1% chance of [a thousand-year flood] happening every year in the future."

As indicated by FEMA's floodplain maps, which are based on historical data rather than potential future climate impacts, almost 100,000 housing units in West Virginia are in floodplains with about 25% occupied by renters (Figure 43). The estimated poverty rate in West Virginia's floodplains is almost 20%.

This can be deceiving as well, however, as in the 2016 flood many affected areas were outside the floodplain and therefore did not have flood insurance--even though they were eligible for this insurance. Many homeowners do not realize that their homes can be flooded even if they live outside a FEMA floodplain. Because of this mistaken assumption, many eligible homeowners do not purchase flood insurance.

This is true not only in West Virginia but nationwide. According to one study,

> the total US population exposed to serious flooding is 2.6–3.1 times higher than previous estimates, and . . . nearly 41 million Americans live within the 1% annual exceedance probability floodplain (compared to only 13 million when calculated using FEMA flood maps). We find that population and GDP growth alone are expected to lead to significant future increases in exposure, and this change may be exacerbated in the future by climate change.

Of the 9,000 applicants for FEMA funding, only 10% had flood insurance. Only 5,000 applicants were approved for FEMA funding, and of those, only 1,776 received referrals to the Small Business Administration for a disaster home loan; of these, only 720 were approved and ultimately 431 disbursed. In addition, the estimated cost for repairing public infrastructure was over $500 million.

As of December 2020, the West Virginia Development Office released its final plan to implement the $106,494,000 of Community Development Block Grant funds received from the U.S. Housing and Urban Development Administration (HUD). This report, which incorporated public comments and utilized a risk-based assessment, provides a number of useful points of information, particularly for the "MID" ("Most Impact and Distressed") counties, as defined by HUD, that were impacted by the floods. In addition, the state supplements the HUD funds for its MID counties. The report provides information on the annualized losses by county due to flooding (Figure 44), and Table 8 provides

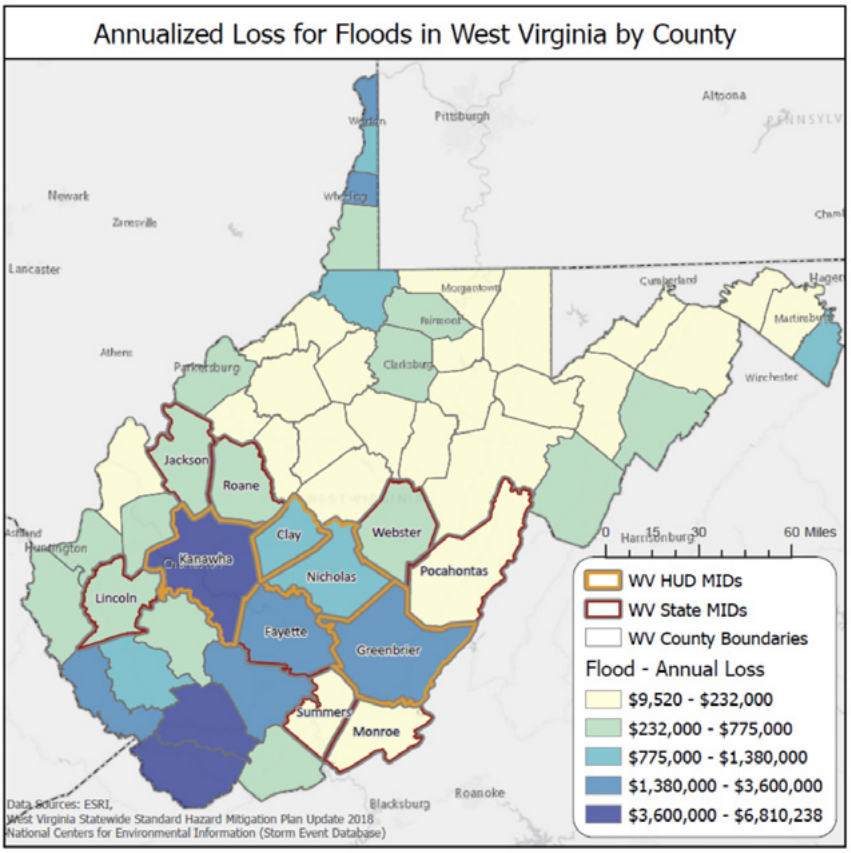


Figure 44. Annualized Loss from Flooding in West Virginia, by County.
(West Virginia Development Office) (2020)

the allocation of funds to enhance infrastructure, planning and capacity, and administration. Clearly, floods such as that in 2016 can have devastating human, social, and economic effects on West Virginians.

As explained in our opening summary, "amenity migration" occurs when new residents come to West Virginia and housing is built for them. Regarding this process, one issue to consider is whether or not there should be a requirement that new housing developments not occur in flood prone areas, or that new home owners be required to carry flood insurance. It is best to prevent flooding from occuring in the first place, as flood insurance does not cover all costs or everyone impacted by flooding. Earlier, we made a number of suggestions related to dams and natural infrastructure that, if put in place, could alleviate the human and financial toll that results from flooding.

CDBG-MIT Program	Allocation	Percent of Overall Funding	LMI Designation Allocation Minimum (50%)	Max Grant Award
Infrastructure	$86,169,300	81%	$43,084,650	-
General Infrastructure Program	$72,169,300	68%	$36,084,650	$10,000,000
Public Facility Hardening Program	$14,000,000	13%	$7,000,000	$5,000,000
Planning and Capacity	$15,000,000	14%	$7,500,000	-
State Planning	$6,500,000	6%	$3,250,000	-
Regional and Local Planning	$6,000,000	6%	$3,000,000	$250,000
Hazard Mitigation Plans	$2,500,000	2%	$1,250,000	$200,000
Administration	$5,324,700	5%	$2,662,350	-
Total Budget	$106,494,000	100%	$53,247,000	-

Table 8. HUD Funding for Community Development Block Grant (Mitigation) in West Virginia. (West Virginia Development Office) (2020)

WEST VIRGINIA CHALLENGES TO REACHING ITS POTENTIAL:

- High level of risk for flooding in all West Virginia counties with only 16% of particularly vulnerable structures covered by flood insurance
- Inadequate and inaccurate FEMA floodplain maps for West Virginia, which put homeowners and businesses at risk since not all homeowners who need insurance know that they should obtain it
- Flood insurance insufficient to meet the needs of those who have it
- Lack of coverage for renter's property by FEMA flood insurance or a typical renter's policy

POLICY OPTIONS FOR DISCUSSION:

West Virginia's policymakers could request that FEMA reconstruct and update its floodplain maps to incorporate both existing and projected extreme rainfall data. This would allow all Americans and governments to better prepare for current and projected increased incidences of flooding due to climate change by improving flood insurance and infrastructure investments.

West Virginia's policymakers could request that the USACE study the potential effects of climate change on existing local flood protection projects (e.g., levees and floodwalls). West Virginia communities can leverage existing USACE authorities to reduce flood risk through technical assistance, such as modeling flood risk or implementing structural and non-structural flood management measures. For example, communities can ask the USACE to conduct studies at no expense to them. Following such studies, the USACE may invest in structural activities to reduce the risk of a West Virginia community flooding. In the historic town of Princeville, North Carolina, for example, the USACE will invest $40 million to upgrade levees along a river with long-standing flooding issues.

West Virginia's policymakers and communities could consider the model housing ordinance proposed by the Columbia Law School, which they indicate "should help communities better protect people and property by bringing older housing stock into current floodplain management requirements more expediently."

West Virginia Emergency Management **could consider incorporating faith-based organizations early in the flood response planning process.** For example, in response to the 2016 flood, the West Virginia governor at the time indicated that the government would not be able to provide financial assistance to residents for rebuilding. Stepping into the breach were faith-based communities, such as the Mennonite Disaster Service, that provided long-term support to West Virginia residents.

Community leaders could consider green infrastructure projects to reduce the impact of flooding and integrate recreation as floodplain management in community comprehensive planning. Two West Virginia communities, Martinsburg (where 30% of the city lacks stormwater infrastructure) and Huntington (an area prone to flash flooding), have demonstrated green infrastructure projects that could serve as models for other communities. As indicated by the Huntington project leader, "uncertainties around flooding can make companies and private investors wary of spending on improvements that might be washed away in the next flood." A plan of action designed for West Virginia is available from the EPA. In addition, floodplain management can be managed to benefit recreation-focused economic development opportunities.

West Virginia Emergency Management could review its flood early warning system (FEWS) to ensure that it incorporates the most up-to-date "internet of things" **technology and that it monitors not only large rivers but small rivers as well.** The most advanced FEWS include telemetric data collection, modeling-based flood forecasting, and continuous monitoring and updates once the flood warning is issued. Most existing streamflow and flood monitors in West Virginia are on large rivers, but smaller headwater streams are more likely to flood, as they have less capacity to store water.

West Virginia's policymakers could consider voluntary buyouts of frequently flooded properties in anticipation of future flooding events, not only after flooding events occur. In Nashville, after a major flood in 2010, the city government used federal, state, and local funds to buy out 20 unsafe homes and restored them to a greenway that will provide a buffer against floods. North Carolina has a strategic buyout program as well. In the past, buy-out programs occurred in Elkins, West Virginia, allowing residents in floodplain areas to move out of the area. This occurred when both Tucker and Randolph counties received Presidential disaster declarations after repeated flooding. According to the 2018 West Virginia State Hazard Mitigation Plan, "the acquisition demolition program has been so successful that communities now equate mitigation to 'buy out' and that has become the new normal."

HUMAN HEALTH AND VECTOR-BORNE DISEASES

West Virginia, like many states, already faces challenges related to vector-borne disease. The primary challenge is ticks, yet it is a topic where we lack the information we need to make wise decisions. One study indicates, for example, that the United States has insufficient and outdated data on medically-important ticks including the presence and prevalence of tick borne pathogens and their geographic locations due to a lack of systematic and routine surveillance. This includes West Virginia, where we have challenges related to ticks causing Lyme disease, but we also lack data. This situation will be exacerbated by climate change.

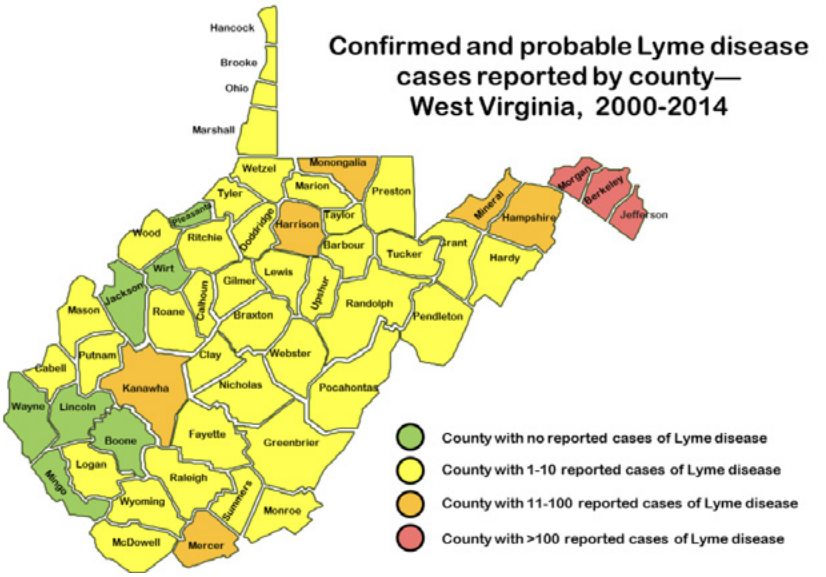


Figure 45. Confirmed and Probable Cases of Lyme Disease in West Virginia by County 2000-2014. (West Virginia Department of Health and Human Resources) (2021)

As illustrated in Figure 45, most of West Virginia has had cases of Lyme disease, which is spread by ticks.

According to the Centers for Disease Control (CDC),

> Climate is one of the factors that influence the distribution of diseases borne by vectors (such as fleas, ticks, and mosquitoes, which spread pathogens that cause illness). The geographic and seasonal distribution of vector populations, and the diseases they can carry, depends not only on climate but also on land use, socioeconomic and cultural factors, pest control, access to health care, and human responses to disease risk, among other factors. . . North Americans are currently at risk from numerous vector-borne diseases, including Lyme, dengue fever, West Nile virus disease, Rocky Mountain spotted fever, plague, and tularemia.

The expectation is that increased precipitation will exacerbate vector-borne diseases in West Virginia due to an increased presence and activity of ticks. Increased precipitation can also lead to challenges in communities with legacy combined sewers, where stormwater and sanitary wastewater are conveyed together in the same pipe, leading to CSOs during periods of intense rainfall. These systems can introduce a variety of waterborne disease agents to waterways that can lead to health effects such as gastroenteritis. However, wastewater monitoring can be used to follow community trends in certain diseases, acting as an early-warning system for potential outbreaks. In 2005, the WVDEP issued a new CSO Long-Term Control Plan Implementing Policy. The EPA also developed nine control measures to help reduce negative effects of CSOs.

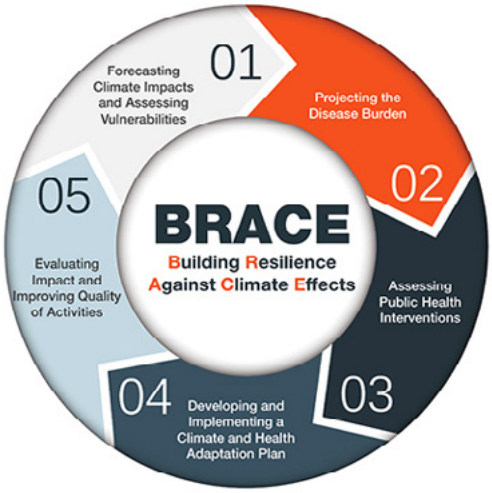


Figure 46. BRACE: Building Resilience Against Climate Effects Graphic. (Centers for Disease Control) (2019)

The CDC recommends that states and cities adopt its BRACE ("Building Resilience Against Climate Effects") agenda (Figure 46), a five-step process where state and local health officials develop strategies and programs that help communities prepare for these changes. Currently, 16 states and two cities have received funding from CDC to participate in this effort. West Virginia is not one of the states participating.

WEST VIRGINIA CHALLENGES TO REACHING ITS POTENTIAL:

- Insufficient surveillance activities for vector borne diseases
- Insufficient public education at the locations where ticks are likely to be prevalent
- Legacy CSOs and sanitary overflows systems, which increase the potential for transmission of diseases through and from waterways

POLICY OPTIONS FOR DISCUSSION:

West Virginia's policymakers could support the Kay Hagen Tick Act. This act would require the U.S. Department of Health and Human Services to develop a national strategy, reauthorize regional centers of excellence for vector-borne disease, and authorize the CDC to provide $20 million annual grants to states to improve data collection, early detection, treatment, and public awareness as well as a public health infrastructure for these diseases.

West Virginia's governor could propose to the CDC director that West Virginia join their Climate-Ready States and Cities Initiative (CRSCI), which helps states and cities implement the BRACE guidelines. CRSCI participants "identify likely climate impacts in their communities, potential health effects associated with these impacts, and their most at-risk populations and locations" so that states can "develop and implement health adaptation plans and address gaps in critical public health functions and services."

West Virginia's legislature could require that parks and recreation take actions to educate and protect West Virginians and tourists. Possible actions include installing warning and educational signs at entrances to state-managed parks describing what actions the public should take to prevent Lyme disease and how to respond to possible exposure; educating hunters and outdoor enthusiasts about vector-borne disease risk and prevention; and implementing tick safe zones in state parks and informing community park leadership and private landowners about how to create tick safe zones.

West Virginia's legislature could require that the West Virginia DHHR increase its surveillance and reporting of vector-borne diseases; develop physician, healthcare provider, and public education materials about ticks and tick-borne diseases; and implement a long-term Wastewater-Based Epidemiology (WBE) system. A WBE system could routinely monitor community wastewater treatment plants for the presence of infectious disease pathogens. In addition, the DHHR could fund studies to determine optimal methodologies for WBE in rural communities.

West Virginia's legislature could require that the West Virginia Division of Labor develop regulations requiring companies to provide at-risk personnel with appropriate equipment and gear for minimizing exposure to tick and insect-borne pathogens. Examples of appropriate equipment include mosquito netting and permethrin-treated clothing. At-risk personnel include workers in construction, landscaping, forestry, brush clearing, land surveying, farming, railroad work, oil field work, utility line work, and park/wildlife management.

RECOMMENDATIONS

Throughout the guide, you have seen the policy options developed by the faculty. The process that we used is described in Appendix B. During this process, the Bridge Initiative hosted five topical roundtables to gather feedback on those options from key stakeholders in business, government, and non-profit groups with a role or interest in the waters of West Virginia. These stakeholders are listed in Appendix C.

Each roundtable was asked to review the policy options and then prioritize them based on the criteria of effectiveness (likelihood of meeting the societal goal), efficiency ("best bang for the buck"), equity (winners and losers), and ease of political acceptability (the degree to which key policymakers and stakeholders would oppose or support the policy).

Based on that input, the WVU faculty and staff who developed this policymaker guide propose that West Virginia national, state, and local policymakers take actions that support the following principles:

W ake up to the full potential and challenges of West Virginia's abundant waters to support its people, business, industry, and job creation opportunities.

A dvance West Virginia's water-related infrastructure so it is better prepared for ever-increasing extreme precipitation events to reduce flooding, which threatens human and economic health.

T ogether, West Virginians will work to provide access to clean and affordable water to protect and enhance public health.

E ngage West Virginia communities to coordinate efforts to enhance the potential of water resources--which flow across political boundaries--to provide prosperity and well-being to all.

R evitalize West Virginia's water resources, and increase the state's resilience to meet the societal and economic needs of today's West Virginians and their future generations.

S howcase West Virginia's natural water resources by marketing their beauty and developing river-related recreation opportunities that increase tourism and recruit new businesses and residents.

The following table provides the top recommendations for each of these principles and illustrations detailing why each action is important for West Virginia.

ACTION	RECOMMENDATION	ILLUSTRATIONS OF WHY ACTION IS IMPORTANT TODAY
Wake up to the full potential and challenges of West Virginia's abundant waters to support its people, business, industry, and job creation opportunities.	West Virginia's policymakers should take actions to establish or review (and, if necessary, reorganize) intercounty/ intercommunity councils to strengthen coordination and consistency, thus reducing the economic burden on local communities and enhancing their economic development.	West Virginia has 32 major watersheds--all of which cross political boundaries, such as county lines. Understanding watersheds is important because adverse conditions (such as pollution) that occur in one area of the watershed may flow to other parts of the watershed, impacting water quality and, consequently, drinking water and ecology. Because of this, water quality is not an isolated problem of any one water management system but is rather a concern of the region as a whole. West Virginia's county and municipal power and taxing authorities are limited and would benefit from reorganization and reconsideration of their authority. West Virginia's population is decreasing. This trend will continue unless West Virginia policymakers develop employment and economic initiatives, increase the availability of essential water-related services, and recruit a remote workforce to retain and increase West Virginia's population.
	West Virginia's policymakers should take action so that the state becomes an innovation leader in addressing challenges and opportunities related to water. This action should include institutional and financial support for technological innovations in wastewater systems that work for rural communities, underground pumped hydropower that utilizes abandoned coal mines, and testbeds to see if treated acid mine drainage (AMD) residue can be sold for commercial use.	Expansion of pumped hydropower energy storage in West Virginia could support both fossil and renewable energy sources by enhancing resiliency for West Virginia's energy utility system. Construction of such facilities could also provide an economic boost to rural development, generating jobs, economic growth, and tax revenue. These possibilities are especially promising for coal communities, where abandoned mines could be used for energy storage. Utilization of AMD sludge could both solve a current challenge related to storing the cleaned sludge and provide a potential revenue source to pay for AMD operations and management through use of the sludge as an economic resource. For example, the annual management cost of the Omega site near Morgantown is $90,000 - $100,000. The primary cost challenge is not the treatment of the water but rather the resulting sludge. If engineering methods could be found that provide beneficial uses for this sludge, then the costs of finding a home for the sludge would decrease and might even turn a profit that could help pay for AMD treatment.

ACTION	RECOMMENDATION	ILLUSTRATIONS OF WHY ACTION IS IMPORTANT TODAY
Advance West Virginia's water-related infrastructure so it is better prepared for ever-increasing extreme precipitation events to reduce flooding, which threatens human and economic health.	West Virginia policymakers should facilitate coordination of regional approaches that bring together water and wastewater management organizations in multiple counties to improve economies of scale and reduce the cost of services to residents. Policymakers should also provide a pool of funding for the matching funds that are needed to apply for federal grants. These regional collaborations should write proposals for federal funding, manage and prioritize the allocation of the available matching funds, encourage brownfield development, and support investment on behalf of rural and disenfranchised counties and communities in their regions.	West Virginia's small, rural communities often lack the financial, management, and technical staff to operate their current infrastructure and apply for grants and other support to improve their infrastructure. » These small, rural communities often pay a higher cost for basic drinking water and wastewater services due to the smaller population from which to draw the revenue needed to build and maintain these facilities, or because they need to purchase their water and wastewater services from another entity. » Often, community members do not recognize the cost involved to produce clean drinking water, nor do rates cover the true cost of producing and transporting treated water. According to the West Virginia Public Service Commission (WVPSC), the cost for these sewer utility services can range from $8 to $92 for the same services, depending on location and circumstances specific to each system. Functional drinking water and wastewater systems are important in making a good first impression on new visitors and businesses to West Virginia. For example, West Virginia's New River Gorge National Park is called a "haven for hiking, climbing, and rafting" by *National Geographic*. The area surrounding it, however, can emit foul odors due to an insufficient wastewater management system. Similarly, Thurmond is a small, historical town with rave reviews on TripAdvisor and interest from new businesses and the National Park Service in commercial property and housing. The challenge for those interested? A lack of wastewater infrastructure. Without access to this vital infrastructure, development that would bring jobs to the region is at a standstill.

ACTION	RECOMMENDATION	ILLUSTRATIONS OF WHY ACTION IS IMPORTANT TODAY
Together, West Virginians will work to provide access to clean and affordable water to protect and enhance public health.	West Virginia policymakers should require that West Virginia Parks and Recreation take actions to educate and protect West Virginians and tourists from vector-borne diseases, such as Lyme's Disease, that are likely to become more prevalent due to increased extreme precipitation and heat. They should also require that the Department of Health and Human Services (DHHR) increase its surveillance and reporting; develop physician, healthcare provider, and public education materials; and implement a long-term Wastewater-Based Epidemiology (WBE) system to provide early warning of potential infectious disease outbreaks.	According to the Centers for Disease Control, the changing climate is likely to increase the presence of ticks and other vectors, thereby increasing the prevalence of vector-borne diseases: From 2000-2014, there were over 1,283 reported cases of Lyme Disease in West Virginia. According to the DHHR, "The number of counties reporting Lyme disease cases has increased in recent years." This reflects a nation-wide trend. According to the Environmental Protection Agency (EPA), "The incidence of Lyme disease in the United States has nearly doubled since 1991, from 3.74 reported cases per 100,000 people to 7.21 reported cases per 100,000 people in 2018. The EPA states the same conclusion: "Studies provide evidence that climate change has contributed to the expanded range of ticks."

ACTION	RECOMMENDATION	ILLUSTRATIONS OF WHY ACTION IS IMPORTANT TODAY
Engage West Virginia communities to coordinate efforts to enhance the potential of water resources--which flow across political boundaries--to provide prosperity and well-being to all.	West Virginia policymakers should take action to establish a grant program for communities to support outdoor recreation initiatives and a "bridge" bill to facilitate public access to West Virginia waterways.	Volunteers throughout West Virginia work together to develop and maintain the waterways in their regions through volunteer organizations such as Mon River Towns and the Elk River Trail Foundation. These organizations, however, need financial resources to undertake their work, which provides vitality, stability, sustainability, and prosperity to the surrounding region. This financial support is particularly important in currently distressed regions so these communities can attract new businesses and jobs. In Utah, for example, every dollar in state money spent to support outdoor recreation opportunities resulted in an additional seven dollars coming to communities from private sources. The result: 700 outdoor jobs were supported, primarily in rural Utah, over five years.
	West Virginia policymakers should propose that the USDA-funded Cooperative Extension Service and the Appalachian Community Technical Assistance and Training (ACTAT) programs support and educate rural communities on water-related economic development opportunities; provide guidance on the management of drinking water and wastewater; identify water recreation opportunities to enhance economic development; augment the water-focused curriculum in K-12 education; and work with community colleges to train staff for work in drinking water, waste water, and recreational water jobs.	The ACTAT team has provided training to over 163 small water and wastewater utilities from West Virginia, Kentucky, and Tennessee, positively impacting over 513,050 citizens. Training focuses on helping utility staff develop sustainable management practices in areas such as infrastructure stability, employee and leadership development, and financial viability. ACTAT works with small water systems from across West Virginia and other Appalachian states to advance the implementation of sustainable best management practices. For example, many small utilities lack a digital record of the location and condition of buried water and wastewater infrastructure and must rely on paper records or institutional knowledge to maintain this critical information. The ACTAT team works with utilities to digitize these records to improve system operation, using methods such as hydraulic modeling, which can support identification of leaks or other operational issues. ACTAT also supports utilities in conducting water audits and reducing the amount of water lost due to pipeline leaks. Less water loss means a more efficient and less costly water utility system.

ACTION	RECOMMENDATION	ILLUSTRATIONS OF WHY ACTION IS IMPORTANT TODAY
Revitalize West Virginia's water resources, and increase the state's resilience to meet the societal and economic needs of today's West Virginians and their future generations.	West Virginia policymakers should request that the USDA fund a 5-year study led by an independent party, such as a university, that would bring together stakeholders to identify, assess, and prioritize corrective water management infrastructure and flood inundation mapping actions in response to the changing climate. This study should include an assessment to determine whether West Virginia employs a sufficient number of engineers with the expertise to inspect dams. Policymakers should encourage the Federal Emergency Management Agency (FEMA) to prioritize remapping West Virginia's flood plains given the state's propensity for catastrophic flooding. Federal and state agencies should work together to take action on water-related infrastructure, particularly dams, drainage, culvert systems, and green infrastructure. In addition, the West Virginia Emergency Management agency should review its flood early warning system (FEWS) to ensure that it incorporates the most up-to-date "internet of things" (IOT) technology and that it monitors not only large rivers but small rivers as well.	According to West Virginia's 2018 Statewide Standard Hazard Mitigation Plan Update 2018, "All counties in West Virginia were ranked as having a high level of risk for flooding." Yet only 16% of particularly vulnerable structures are covered by flood insurance. FEMA's flood plain maps are often inadequate and inaccurate for West Virginia. This deficiency puts homeowners and businesses at risk, as not all homeowners who need insurance know that they could obtain it. When flood insurance is purchased, it is often insufficient to meet the purchaser's needs. Renters' properties are not covered by FEMA flood insurance or a typical renter's policy. West Virginia's June 2016 "extreme rainfall" flood, in which 8-10 inches fell in twelve hours, led to a state of emergency in 44 of West Virginia's 55 counties. Twenty-three lives were lost, over 2,300 people stayed overnight in shelters, and 1,700 families requested long-term help. West Virginia's 30 federal dams are now more than 50 years old. These dams were designed for last century's climate and are potentially undersized for current and future predicted precipitation regimes. Most dams in West Virginia (278) are privately owned, and many (203) are owned by local governments. The West Virginia state government has only three engineers to monitor the safety of all the dams in the state. Two West Virginia communities, Martinsburg (where 30% of the city lacks stormwater infrastructure) and Huntington (an area prone to flash-flooding), have demonstrated green infrastructure projects that could serve as models for other communities. As indicated by the Huntington project leader, "Uncertainties around flooding can make companies and private investors wary of spending on improvements that might be washed away in the next flood."
Showcase West Virginia's natural water resources by marketing their beauty and developing river-related recreation opportunities that increase tourism and recruit new businesses and residents.	West Virginia policymakers should introduce a "West Virginia Headwaters Legacy Act" that would provide a federal-designation and protect West Virginia's scenic rivers to ensure water quality is maintained or enhance a river's special values.	West Virginia has the greatest density of whitewater runs in the country, some of the best climbing in the eastern U.S., and thousands of miles of trails for hiking, trail running, backpacking, nature watching, and mountain biking. However, in 2019, outdoor recreation contributed only 1.9% to the state's overall state GDP, compared to rates of 4.7% in Montana, 3.3% in Utah, and 3.1% in Colorado.

APPENDIX A: PARTICIPATING WEST VIRGINIA UNIVERSITY FACULTY, STAFF, AND STUDENTS

This policymaker's guide was developed by the WVU faculty, staff, and students listed below under the Bridge Science and Technology Policy, Leadership, and Communications Initiative directed by Joan Centrella. John Deskins, Jennifer Hause, and Nicolas Zegre led the working groups that developed the content for this guide. Deborah Stine was the study director as a consultant to WVU. Jay Cole was the WVU President's liaison.

WATERS OF WEST VIRGINIA COMMITTEE MEMBERS

Jorge Atiles - Dean, Extension and Engagement; Director, WVU Extension Service

Robert Burns - Director, Division of Forestry and Natural Resources; Professor of Recreation, Parks & Tourism Resources

Peter Butler - Director, School of Design and Community Development; Associate Professor of Landscape Architecture; Landscape Architecture Extension Specialist

Greg Corio - Assistant Vice President, The Brad and Alys Smith Outdoor Economic Development Collaborative

John Deskins - Director, Bureau of Business and Economic Research (BBER); Assistant Dean for Outreach and Engagement, John Chambers College of Business and Economics; Associate Professor of Economics

Michael Dougherty - Professor and Extension Specialist, Community Resources and Economic Development

Timothy Driscoll - Associate Professor of Biology

Emily Garner - Assistant Professor of Civil and Environmental Engineering

Jennifer Hause - Program Manager, WVU Energy Institute, National Environmental Services Center

Ronnie Helmondollar - Program Director, Agriculture & Natural Resources, WVU Extension Service

Leslie Hopkinson - Associate Professor of Civil and Environmental Engineering

Jason Hubbart - Director, Institute for Water Security and Science; Professor of Hydrology and Water Quality

Charlene Kelly - Teaching Assistant Professor of Forest Resources Management and Plant and Soil Sciences

Tony Michael - Program Director, Family & Community Development, WVU Extension Service

Christopher Plein - Professor of Public Administration, Eberly Family Professor for Outstanding Public Service; Adjunct Extension Specialist, Family and Community Development

John Quaranta - Associate Professor of Civil and Environmental Engineering

Javier Reyes - Vice President, Start-Up West Virginia; Dean, John Chambers College of Business and Economics

Shikha Sharma - Professor of Geology; Director, IsoBioGeM Laboratory

Jamie Shinn - Assistant Professor of Geography

Hema Siriwardane - Professor and Chair, Civil and Environmental Engineering

Samuel Taylor - Assistant Director, WVU Energy Institute

Danny Twilley - Assistant Dean, The Brad and Alys Smith Outdoor Economic Development Collaborative

Nicolas Zégre - Associate Professor of Forest Hydrology; Director, Mountain Hydrology Lab

STUDY STAFF

Joan Centrella - Director, Bridge Initiative for Science and Technology Policy, Leadership, and Communications

Deborah Stine - Study Director, Consultant to WVU

Jay Cole - Study Advisor

April McGinnis - Editor

Samuel Wilkinson - Project Manager

POLICY ANALYSIS ASSISTANTS:

Ph.D. Students:
Brooke Eastman
Luis Andres Guillén
Michael Jones
Rachel Hostetler
Rachel Yesenchak

Master's Students:
Scott Lopez
Bryan Phillips
Eric Sjöstedt

Undergraduate Students:
Payton Seats
Wilson McNeil

Volunteer:
Jasmine Gonlin

APPENDIX B: STUDY PROCESS

The Waters of West Virginia policymaker guide is the first product of WVU's Bridge Science and Technology Policy, Leadership, and Communications Initiative. The purpose of this appendix is to provide an overview of the process that we used.

The policymaker guide provides the views of WVU faculty and staff who are experts in the topics discussed in the guide. The Bridge staff support the effort by writing the policymaker guide based on the faculty's and research staff's views, providing research support, managing the logistics of bringing the faculty and stakeholders together, moderating the peer review process, summarizing meetings, and developing consensus on the policy options and recommendations.

Provided on the following page is the timeline of activities.

Given that this is the Bridge Initiative's first study, we expect to enhance the process in the future based on the lessons learned from this study.

STEP	TIMEFRAME
1. **Concept Development** a. Identify science and technology (S&T) policy area of interest to West Virginians based on discussions with WVU deans and faculty/staff, stakeholders, and other experts b. Gather information and data on current policy and science and engineering research ("status quo") c. Develop draft statement of work (SOW) d. Consult with WVU faculty/staff and non-governmental organizations on SOW e. Revise SOW based on feedback f. Identify relevant WVU faculty/staff and stakeholders g. Recruit working group chairs	Summer-early Fall 2020
2. **Kick-off Meeting** a. President, Provost, and VP for Research explain importance of initiative b. Attendees engage in breakout sessions to develop working groups to discuss draft SOW c. Finalize SOW (see details below)	October 2020
3. **Working Groups** a. Working groups meet to develop findings and policy options to respond to those findings b. Outline policymaker guide, by working group c. Develop draft policymaker guide text, by working group, through an iterative process that occurred on a roughly weekly basis where Bridge staff developed text based on faculty/staff discussions which were then reviewed	October-December 2020
4. **Full Policymaker Guide Text** a. Synthesize sections based on individual working groups to develop full draft of policymaker guide b. All working groups meet to review and finalize full policymaker guide draft (version 1)	December 2020- January 2021
5. **External Review** a. Send policymaker guide (version 1) to non-WVU experts for peer review and to the staff of several West Virginia members of Congress to gather their thoughts and questions b. Incorporate peer review comments into text (version 2)	February-March 2021
6. **Stakeholder Roundtables** a. Send policymaker guide (version 3) to stakeholders for comment and post on website for public comment b. Five stakeholder "listening" roundtables review policy options and develop and prioritize recommendations to policymakers (see details below)	April-May 2021
7. **Policymaker Guide Text Finalized** a. Working groups meet individually and then in a plenary session to discuss stakeholder input b. Working groups meet in plenary session to finalize and prioritize policymaker guide recommendations	May 2021
8. **Policymaker Guide Formalized and Released** a. Edit, format, and prepare policymaker guide for dissemination b. Release policymaker guide and disseminate it to policymakers, stakeholders and the public	Summer-Fall 2021

STATEMENT OF WORK

The study began with the following statement of work:

What actions, if any, should West Virginia policymakers take to enhance West Virginia's resiliency to adverse climate-related water events as well as the development of its existing and potential water-related economic and societal opportunities?

The definition of resilience was based on that of the Rockefeller Foundation's international cities resilience network, which points to "the capacity of individuals, communities and systems to survive, adapt and grow in the face of changes, even catastrophic incidents."

Stresses are further defined as longer-term events that gradually weaken a place, whereas shocks are sudden, severe events. There are different ways to categorize stresses and shocks--for example, as natural/environmental, biological or man-made, or as social, economic, and environmental.

The three working groups were asked to focus on the following questions:

1. Working Group 1: What is the current relationship of the waters of West Virginia to its economy, society, and related infrastructure (e.g., poor drinking water quality, crumbling dams and bridges)?
2. Working Group 2: What is the current societal and economic impact of adverse climate events related to the waters of West Virginia (e.g., flooding, drought)?
3. Working Group 3: How might West Virginia enhance its development of potential economic and societal opportunities related to water based on current scientific, technical, and financial opportunities (e.g., stimulus/infrastructure bill; hydropower partnerships)?
4. All working groups: What policies (e.g., infrastructure investments) might be put in place at the federal, regional, state, county, and local levels as well as across watersheds to make West Virginia more resilient to adverse climate events (should it be deemed necessary to do so) and to take advantage of economic and societal water-related opportunities?

The working groups focused independently on the first three questions as indicated, then merged together at the end to respond to the fourth question. All meetings were held via Zoom. The assessment and prioritization of these policies was done according to their effectiveness, economic efficiency, equity, and ease of political acceptability, and will incorporate stakeholder input.

KICKOFF MEETING

The agenda for the kickoff meeting, held via Zoom, is provided below:

West Virginia Waters:
Bridging Science to Policy to Enhance Resiliency and Economic Development

October 14, 2020
Meeting Agenda

11:30 am – Introductory Remarks
- Gordon Gee, President
- Maryanne Reed, Provost
- Fred King, Vice President for Research
- Jay Cole, Senior Advisor to President Gee

11:45 am – Plenary I
- Meeting Goals – Joan Centrella
- Review of WV Waters Project Plan – Debbie Stine
  - Definition of resiliency
  - Study Questions
  - Overall plan

12:00 noon – Breakout sessions for Working Groups
- Working Group 1: What is the current relationship of the waters of West Virginia to its economy, society, and related infrastructure? (e.g., poor drinking water quality, crumbling dams and bridges)
- Working Group 2: What is the current societal and economic impact of adverse climate events related to the waters of West Virginia? (e.g., flooding, drought)
- Working Group 3: How might West Virginia enhance its development of potential economic and societal opportunities related to water based on current scientific, technical, and financial opportunities? (e.g., stimulus/infrastructure bill; hydropower partnerships)

12:25 pm – Plenary II
- Reports from Working Groups
- Moving forward – next steps

12:45 pm – Adjourn

ROUNDTABLES

The Bridge Initiative hosted five topical roundtables, held via Zoom, to gather feedback on those options. Roundtable participants included key stakeholders interested in the waters of West Virginia from business and industry, government, and non-governmental organizations. Appendix C provides a list of those who participated. The roundtables were broken down into the following topics based on the content of the policymaker guide:

- Roundtable 1: Drinking Water Infrastructure and Wastewater Management (Monday, April 19, 2021, 12:00pm-2:00 pm)
- Roundtable 2: Dams/Pumped Hydropower Energy Storage/Acid Mine Drainage Management (Friday, April 23, 2021, 12:00pm-2:00pm)
- Roundtable 3: Flooding/Vector-Borne Disease/Ticks (Thursday, April 29, 2021, 11:00am-12:15pm)
- Roundtable 4: Rivers and Recreation (Thursday, April 29, 2021, 12:45pm-2:00pm)
- Roundtable 5: Regionalization and Rural Community Support (Monday, May 3, 2021, 12:00pm-2:00pm)

During each roundtable, stakeholders were asked to review the policy options then prioritize them based on the criteria of effectiveness (likelihood of meeting the societal goal), efficiency ("best bang for the buck"), equity (winners and losers), and ease of political acceptability (the degree to which key policymakers and stakeholders would oppose or support the policy). WVU faculty/staff and the Bridge team were in "listening mode" intentionally focused on hearing the views of the stakeholders, as well as asking clarifying questions rather than presenting their own views during the conversation. The meetings, held over 2 hours, had the following agenda:

Welcome
Dr. Joan Centrella, Director, Bridge Initiative in Science and Technology Policy, Leadership, and Communications

Roundtable Goals
Dr. Deborah Stine, Study Director, Consultant to WVU

WVU Faculty and Staff Introductions

Roundtable Participant Introductions with Overview Thoughts on the Policymaker Guide

Discussion and Prioritization of Policy Options
- How would you rank the options in terms of effectiveness (most likely to reach a societal goal)?
- How would you rank the options in terms of efficiency (biggest bang for the buck)?
- How would you rank the options in terms of equity (winners/losers)?
- How would you rank the options in terms of ease of political acceptability (support/opposition of policymakers and key stakeholders)?

What is your overall assessment in terms of ranking the options?

Final thoughts

Conclusion

Overall, the Bridge staff and WVU faculty/staff felt the process worked well. Consensus on the text and policy options was achieved through reliance on the expertise of their colleagues who specialize in the issues. A particularly influential aspect was the incorporation of the views and priorities of stakeholders during the roundtable discussions. The budget for the study was low, primarily because all meetings were held via Zoom. The use of Zoom also led to a more equitable access to the roundtable discussions as no travel time or funds were required. That being said, this was the Bridge Initiative's first study, and the staff plan to continually improve the process, such as by incorporating stakeholder feedback earlier in the process.

APPENDIX C: ROUNDTABLE PARTICIPANTS

West Virginia University's Bridge Science and Technology Policy, Leadership, and Communications Initiative acknowledges the helpful comments from the following persons who attended one or more of the Roundtable Discussions, held in April and May, 2021:

Christie Bailey
Executive Director, National Coal Heritage Area Authority

Robert Burton
President, American Water

Autumn Crowe
Staff Scientist, WV Rivers Coalition

Andrew Davis
Special Projects Coordinator, New River Gorge Regional Development Authority

Ben Faulkner
Chairman, WV Mine Drainage Task Force

Jacob Fowler
Outdoor Recreation Coordinator, WV Tourism Office

Vernon Haltom
Executive Director, Coal River Mountain Watch

Jacob Harrell
Coordination Biologist - Hydropower, WV Division of Natural Resources

Allison Keller
Geologist, Source Water and Wellhead Protection Program, WV DHHR Office of Environmental Health

Corey Lilly
Executive Director, Piney Creek Watershed Association

Christina Mickey
Environmental Resource Specialist, Source Water Assessment and Wellhead Protection Program, WV Department of Health and Human Resources

Jeremy Morris
Consultant, WV Rivers Coalitions

Owen Mulkeen
Associate Director, Friends of the Cheat

Phillip Musegaas
Vice President and General Counsel, Potomac Riverkeeper

Anna Plantz
Director of Partner Programs, WV Tourism Office

Amanda Pitzer
Executive Director, Friends of the Cheat

Garrett Richardson
Monitoring Technician, Friends of the Cheat

Angie Rosser
Executive Director, WV Rivers Coalition

Bryan Smith
Treasurer, Save the Tygart Watershed

Dennis Stottlemyer
Deputy Environmental Advocate, WV Department of Environmental Protection

Kenneth Tawney
President, Elk River Trail Foundation

Melanie Thornton
Professional Staff, Senator Shelley Moore Capito, U.S. Senate

Monica Whyte
Environmental Resource Specialist, Office of Environmental Health Service; Source Water Assessment and Wellhead Protection Program, WV Bureau of Public Health

Tim Williamson
CEO, FreedomWorks, LLC

West Virginia University

BRIDGE INITIATIVE FOR SCIENCE & TECHNOLOGY
POLICY, LEADERSHIP, AND COMMUNICATIONS

West Virginia University's Bridge Initiative for Science and Technology Policy, Leadership, and Communications identifies challenges and opportunities facing West Virginia and provides a bridge between the science and technology expertise of WVU faculty and staff and West Virginia's national, state, and local policymakers.

In our work, we gather the views of stakeholders throughout the state to ensure we are making recommendations that serve the needs of West Virginians. This work supports WVU's critical land-grant mission to lead "transformation in West Virginia and the world through local, state and global engagement."

http://scitechpolicy.wvu.edu