4.12 Drought

4.12.1 Hazard Profile

Drought refers to an extended period of deficient rainfall relative to the statistical mean established for a region. A drought can be characterized in several different ways depending on the impact. The National Weather Service (NWS) describes four types of drought: meteorological, agricultural, hydrological, and socioeconomic.

- **Agricultural** drought is the most common form of drought. It is characterized by unusually dry conditions during the growing season. It occurs when there is insufficient soil moisture to satisfy the water budget of a specific crop, leading to destroyed or underdeveloped crops, with greatly depleted yields.
- **Meteorological** drought is an extended period of time (6 or more months) with precipitation less than 75 percent of the normal precipitation.
- **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 as a result of weather-related deficits in the water supply.

4.12.1.1 Geographic Location/ Extent

Drought is a gradual phenomenon, and its condition occurs naturally in a broad geographic area. Since 2000, the longest duration of drought (D1-D4, See Table 4-137 for descriptions) in Virginia lasted 103 weeks beginning in May, 2007 and ending in April, 2009 (Figure 4-136). The most intense period of drought occurred the week of August 20, 2002 where D4 affected 30.53% of Virginia land (National Integrated Drought Information System, 2019). [62]

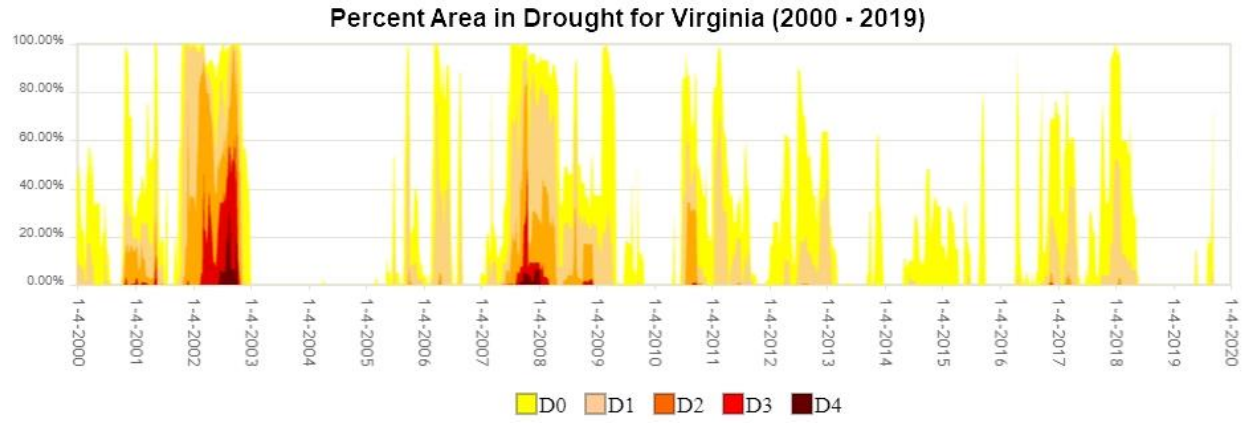
4.12.1.2 Magnitude/ Severity

The U.S. Drought Monitor (USDM)'s drought intensity scale is composed of five different levels: D0, D1, D2, D3, and D4. The USDM's weekly report uses this classification scale in combination with a color-coded map to provide a tool for decision making and drought planning. It also plays a key role in heightening awareness of drought as a hazard through dissemination by various media sources and state and federal agencies. Linking indices, such as the USDM, to impacts also allows decision makers to subsequently develop threshold alerts for communities to take action in response to drought conditions. Figure 4-137 presents the drought condition across the Commonwealth in September 2019.

[62] https://www.drought.gov/drought/states/virginia

Table 4-137 Drought Severity Classification

Drought Scale	Impacts
D0 Abnormally Dry	‣ Short-term dryness slowing planting, growth of crops ‣ Some lingering water deficits ‣ Pastures or crops not fully recovered
D1 Moderate Drought	‣ Some damage to crops, pastures ‣ Some water shortages developing ‣ Stream, reservoir, or well levels are low ‣ Voluntary water-use restrictions requested
D2 Severe Drought	‣ Crop or pasture losses are likely ‣ Water shortages are common ‣ Fire risk is very high ‣ water restrictions are typically voluntary or mandated
D3 Extreme Drought	‣ Major crop/pasture losses ‣ Fire risk is extreme ‣ Widespread water shortages or restrictions
D4 Exceptional Drought	‣ Exceptional and widespread crop/pasture losses ‣ Exceptional fire risk ‣ Shortages of water creating water emergencies



(Source: U.S. Drought Monitor)

Figure 4-136 Percent Area in Drought for Virginia, 2000 - 2019

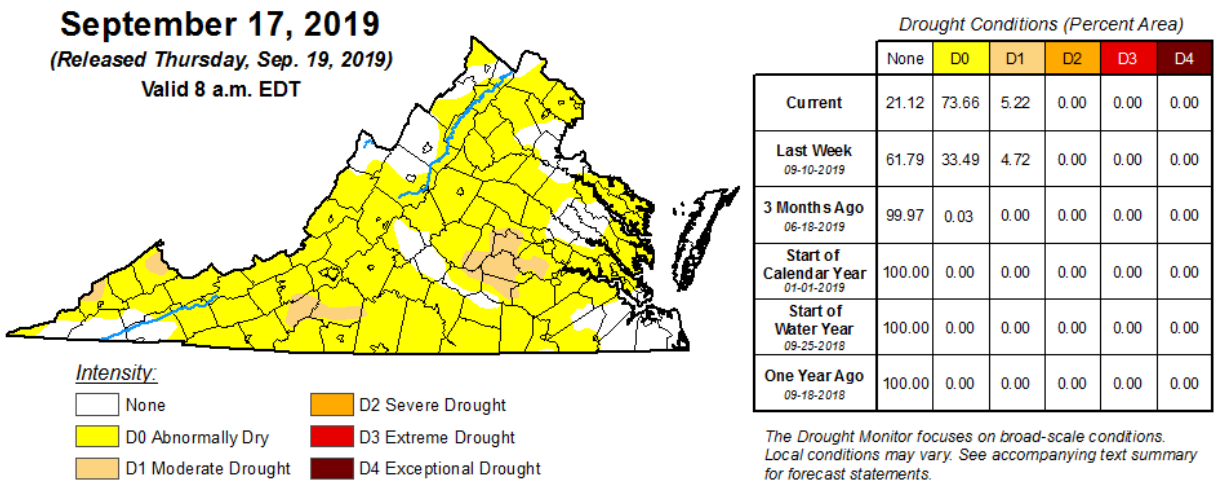


Figure 4-137 Drought Condition in Virginia from U.S. Drought Monitor (on September 17, 2019)

The responsibility for monitoring drought conditions rests with the Virginia Drought Monitoring Task Force (DMTF). The DMTF is activated with the first occurrence of moderate drought conditions (D1) in the Commonwealth or the occurrence of smaller scale moisture deficits that may fall beneath the level of resolution of the U.S. Drought Monitor. DMTF uses four hydrologic indicators across thirteen Drought Evaluation Regions to gauge the presence and severity of hydrological drought[63]. The indicators are based on the amount of precipitation and the effect of the precipitation (or lack of precipitation) on the hydrologic system.

- ***Groundwater levels*** are monitored at key shallow water-table observation wells that are part of the Virginia Climate Response Network.
- ***Precipitation*** *deficits* are monitored by comparing current precipitation amounts with historical precipitation values as a percent of normal long-term values.
- ***Streamflow*** is monitored at real-time stations with a long-term period of record on streams that have moderately large drainage areas and no significant regulation of flow by dams or impoundments.
- ***Reservoir storage*** is monitored at large multi-purpose reservoirs or at water-supply reservoirs.

The CVPDC area is covered by two Drought Evaluation Regions: the Roanoke region and Middle James region (Figure 4-138). The current drought condition for these evaluation regions can be found at the Virginia DEQ website. [64]

[63] https://www.deq.virginia.gov/Programs/Water/WaterSupplyWaterQuantity/Drought/DroughtMonitoring.aspx

[64] https://www.deq.virginia.gov/Programs/Water/WaterSupplyWaterQuantity/Drought/CurrentDroughtConditionsMap.aspx

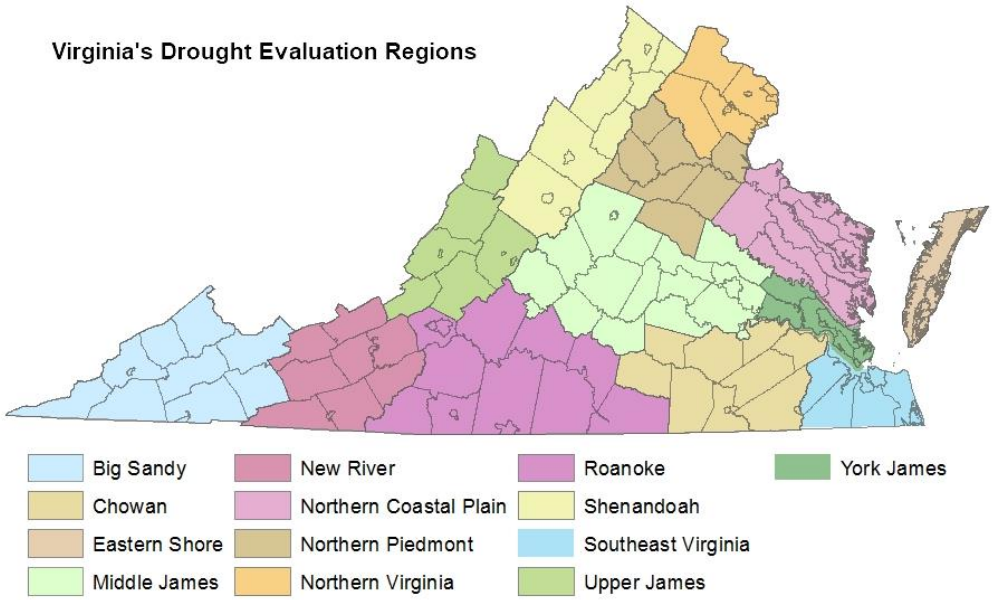


Figure 4-138 Virginia's Drought Evaluation Regions

The DMTF monitors the advance of drought conditions in the Commonwealth, not only using the drought indicators, but also other indicators such as the Standardized Precipitation Index, Palmer Drought Severity Index, Crop Moisture Index, Keetch-Byrum Drought Index, and NOAA monthly and seasonal precipitation outlooks. There is no single definition of drought and it is difficult to determine when a drought begins and ends. There are various tools developed by the researchers to help define the onset, severity, and end of droughts. Drought indices take thousands of bits of data on rainfall, snowpack, streamflow, etc., analyze the data over various time frames, and turn the data into a comprehensible big picture (National Drought Mitigation Center). [65]

Recently, the USDM created a Drought Severity and Coverage Index (DSCI) for converting drought levels (D0 to D4) from the U.S. Drought Monitor map to a single value for an area by a weighted sum:

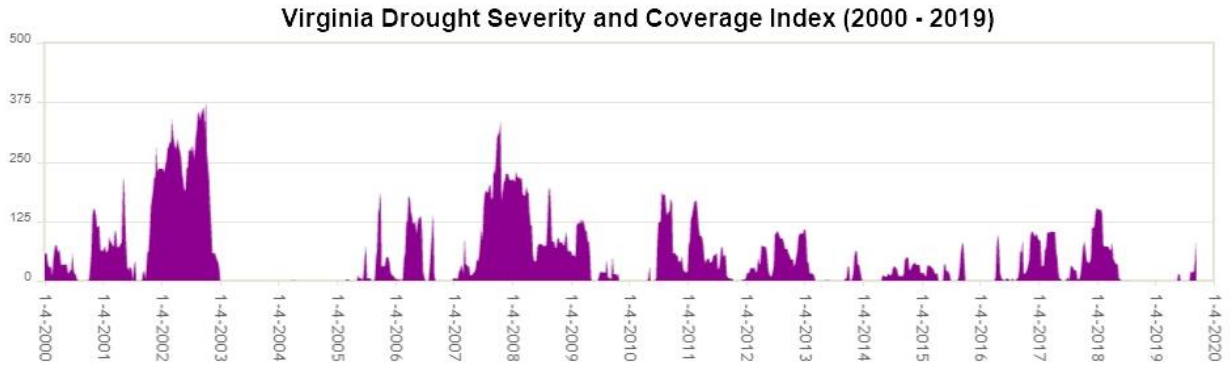
$$1(D0) + 2(D1) + 3(D2) + 4(D3) + 5(D4) = DSCI$$

The DSCI provides a convenient way to convert USDM data from categorical to continuous, and to aggregate from spatially specific to geopolitical boundaries. Figure 4-139 shows Virginia's DSCI during 2000 to 2019.

4.12.1.3 Previous Occurrences

Table 4-138 includes descriptions of major droughts that have occurred in CVPDC jurisdictions. Events have been broken down by the date of occurrence and when available, by individual community descriptions. When no community specific description is available, the general description should be used as representing the entire planning area. According to NCEI storm events database, there were 39 drought events reported in the CVPDC area from 1994 to 2019, resulting in about $13.4 million agricultural damage (Figure 4-140, Figure 4-141). There was no new drought event reported since the last plan.

[65] https://drought.unl.edu/ranchplan/DroughtBasics/WeatherandDrought/MeasuringDrought.aspx



(Source: U.S. Drought Monitor) [66]

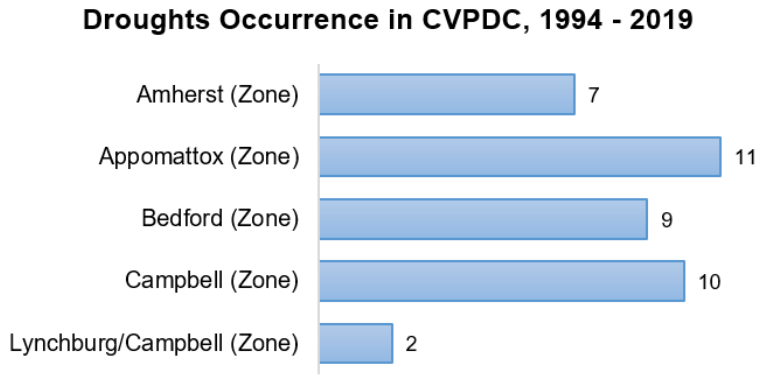
Figure 4-139 Virginia Drought Severity and Coverage Index, 2000 - 2019

Table 4-138 Drought Hazard History

Date	Damages
1976-1977	Ten months of below average precipitation. The drought began in November of 1976 when rainfall totaled to only 50% to 75% of normal.
1985-1986	Very little rainfall began in December and the trend continued throughout the summer. Total precipitation January and February was 2 inches.
2001-2002	Stream levels were below normal with record lows observed at gages for the York, James, and Roanoke River Basins. By November of 2002, the US Secretary of Agriculture had approved 45 counties for primary disaster designation, while 36 requests remained pending.
2007-2008	Drought conditions were observed by the NOAA drought monitor throughout the commonwealth and remained stable in 2007. Drought conditions showed minor improvement in March of 2008, but statewide precipitation was below normal for the 2 year span (81% of normal).

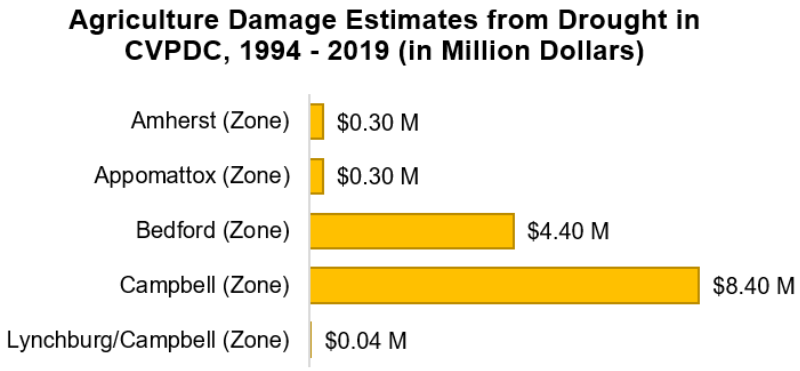
(Source: FEMA)

[66] https://droughtmonitor.unl.edu/Data/Timeseries.aspx



(Source: NCEI storm events database) [67]

Figure 4-140 Droughts Occurrence in CVPDC, 1994 – 2019



(Source: NCEI storm events database)

Figure 4-141 Agriculture damage estimates from drought period in CVPDC, 1994-2019

The worst drought of the 20th century in Virginia occurred in 1930. Other less severe droughts occurred in 1954, 1963, 1966, and 1977. In 2002, Virginia experienced another record-setting drought. During this drought of record, Amherst County's reservoir went nearly dry; Amherst County Services Authority had to put an emergency water intake on James River to keep its customers in water. According to NCEI, the most recent large single drought event occurred on September 1, 2007, as Bedford and Campbell fell into a one month Severe Drought (D2). In total, this drought event affected 17 counties across southwestern Virginia, and led to $12 million in crop losses across Bedford/Campbell.

[67] https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=51%2CVIRGINIA

The southwest portion of Campbell County had the greatest losses, with hay, grain, soy, and tobacco production falling forty to fifty percent. In Bedford County, the southern tip was most affected, as hay, corn, and soy production were down 30 to 40 percent.

4.12.1.4 Relationship to Other Hazards

Figure 4-142 shows the interrelationship (causation, concurrence, *etc.*) between this hazard and other hazards discussed in this plan update.

4.12.2 Impact and Vulnerability

Droughts can have economic, environmental, and social impacts. Severity of droughts often depends on the community reliance on a specific water source. Many problems can arise at the onset of a drought, some of which include diminished water supplies and quality, livestock and wildlife becoming undernourished, crop damage, and possible wildfires.

In addition to the primary impacts of drought, there are also secondary impacts that can increase the potential for other hazards to occur. Extended periods of drought can increase the risk of wildfire occurrences. Wildfire occurrences can lead to an increase of burned woody debris that could increase the potential for landslides or mudflows.

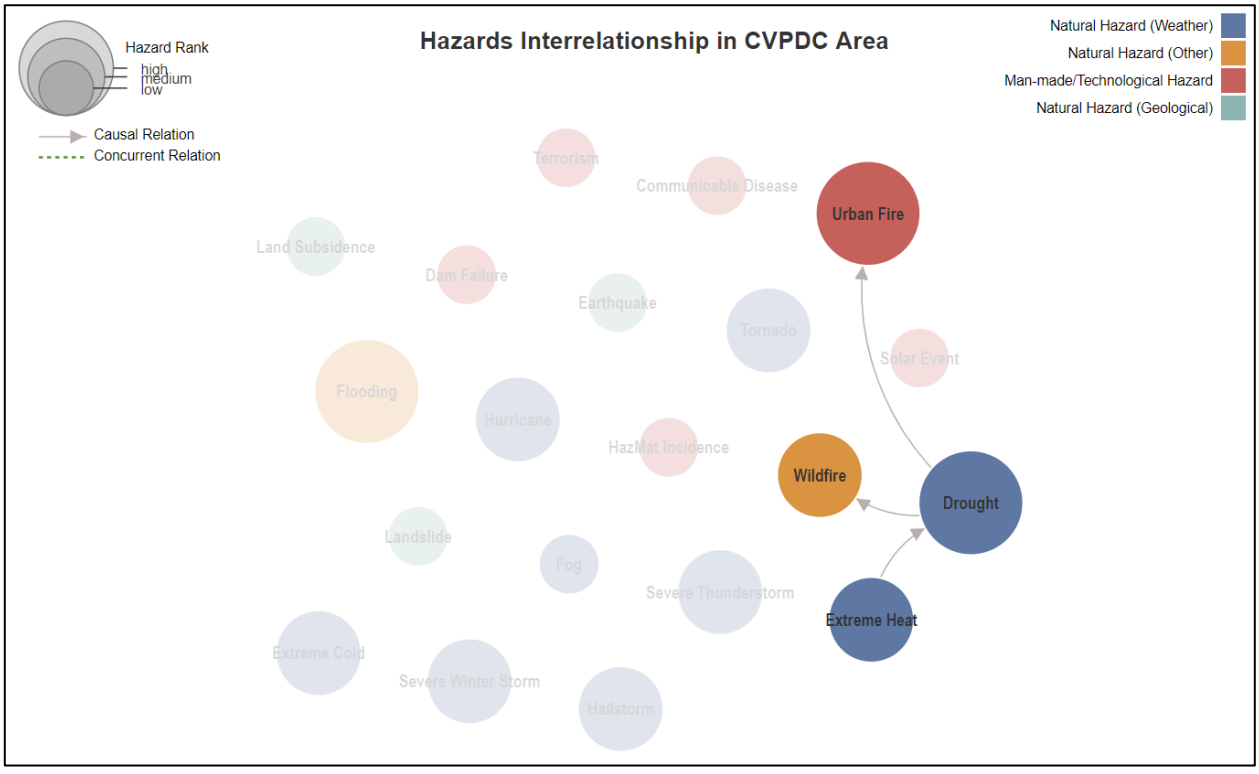


Figure 4-142 Hazards interrelationship

A significant secondary impact of drought due to the reduced availability of surface water is land subsidence caused by groundwater pumping from wells (see *Land subsidence, Sinkhole and Karst* chapter). Although

pumping of groundwater occurs in both drought and non-drought years to support urban, rural, and agricultural water needs, it is greatly increased during dry years. Land subsidence due to groundwater pumping can permanently damage or collapse underground aquifers, increase flood risk in low-lying areas, and pose hazards to buildings, critical infrastructure, and water storage facilities.

Drought also amplifies the risk of loss of biodiversity and affects animal and plant species. Economic impacts include reductions of income to farmers, and higher food and lumber prices. Drought can shrink the food supplies of animals and plants dependent on water and damage their habitats. Sometimes the environmental damage caused by a drought is temporary, and other times it is irreversible. Socioeconomic impacts of the drought may include anxiety and depression about economic impacts of drought, health problems associated with poor water quality, fewer recreational activities, higher incidents of heat stroke, and even loss of human life.[68]

Table 4-137 provides a summary of USDM's drought categories and impacts. Notice that water restrictions start off as voluntary and then become required. For excessive heat, the National Weather Service utilizes heat index thresholds as criteria for the issuance of heat advisories and excessive heat warnings.

Drought response plans have been prepared for the region which contain pertinent information on how the region responds on the eve and during drought conditions.

Public supply *refers to water withdrawn by public and private water suppliers that provide water to at least 25 people or have a minimum of 15 connections. Public-supply water is delivered to users for domestic, commercial, and industrial purposes. Community water system is a public water system that supplies water to the same population year-round.*

Domestic water *use includes indoor and outdoor uses at residences, and includes uses such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, watering lawns and gardens, and maintaining pools. Domestic water use includes potable and non-potable water provided to households by a public water supplier (domestic deliveries) and self-supplied water use. Self-supplied domestic water use is typically withdrawn from a private source, such as a well, or captured as rainwater in a cistern.*

During long periods of drought, each locality can impose restrictions on water use. Some mitigation actions detail voluntary restrictions, community education, and developing and maintaining secondary water supplies on a regional basis.

4.12.3 Risk Assessment and Jurisdictional Analysis

The U.S. Geological Survey's National Water Use Science Project produced an estimated use of water at the county level in the United States. The latest dataset contains total population data and water-use estimates for 2015 for the following categories: public supply, domestic, irrigation, thermoelectric power, industrial, mining, livestock, and aquaculture. Table 4-139 is an excerpt of the dataset, showing the population served by the Community Water System for 2015 in the CVPDC area.

U.S. Census data contains detailed information about the source of water per census block group. For purposes of this analysis, it was assumed that areas with populations having less than 25% of public or private water

[68] https://www.ncdc.noaa.gov/news/drought-monitoring-economic-environmental-and-social-impacts

systems had a high vulnerability ranking. When a drought occurs, these areas would likely have a larger impact since most homes receive their water from wells, which may dry up during a drought. Low vulnerability was assigned to regions with more than 50% of their population drawing from public or private water systems. As a result of using the U.S. Census data, at the tract level, there are some discrepancies with the town boundaries. Boundary adjustments into "high vulnerability" areas are a result of the older census data, which is a data limitation issue and remains an issue in both the previous plan and this update. Future updates of this plan will use, if available, the most current census data for water systems.

Figure 4-143 shows each of the designated categories for each of the localities. Most towns and Lynchburg City are supplied by a public or private water system. Mitigation actions for the region reflect the regions concern for drought and water supply. Although there are areas in the CVPDC area that have a "low" drought vulnerability distinction, the entire planning region is susceptible to future drought conditions.

Table 4-139 Population served by public supply and self-supplied water for 2015 in the CVPDC area

Jurisdiction	Total population (in 2015)	Public Supply, total population served	Domestic, self-supplied population
Amherst County	31,914	18,785	13,129
Appomattox County	15,414	1,997	13,417
Bedford County	77,724	31,766	45,958
Campbell County	55,086	29,168	25,918
Lynchburg City	79,812	79,812	0

(Towns included in the county numbers. Source: USGS) [69]

[69] https://water.usgs.gov/watuse/data/

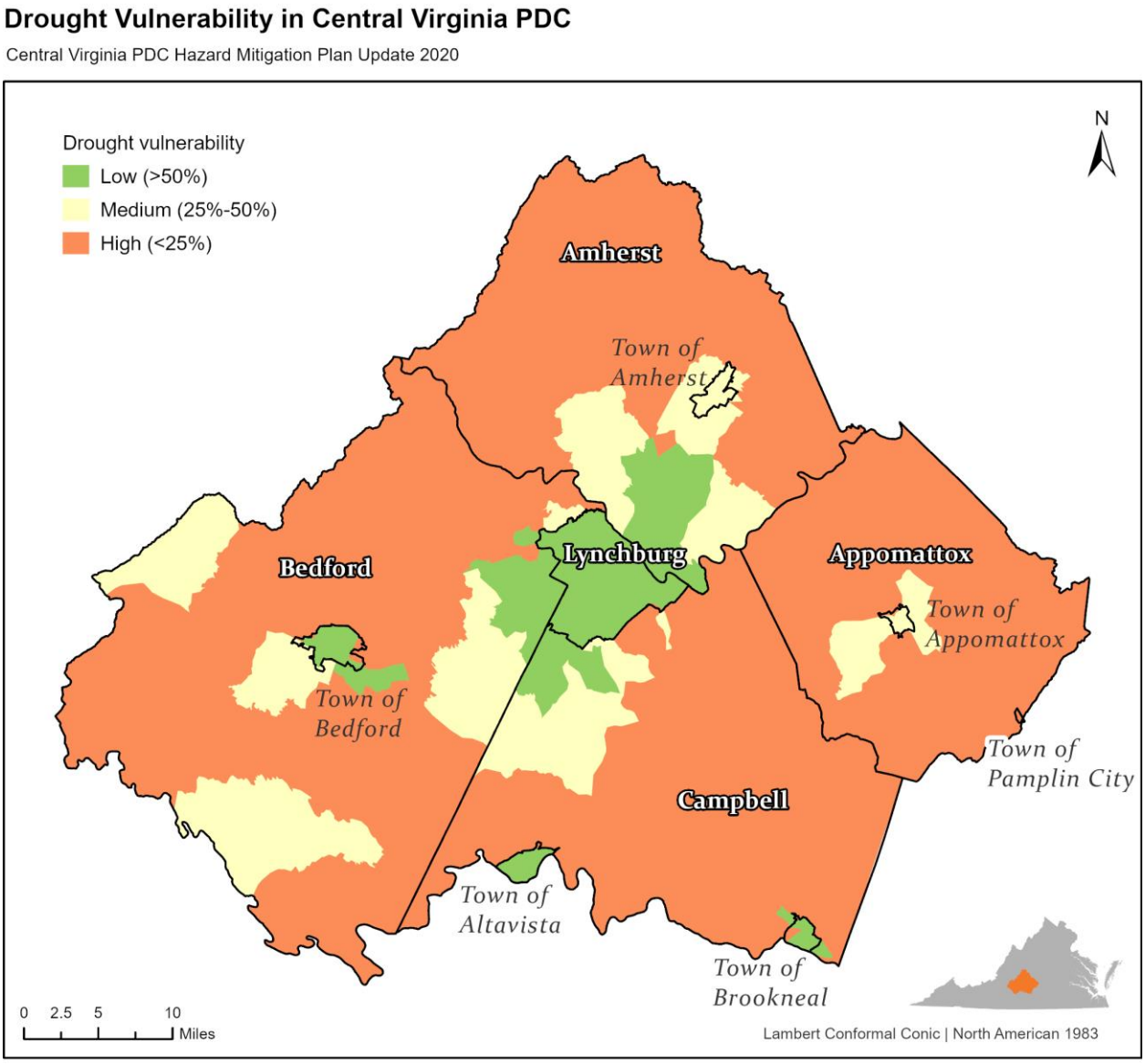


Figure 4-143 Drought Vulnerability in CVPDC Area

4.12.4 Probability of Future Occurrences

Drought was of high concern in the previous plan. The data in this section also suggests a high degree of probability for future drought events in CVPDC localities.

4.12.5 References

- Bradley, M,W., comp., 2017, *Guidelines for preparation of State water-use estimates for 2015*: U.S. Geological Survey Open-File Report 2017–1029, 54 p., https://doi.org/10.3133/ofr20171029.
- Dieter, C.A., Linsey, K.S., Caldwell, R.R., Harris, M.A., Ivahnenko, T.I., Lovelace, J.K., Maupin, M.A., and Barber, N.L., 2018, *Estimated use of water in the United States county-level data for 2015* (ver. 2.0, June 2018): U.S. Geological Survey data release, https://doi.org/10.5066/F7TB15V5.
- NOAA National Centers for Environmental Information. *Storm Events Database - Search Results*. https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=%28Z%29+Drought&beginDate_mm=01&beginDate_dd=01&beginDate_yyyy=1950&endDate_mm=12&endDate_dd=31&endDate_yyyy=2019&county=AMHERST%3A9&county=APPOMATTOX%3A11&county=BEDFORD%3A19&county=BEDFORD%2B%2528C%2529%3A515&county=CAMPBELL%3A31&county=LYNCHBURG%2B%2528C%2529%3A680&hailfilter=0.00&tornfilter=0&windfilter=000&sort=DT&submitbutton=Search&statefips=51%2CVIRGINIA
- NOAA National Centers for Environmental Information. *Drought: Monitoring Economic, Environmental, and Social Impacts*. https://www.ncdc.noaa.gov/news/drought-monitoring-economic-environmental-and-social-impacts
- U.S. Geological Survey. *Estimated Use of Water in the United States County-Level Data for 2015*. June 2018. https://water.usgs.gov/watuse/data/data2015.html
- Virginia DEQ. *Virginia Drought Assessment and Response Plan*. 2003. https://www.deq.virginia.gov/Portals/0/DEQ/Water/WaterResources/VirginiaDroughtStatus/DroughtAssessment_ResponsePlan_2003.pdf