5.2 Drought

2023 SHMP Update Changes

- Drought events that occurred in the State of West Virginia (the State) from January 1, 2015, through December 31, 2022, were researched for this 2023 State Hazard Mitigation Plan (SHMP) update.
- New and updated figures from federal and state agencies were incorporated.
- A qualitative vulnerability assessment was conducted at the state level to discuss drought impacts to state assets, critical facilities and lifelines, population, socially vulnerable populations, and future changes.

5.2.1 Hazard Profile

Hazard Description

Drought is a gradual phenomenon and is defined as a deficiency of precipitation over an extended period resulting in a water shortage (National Integrated Drought Information System 2022). This can lead to serious problems, including crop damages/losses and water supply shortages (National Weather Service 2022).

Types of Drought Defined

- Agricultural drought refers to the impacts on agriculture by factors such as rainfall deficits, soil water deficits, reduced ground water, or reservoir levels needed for irrigation.
- Meteorological drought is based on the degree of dryness or rainfall deficit and the length of the dry period.
- Hydrological drought is based on the impact of rainfall deficits on the water supply such as stream flow, reservoir and lake levels, and ground water table decline.
- Socioeconomic drought considers the impact of drought conditions (meteorological, agricultural, or hydrological drought) on supply and demand of some economic goods such as fruits, vegetables, grains, and meat. Socioeconomic drought occurs when the demand for an economic good exceeds supply because of a weather-related deficit in water supply (National Weather Service 2022).
- Ecological drought is a prolonged and widespread deficit in naturally available water supplies — including changes in natural and managed hydrology — that create multiple stresses across ecosystems (National Drought Mitigation Center 2022).

Location

All areas of the state are susceptible to drought, although the extent and severity of the drought will depend on the variance of rainfall throughout the state based on location. The identification of areas that are vulnerable to drought impacts is difficult due to the differences in microclimate and impact sectors.

West Virginia receives an annual average of 44.2 inches of precipitation, which replenishes ground water and reservoirs. Extended droughts can severely diminish the amount of water in streams, reservoirs, and aquifers. The population of West Virginia is equally dependent on public ground water systems, private wells or cisterns, and surface water for their water supply. Longer periods of drought can impact drinking water for those people (West Virginia Emergency Management Division 2016).

EXTENT

The State monitors precipitation, ground water levels, stream flows, snowpack, and water quality. The State uses a combination of five indices for information regarding drought conditions. This includes the Palmer Drought Severity Index (PDSI), Palmer Z Index, Crop Moisture Index (CMI), Standardized Precipitation Index (SPI), and the National Fire Danger Rating System (West Virginia Emergency Management Division 2016).

Drought Indices

Palmer Drought Severity Index

The PDSI allows for a categorization of various levels of wetness and dryness that are prominent over an area. The PDSI is calculated based on precipitation and temperature data as well as the local Available Water Content (AWC) of the soil (National Drought Mitigation Center 2023).

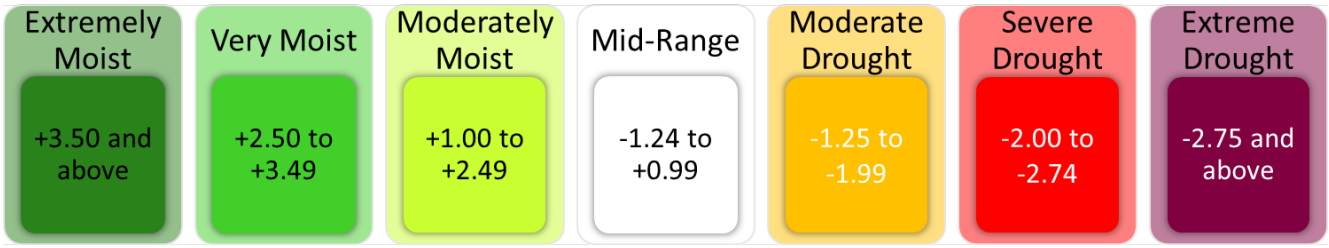
Figure 5.2-1. Palmer Drought Severity Index

Source: National Drought Mitigation Center 2023

Palmer Z Index

The Palmer Z Index measures short-term drought on a monthly scale (National Centers for Environmental Information 2023).

Figure 5.2-2. Palmer Z Index

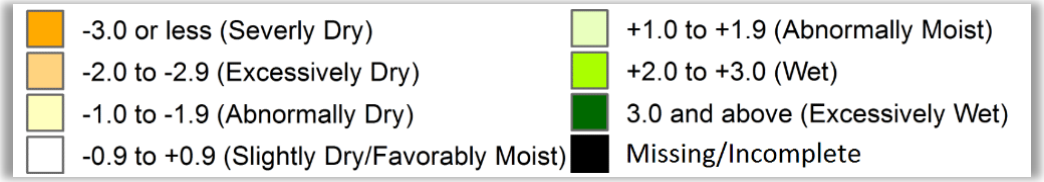


Source: National Centers for Environmental Information 2023

Crop Moisture Index

The CMI gives the short-term or current status of purely agricultural drought or moisture surplus and can change rapidly from week to week. The CMI indicate general conditions and not local variations caused by isolated rain. Input to the calculations include the weekly precipitation total and average temperature, division constants (water capacity of the soil, etc.), and previous history of the indices. The CMI can be used to measure the status of dryness or wetness affecting warm season crops and field activities (National Weather Service (NWS) Climate Prediction Center (CPC) 2023).

Figure 5.2-3. Crop Moisture Index



Source: National Weather Service (NWS) Climate Prediction Center (CPC) 2023

Standardized Precipitation Index

The SPI measures water supply, specifically precipitation. The SPI is computed over several time scales, typically from 1 month to 24 months, to evaluate both short-term drought and long-term drought. It can also measure precipitation excess (National Centers for Environmental Information 2023). A drought event occurs any time the SPI is continuously negative and reaches an intensity of -1.0 or less. The event ends when the SPI becomes positive (National Drought Mitigation Center 2023).

National Fire Danger Rating System

The National Fire Danger Rating System (NFDRS) is a system that allows fire managers to estimate today's or tomorrow's fire danger for a given area. The key inputs into the NFDRS model are fuels, weather, topography, and risks. The ratings describe conditions that reflect the potential, over a large area, for a fire to ignite, spread, and require suppression action (U.S. Forest Service 2023). During longer periods of drought, fire danger levels are more likely to be high and the risk of wildfires occurring in areas experiencing drought are higher as well.

Figure 5.2-4. NFDRS

Source: U.S. Forest Service 2018

Warning Time

The State has a drought monitoring and assessment system in place that helps provide warning time for drought. There are four stages used to guide implementation of the State's drought response (refer to Table 5.2-1). Each stage is determined by referring to the five indices and assistance from National Oceanic and Atmospheric Administration (NOAA) to determine drought severity. The criteria is reassessed each month (West Virginia Emergency Management Division 2016). These outlooks can provide guidance for residents, farmers, business owners, and other industries in preparation of drought conditions, taking proactive measures to lessen drought impacts (U.S. Climate Resilience Toolkit 2021).

Table 5.2-1. West Virginia Drought Stages

Stage	Details
Normal	Refers to conditions that do not negatively impact water supplies, vegetation, or water quality in the state. No action needed.
Alert	1) When the PDSI reads -2.00 to -2.99 and stream flow, reservoir levels, and ground water levels are below normal over a several month period and/or the WVDHSEM Director, in coordination with appropriate state officials, determines Stage II activities are required, the Governor is to be requested to make a Drought Alert Declaration. 2) The alert can be rescinded once rainfall, stream flows, reservoir levels, and ground water levels return to normal or near normal levels for that time of year. The PDSI would be above - 1.0 for normal or near normal levels.
Conservation	1) Activated when the PDSI is between -3.00 to -3.99 and/or when the Director of WVDHSEM, in coordination with appropriate state officials, determines that Stage III activities are required. Stream flow, reservoir levels, and ground water levels continue to decline and forecasts indicate an extended period of below normal precipitation. 2) A return to Alert level happens when precipitation increases; stream flows, reservoir levels, and ground water levels stop their decline; and the PDSI begins to rise to -2.99 or higher or when the Director of WVDHSEM, in coordination with appropriate state officials, determines that Stage II activities are required. Extended forecasts should indicate a return to normal conditions.
Emergency	1) Activated when the PDSI is lower than -4.00 and/or the Director of WVDHSEM, in coordination with appropriate state officials, determines that Stage IV activities are required. The Governor may issue a Drought Emergency Declaration when water supplies are inadequate to meet projected demands and extreme measures must be taken. Forecasts are to indicate that precipitation levels, stream flows, reservoir levels, and ground water levels will continue to decline. 2) The Governor's declaration empowers state agencies to review allocation of supplies in communities not adequately responding to their water shortage and to implement emergency programs and actions as provided in the West Virginia Code.

Source: West Virginia Emergency Management Division 2016

Previous Occurrences and Losses

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1954 and 2022, West Virginia was included in two major disaster (DR) or emergency (EM) declarations for drought-related events (FEMA 2023). Table 5.2-2 summarizes these declarations.

Table 5.2-2. Drought-Related Federal Declarations, 1953 to 2022

Incident Date(s)	Declaration	Incident Type	Declaration Title	Counties Declared
January 19, 1977	FEMA-EM-3021	Drought	Drought	Fayette, Grant, Greenbrier, Hampshire, Hardy, Mercer, Mineral, Monroe, Pendleton, Raleigh, Summers, Wyoming
August 24, 1977	FEMA-EM-3051	Drought	Drought	Grant, Greenbrier, Hampshire, Hardy, Mineral, Monroe, Pendleton, Pocahontas, Summers

Sources: USDA 2023, FEMA 2023
FEMA Federal Emergency Management Agency
N/A Not Applicable

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the USDA is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, West Virginia was included in five drought-related agricultural disaster declarations. Table 5.2-3 provides the USDA Secretarial disaster declarations in all West Virginia counties from January 1, 2012 through December 31, 2022 (USDA 2022).

Table 5.2-3. Drought-Related USDA Declarations, 2012 to 2022

Date(s) of Event	Designation Number	Description of Disaster	Counties Declared
November 4, 2019	USDA-S4565	Drought	Mingo
February 5, 2020	USDA-S4605	Drought and Excessive Heat	McDowell, Mercer, Mingo, Monroe, Summers
February 5, 2020	USDA-S4589	Drought and High Temperatures	Wayne
February 5, 2020	USDA-S4606	Drought	Jefferson
January 18, 2022	USDA-S5122	Drought and Excessive Heat	Berkeley, Jefferson, Morgan

Sources: USDA 2023
N/A Not Applicable
USDA U.S. Department of Agriculture

Previous Events

Table 5.2-4 lists periods of drought or drought events that have impacted the State since 1930. This table includes events identified in the 2018 SHMP and events that occurred between January 1, 2015, through December 31, 2022.

Table 5.2-4. Drought Events in the State of West Virginia (1929 to 2022)

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
1929-1930	Dust Bowl	N/A	Statewide	Drought was greater in length and intensity than any events previously recorded or recorded since. Public water supplies suffered, resulting in public health concerns for water and lack of flow for sewage.
January 19, 1977	Drought	FEMA-EM-3021	Fayette, Grant, Greenbrier, Hampshire, Hardy, Mercer, Mineral, Monroe, Pendleton, Raleigh, Summers, and Wyoming	No additional details regarding this event were found during the plan update.
August 24, 1977	Drought	FEMA-EM-3051	Grant, Greenbrier, Hampshire, Hardy, Mineral, Monroe, Pendleton, Pocahontas, and Summers	No additional details regarding this event were found during the plan update.
July 1997	Drought	N/A	Statewide	A very dry month, containing one seven-day heat wave, exacerbated drought-like conditions across much of the fertile farmland of eastern West Virginia. The weather in July proved to be the death knell for much of the crop yields, including corn, hay, and pasture. The West Virginia Farm Service Agency reported the following damage statistics: Corn, hay, and pasture yields were 40- to 50 percent of normal. Estimated damage to the corn crop included 2,500 to 3,000 acres per county in the Potomac Highlands (WVZ048>051, 055) but as much as 10,000 acres in the Eastern Panhandle (WVZ052>053). Hay damage was estimated to be 40,000 acres per county; pastureland an additional 80,000 acres per county. No significant damage to alfalfa was noted. In May 1999, Governor Underwood declared a statewide drought disaster for the entire state as a result of extreme heat, lack of rainfall, and drought conditions causing extensive damage and severe losses to farmers throughout the state
1999-2000	Drought	N/A	Statewide	This was the worst drought in state history since the Great Depression. 30 percent of rural water wells and cisterns dried up; the water flow of the South Branch of the Potomac River, a major waterway through the Eastern Panhandle, was 50 percent below the record set in the Dust Bowl drought of 1929-1930; farmers lost $100 million due to the drought; and an estimated 2,000 farmers faced starting over because of the conditions . The West Virginia Department of Agriculture reported the agricultural economy of West Virginia suffered a loss of more than $200 million, the long-term effects of the 1999 drought are still being witnessed.
October 2014	Drought	N/A	Greenbrier, Pocahontas, and Pendleton Counties	A Secretarial disaster designation was declared for Greenbrier, Pocahontas, and Pendleton Counties.

Date(s) of Event	Event Type	Federal Disaster Declaration (if applicable)	Counties Affected	Description
March 2015	Drought	N/A	McDowell, Mercer, Raleigh, and Wyoming Counties	An unusually dry spring resulted in a drought designation for much of Region 10 and counties bordering Ohio in Region 5.
October 1-22, 2019	Drought	USDA-S4565 (Mingo)	Greenbrier, Mingo, Monroe, Summers, and Mercer	Four counties (Monroe, Greenbrier, Summers, and Mercer) in West Virginia entered severe drought conditions starting October 1 and remained in severe drought for three weeks through October 22. Mingo County was included in a USDA declaration related to the drought conditions. Agricultural damages were severe, with estimated losses per the USDA Farm Service Agency at $920,000 from pastures and $1.4 million from hay losses.
2019 - 2020	Drought and Excessive Heat	USDA-S4605 USDA-S4589 USDA-S4606	Jefferson, McDowell, Mercer, Mingo, Monroe, Summers, and Wayne	Much of West Virginia was in a drought by the fall of 2019 when moderate drought conditions extended into the southern part of the state from the north (Stacker 2021). It was the last widespread drought there, and although the state mostly emerged, the dry conditions plaguing parts of Pennsylvania extended into West Virginia (Stacker 2021). Throughout 2019 and 2020, West Virginia experienced abnormally dry and/or moderate drought conditions. Two of these periods occurred during January 2019 and March-April 2020. The largest and longest dry period, during late 2019, impacted 100 percent of the state, and similarly, late 2020 also had a dry period.
December 2021 – January 2022	Drought and Excessive Heat	USDA-S5122	Berkeley, Fayette, Jefferson, Morgan, Raleigh, and Summers	Dry conditions in December 2021 contributed to several brush fires in Fayette, Raleigh, and Summers Counties. Due to these dry conditions, the USDA included Berkeley, Jefferson, and Morgan Counties in a declaration related to drought and excessive heat.

Sources: National Centers for Environmental Information 2023, National Drought Mitigation Center, University of Nebraska 2023, FEMA 2023, USDA 2023, West Virginia Department of Environmental Protection 2020, West Virginia Emergency Management Division 2018, NPR 1999, Tuckwiller 1999, West Virginia Archives & History 1999

FEMA Federal Emergency Management Agency

USDA U.S. Department of Agriculture

PROBABILITY OF FUTURE HAZARD EVENTS

Overall Probability

Extended periods of dry weather with significant negative impacts on crops, livestock, and people have occurred in the past and will likely be decreasing in the future as rainfalls are projected to increase. Because drought is highly unpredictable and may vary locally, assessing probability of its occurrence is difficult. Quantifying drought in terms of historical frequency also proves to be a difficult task because of the variations in drought definition and the very limited and somewhat spotty nature of past drought reporting (West Virginia Emergency Management Division 2018).

According to USDA, FEMA, National Drought Mitigation Center, National Centers for Environmental Information, and the 2018 SHMP, the State experienced over 500 drought events between 1930 and 2022, as summarized in Table 5.2-5. Overall, the state is likely to experience at least five drought events of any magnitude or severity each year, with the possibility of an increase in frequency due to future changing conditions.

Table 5.2-5. Probability of Future Landslide Events in West Virginia

Hazard Type	Number Of Occurrences Between 1930 and 2022	Percent Chance of Occurrence in Any Given Year
Drought	505	100%

Sources: USDA 2023; FEMA 2023; National Drought Mitigation Center, University of Nebraska 2023; National Centers for Environmental Information 2023
Note: Drought events listed in the NOAA-NCEI database are those events classified as severe, extreme, or exceptional.

Projected Future Conditions

Drought is a serious environmental threat to West Virginia. Projected future conditions can exacerbate droughts by making them occur more frequent, more severe, and for longer periods of time (USGS 2023). Temperatures in West Virginia have risen approximately 1°F over the last century. Rising temperatures and changing rainfall patterns will likely increase the intensity of both floods and droughts. During the next century, average annual precipitation and the frequency of heavy downpours are likely to keep rising. Average precipitation is likely to increase during winter and spring but not change significantly during summer and fall. Rising temperatures will melt snow earlier in spring and increase evaporation, and thereby dry the soil during summer and fall. As a result, the projected change in future conditions is likely to intensify flooding during winter and spring and droughts during summer and fall (U.S. Environmental Protection Agency 2016).

> Droughts are projected to be more intense in the future due to rising temperatures increasing the rate of soil moisture loss during dry periods (National Centers for Environmental Information 2022).

5.2.2 Vulnerability Assessment

STATE ASSETS

The entire State is exposed and vulnerable to drought. While drought events typically do not impact buildings, infrastructure that provides water may be impacted. This can include loss or severe reduction of water supply, loss of water pressure, or poor water quality. Even though droughts do not directly affect state buildings, there

are secondary impacts related to drought that state buildings would be more susceptible to wildfires and tree mortality. Droughts can put more stress on trees, making them more susceptible to pest infestations and other diseases and dying trees. This leads to increased risk of tree limbs falling and damaging buildings and infrastructure and creating more fuel for wildfires (Borunda 2020).

In relation to wildfire, drought conditions can create more prolonged fires fueled by excessively dry vegetation, along with reduced water supply for firefighting (NOAA - NIDIS n.d.). Risk to life and property is greatest in areas where forested areas adjoin urbanized areas known as the wildland urban interface (WUI). Therefore, all state buildings and critical facilities (discussed below) in and adjacent to the WUI zone and located in high wildfire risk areas are considered vulnerable to wildfire. Section 4.15 (Wildfire) describes the state's vulnerability to the wildfire hazard.

Critical Facilities and Community Lifelines

As stated previously, drought does not directly impact structures. However, water-dependent community lifelines and critical facilities may be impacted. Under extreme drought conditions, where local water supplies are depleted and water utilities are unable to supply adequate water pressure, fire departments and healthcare facilities could be impacted. Additionally, similar to state-owned buildings, critical facilities, and community lifelines have an increased risk of wildfires, especially those located in the WUI.

Population

The entire population of the State is either directly or indirectly impacted and vulnerable to drought events. For those that rely on surface water (e.g., reservoirs and lakes) for potable water, a decline in surface water flows can be detrimental to the water supply (Moreland 2016).

Impacts on Socially Vulnerable Populations

Overall, the entire population of the State is exposed and vulnerable to drought. Therefore, the exposed socially vulnerable population to drought is equal to the statewide percentage: 60.4 percent of the total population.

Future Changes That May Impact State Vulnerability

Understanding future changes that may impact vulnerability in the State can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors in examining potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including impacts of future conditions

Potential or Projected Development

Any sections of growth and development, especially in areas that rely on surface water, could be impacted by drought. As water levels are lowered due to increase rates of use, drought can occur more readily than from lack of precipitation alone.

Projected Changes in Population

While statewide population has declined over the past 10 years, the population has increased in several areas throughout the state (e.g., Berkely, Jefferson, and Monongalia Counties). From 2010 to 2019, the state's overall population decreased by 3.3 percent, and it is projected to decrease 7.8 percent by 2040 (West Virginia Department of Transportation 2020). As the overall population decreases, fewer people will be exposed to drought impacts. However, counties with projected population increases, especially those with larger percentages that use surface water for potable water, will have an increased risk of drought impacts.

Other Factors of Change

As discussed above, projected future conditions for West Virginia indicate more intense droughts due to rising temperatures and changing rainfall patterns. Refer to Projected Future Conditions for details on how future conditions can impact droughts.

5.2.3 Consequence Analysis

Impacts to the Public

The entire population of the State is either directly or indirectly impacted and vulnerable to drought events, with the greatest impacts on water supply. The population of West Virginia is equally dependent on public ground water systems, private wells or cisterns, and surface water for their water supply (West Virginia Emergency Management Division 2016). For those who rely on surface water (e.g., reservoirs and lakes) for potable water, lower surface water levels can be detrimental to the water supply, diminishing the amount of water in reservoirs, lakes, and streams (Moreland 2016). Overall, the entire population of the State is exposed and vulnerable to drought. Therefore, the exposed socially vulnerable population to drought is equal to the statewide percentage: 60.4 percent of the total population.

Impacts to Responders

Limited impacts to first responders related to drought are anticipated in West Virginia. However, drought may limit water supplies available for firefighting activities.

Impacts to Continuity of Operations

While droughts can impact the entire State, it is not anticipated that drought conditions will impact the State's ability to continue operations during and after a drought.

Impacts to Property, Facilities, and Infrastructure

The entire State is exposed and vulnerable to drought, as described in the State Assets section of Section 5.2.2.

Impacts to the Environment

Environmental losses from drought are associated with damage to plants, animals, wildlife habitat, and air and water quality; forest and range fires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term, and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent.

Impacts to the Economic Condition of the State

Drought can impact the economy in many ways because water is an important part of so many businesses and activities. Farms rely on water to grow food, and animals need water to survive. The economic impacts of drought can lead to losses to those businesses that rely on water, including losses from agriculture businesses and losses associated with recreation (e.g., boating, finishing) (National Drought Mitigation Center 2023).

A prolonged drought event could have significant impacts in counties that have large amounts of agricultural lands. West Virginia has extensive agricultural operations throughout the state, many of which are vulnerable to shortages in rainfall. Short-term droughts can impact agricultural productivity, while longer-term droughts are more likely to impact agriculture and water supply. Jurisdictions that have invested in water supply and distribution infrastructure are generally less vulnerable to drought. Short- and long-term drought may lead to an increase in the incidence of wildfires, which might, in turn, lead to increased potential for landslides or mudflows once rain occurs (West Virginia Emergency Management Division 2018).

According to the current Census of Agriculture 2017 State Profile, there are 23,622 farms across West Virginia covering more than 3.6 million acres. The Counties of Preston (4.8 percent), Jackson (4.2 percent), and Berkeley (4.0 percent) have the greatest percentage of farms in the state. The market value of products sold is estimated at $754.2 million (USDA 2017). Table 5.2-6 provides a summary of the market value for crops and livestock in the state.

Table 5.2-6. State of West Virginia Agriculture Market Value (2017)

Agricultural Products Sold	Market Value
Value of crops, including nursery and greenhouse	$153,117,000.00
Value of livestock, poultry, and their products	$601,162,000.00
Total value of agricultural products sold	**$754,279,000.00**

Impacts to Public Confidence in State Governance

Public confidence would largely depend upon how effectively the State and county and local governments prepare for and respond to a drought event.