4.3.2 Drought and Water Supply Deficiencies

This section provides a profile and vulnerability assessment of the drought and water supply deficiencies hazard in Chester County. Drought is a period characterized by long durations of below-normal precipitation. Drought conditions occur in virtually all climatic zones, yet characteristics of drought vary significantly from one region to another, relative to normal precipitation within respective regions. Drought and water supply deficiencies can affect agriculture, water reserve, aquatic ecology, wildlife, and plant life. Drought is a temporary irregularity in typical weather patterns and differs from aridity, which reflects low rainfall within a specific region and is a permanent feature of the climate of that area.

Drought can be defined or grouped into four categories:

- Meteorological drought is a measure of departure of precipitation from normal, defined solely by reference to relative degree of dryness. Because of climatic differences, dryness considered a drought at one location of the country may not be considered drought at another location.
- Agricultural drought links various characteristics of meteorological (or hydrological) drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, reduced groundwater or reservoir levels, and other parameters. Agricultural drought occurs when not enough water is available for a crop to grow at a particular time. Agricultural drought is defined in terms of soil moisture deficiencies relative to water demands of plant life, primarily crops.
- Hydrological drought is associated with below-normal surface or subsurface water supply resulting from periods of precipitation shortfalls (including snowfall). Hydrological drought is related to effects of precipitation shortfalls on stream flows and water levels in reservoirs, lakes, and groundwater.
- Socioeconomic drought is associated with supply and demand of an economic good, with elements of meteorological, hydrological, and agricultural drought categories. This differs from the aforementioned types of drought because its occurrence depends on supply and demand to identify or classify droughts. Supplies of many economic goods, such as water, silage, food grains, fish, and hydroelectric power, depend on weather. Socioeconomic drought occurs when demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply (National Drought Mitigation Center ([NDMC] 2017).

Drought and water supply deficiencies can affect many sectors of an economy and can reach beyond an area undergoing physical drought. Because water is essential for producing goods and providing services, drought can reduce crop yield, increase fire hazard, lower water levels, and damage wildlife and fish habitats. Further consequences include: reductions in crop yields, rangeland, and forest productivity that may lower incomes of farmers and agribusinesses; increase in prices of food and timber; increase in unemployment; reduction of tax revenues as expenditures decline; increase in crime, foreclosures, and migration; and depletion of disaster relief funds. The many impacts of drought can be categorized as economic, environmental, or social.

4.3.2.1 Location and Extent

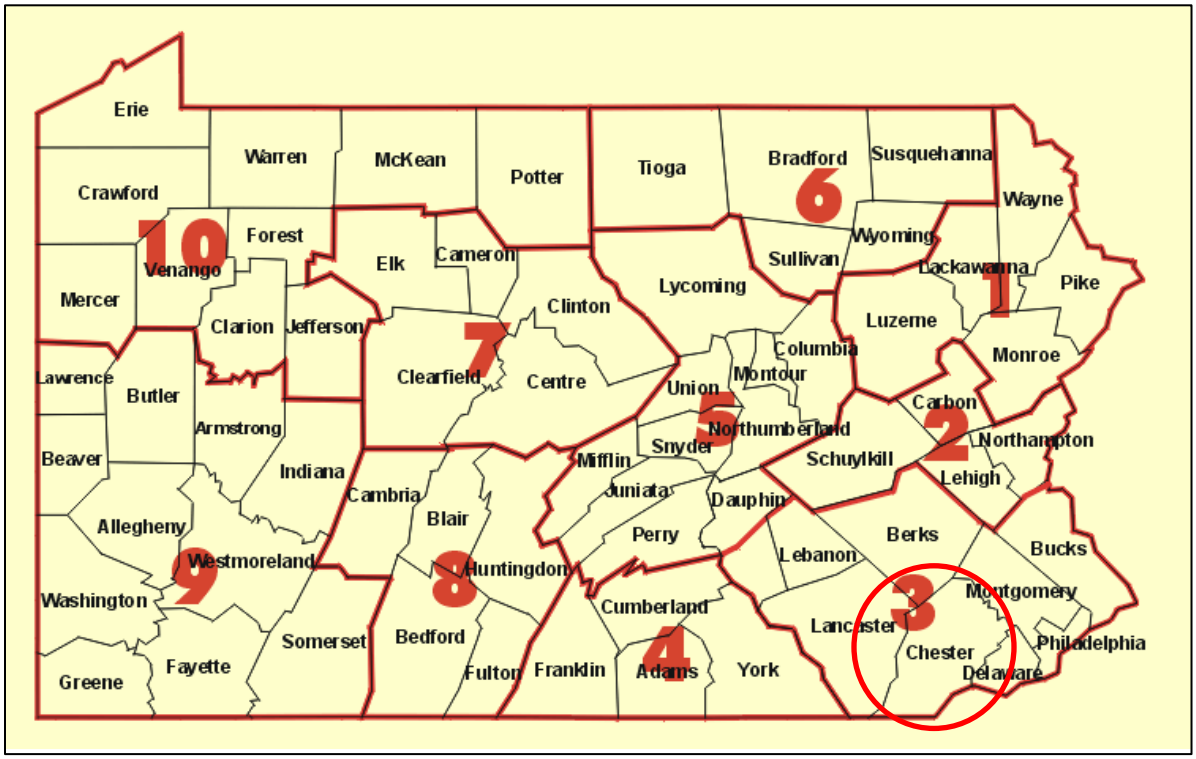
Droughts and water supply deficiencies are regional in scope and may affect the entirety of Chester County rather than only individual municipalities within the county. Droughts and water supply deficiencies may also concurrently affect other counties near Chester County, or even the entire Commonwealth. Generally, areas along waterways will reveal drought conditions later than areas away from waterways.

Climate divisions are regions within a state that are climatically homogenous. The National Oceanic and Atmospheric Administration (NOAA) has divided the United States into 359 climate divisions. The boundaries

of these divisions typically coincide with county boundaries, except in the western United States where they are based largely on drainage basins (National Weather Service [NWS] 2005).

According to NOAA, Pennsylvania includes 10 climate divisions: Pocono Mountains, East Central Mountains, Southeastern Piedmont, Lower Susquehanna, Middle Susquehanna, Upper Susquehanna, Central Mountains, South Central Mountains, Southwest Plateau, and Northwest Plateau Climate Division (National Centers for Environmental Information [NCEI] 2012). Figure 4.3.2-1 shows the climate divisions of Pennsylvania. Chester County is within the Southeastern Piedmont climate division.

Figure 4.3.2-1. Climate Divisions of Pennsylvania



Source: NWS 2005
Note: Highlight added.
The climate divisions for Pennsylvania are:
1 = Pocono Mountains; 2 = East Central Mountains; 3 = Southeastern Piedmont; 4 = Lower Susquehanna; 5 = Middle Susquehanna; 6 = Upper Susquehanna; 7 = Central Mountains; 8 = South Central Mountains; 9 = Southwest Plateau; 10 = Northwest Plateau

Water supplies are vulnerable to effects of drought and thus can impact the severity of a drought, particularly at locations where citizens rely on wells for drinking water. Residents depending on well water can more easily handle short-term droughts without major inconveniences than can populations that rely on surface water. However, longer-term droughts inhibit groundwater aquifers from recharging and can thus extend the problems of well owners for an indeterminate amount of time. Chester County residents who depend on private domestic wells have this greater "hidden vulnerability" to droughts. According to the United States Geological Survey (USGS) National Water Information System, the 2015 average daily domestic self-supplied groundwater withdrawals of fresh water in Chester County was 12.68 million gallons (Mgal) per day.

Table 4.3.2-1 lists the number of reported domestic wells within each municipality of Chester County. The well data were obtained from the Pennsylvania Groundwater Information System (PaGWIS). PaGWIS is maintained by PA DCNR and relies on voluntary submissions of well record data by well drillers; as a result, it is not a complete database of all domestic wells in the county. It is, however, the most complete dataset of domestic wells available.

Table 4.3.2-1. Domestic Wells in Chester County

Municipality	Number of Reported Domestic Wells	Municipality	Number of Reported Domestic Wells
Atglen Borough	0	North Coventry Township	1014
Avondale Borough	99	Oxford Borough	743
Birmingham Township	373	Parkesburg Borough	60
Caln Township	569	Penn Township	626
Charlestown Township	996	Pennsbury Township	717
Coatesville City	1910	Phoenixville Borough	166
Downingtown Borough	122	Pocopson Township	665
East Bradford Township	891	Sadsbury Township	487
East Brandywine Township	1138	Schuylkill Township	318
East Caln Township	124	South Coatesville Borough	38
East Coventry Township	879	South Coventry Township	572
East Fallowfield Township	1034	Spring City Borough	35
East Goshen Township	589	Thornbury Township	332
East Marlborough Township	1350	Tredyffrin Township	578
East Nantmeal Township	515	Upper Oxford Township	614
East Nottingham Township	1592	Upper Uwchlan Township	1035
East Pikeland Township	752	Uwchlan Township	473
East Vincent Township	1047	Valley Township	505
East Whiteland Township	668	Wallace Township	1047
Easttown Township	359	Warwick Township	620
Elk Township	475	West Bradford Township	1286
Elverson Borough	349	West Brandywine Township	1347
Franklin Township	1126	West Caln Township	2133
Highland Township	309	West Chester Borough	380
Honey Brook Borough	531	West Fallowfield Township	558
Honey Brook Township	523	West Goshen Township	825
Kennett Square Borough	110	West Grove Borough	25
Kennett Township	1285	West Marlborough Township	250
London Britain Township	940	West Nantmeal Township	616
London Grove Township	966	West Nottingham Township	525
Londonderry Township	458	West Pikeland Township	869
Lower Oxford Township	608	West Sadsbury Township	596
Malvern Borough	31	West Vincent Township	1103
Modena Borough	72	West Whiteland Township	785
New Garden Township	1339	Westtown Township	461
New London Township	1090	Willistown Township	884
Newlin Township	500	-	-

Source: PA DCNR 2017a

In addition to domestic wells in the county, some residents also receive their water from municipal water providers. There are 16 water purveyors providing water to residents. Primary water sources include Octorara and Schuylkill Rivers, the east and west branches of the Brandywine Creek, and Pickering Creek. AQUA Pennsylvania Inc. is the largest public water provider followed by private wells. Additional municipal water

providers include Pennsylvania-American Water Company and Chester Water Authority (Chester County 2015 HMP).

Jurisdictions designated for agricultural use are particularly vulnerable to drought. Agriculture is the predominant land use in the county, representing 24 percent of land (Chester County 2020). A total of 1,191 acres of land in the county needs to be irrigated (Agricultural Census 2017). In Chester County, the following municipalities have large portions zoned for agricultural use: Elk Township, Highland Township, Honey Brook Township, Londonderry Township, Upper Oxford Township, West Caln Township, and West Fallowfield Township. Areas designated for agricultural use are illustrated in Figure 2-5 in Section 2.

4.3.2.2 Range of Magnitude

Effects of droughts vary depending on their severity, timing, duration, and location. Some droughts may exert their greatest impact on agriculture, while others may have stronger effects on water supply or recreational activities. Droughts can adversely affect the following significantly:

- Public water supplies for human consumption
- Rural water supplies for livestock consumption and agricultural operations
- Water quality
- Natural soil water or irrigation water for agriculture
- Water for forests and for fighting forest fires
- Water for navigation and recreation

PADEP and Pennsylvania Emergency Management Agency (PEMA) manage water supply droughts according to the following four conditions of drought, as defined in the Commonwealth of Pennsylvania 2019 Standard Hazard Mitigation Plan (PA HMP):

- Drought Watch: This is a period to alert government agencies, public water suppliers, water users, and the public regarding potential for future drought-related problems. The focus is on increased monitoring, awareness, and preparation for response in the event that conditions worsen. A request for voluntary water conservation is issued with the objective of reducing water use by 5 percent within the affected areas. Because of varying conditions, individual water suppliers or municipalities may propose more stringent conservation actions.
- Drought Warning: This is a drought stage involving a coordinated response to imminent drought conditions and potential water supply shortages through concerted voluntary conservation measures to avoid or reduce shortages, relieve stressed sources, develop new sources, and, if possible, forestall the need to impose mandatory water use restrictions. The objective of voluntary water conservation measures during a drought warning is to reduce overall water use by 10 to 15 percent within the affected areas. Because of varying conditions, individual water suppliers or municipalities may propose more stringent conservation actions.
- Drought Emergency: During this drought stage, water management entities assemble all available resources to respond to actual emergency conditions, avoid depletion of water sources, ensure at least minimum water supplies are available to protect public health and safety, support essential and high-priority water uses, and avoid unnecessary economic upsets. If deemed necessary and if ordered by the Governor during this stage, imposition of mandatory restrictions on nonessential water usage could occur as provided for in 4 *Pa. Code* Chapter 119. Objectives of water use restrictions (mandatory or voluntary) and other conservation measures during a drought emergency are to reduce consumptive water use within the affected areas by 15 percent, and to reduce total use to the extent necessary to preserve public water system supplies, avoid or mitigate local or area shortages, and ensure equitable sharing of limited supplies.

- Local Water Rationing: This fourth condition of drought is not defined as a drought stage. Local municipalities may, with the approval of the PEMA Council, implement local water rationing to share a rapidly dwindling or severely depleted water supply within designated service areas. These individual water rationing plans, authorized through provisions of 4 *Pa. Code* Chapter 120, require specific limits on individual water consumption to achieve significant reductions in use. Under both mandatory restrictions imposed by the Commonwealth and local water rationing practices, procedures are specified for granting variances in consideration of individual hardships and economic dislocations (PEMA 2019).

Pennsylvania uses five parameters to assess drought conditions: precipitation deficits, stream flows, reservoir storage levels, groundwater levels, and a measure of soil moisture. These are described in detail below.

- Precipitation Deficits: As rainfall provides the basis for both groundwater and surface water resources, precipitation deficits are the earliest indicators of a potential drought. The NWS records "normal" monthly precipitation data for each county in Pennsylvania. These figures are generated from long-term monthly and decennial averages of precipitation and are updated at the end of each decade based on the most recent 30 years. Monthly totals with less than normal values represent precipitation deficits, which are then converted to percentages of the normal values. Table 4.3.2-2 lists the drought conditions (defined in the PA HMP and noted above) indicated by various precipitation deficit percentages (PEMA 2019).

Table 4.3.2-2. Precipitation Deficit Drought Indicators for Pennsylvania

Duration of Deficit Accumulation (Months)	Drought Watch (deficit as percent of normal precipitation)	Drought Warning (deficit as percent of normal precipitation)	Drought Emergency (deficit as percent of normal precipitation)
3	25%	35%	45%
4	20%	30%	40%
5	20%	30%	40%
6	20%	30%	40%
7	18.5%	28.5%	38.5%
8	17.5%	27.5%	37.5%
9	16.5%	26.5%	36.5%
10	15%	25%	35%
11	15%	25%	35%
12	15%	25%	35%

Source: PEMA 2019

Table 4.3.2-3 lists normal monthly and annual precipitation from 1981 to 2010 (the most current three-decade data available) at the four NOAA weather stations in Chester County. Data from the NOAA weather stations are available through the NCEI, which compiles monthly and annual normal total precipitation (inches) data retrieved from both NWS Cooperative Network (COOP) and Principal Observation (First-Order) locations throughout the United States.

Table 4.3.2-3. Normal Monthly and Annual Precipitation (total in inches) from 1981 to 2010 at NOAA Weather Stations in Chester County

Station Name	January	February	March	April	May	June	July	August	September	October	November	December	ANNUAL
Glenmoore	3.63	3.22	4.13	4.11	4.24	4.06	5.03	4.05	4.56	4.18	3.81	4.01	49.03
Honey Brook 2 SSE	3.02	2.49	3.70	3.63	4.03	3.88	4.96	3.80	4.19	4.16	3.65	3.71	45.22
Phoenixville 1 E	3.17	2.74	3.59	3.76	3.67	3.49	4.18	3.55	4.30	3.66	3.54	3.71	43.36
West Chester 2 NW	3.45	3.22	4.30	3.79	4.21	3.79	4.09	3.79	5.14	4.15	3.78	4.13	47.84

Source: Arguez et al 2010

- Stream Flows: Stream flows, which typically lag up to 2 months behind normal precipitation amounts in signaling a drought, offer the second earliest indication of drought conditions. PA DEP uses 61 USGS-maintained stream gauges throughout the Commonwealth as its drought monitoring network, computing 30-day average stream flow values for each stream gauge based on the entire period of record for each gauge. The USGS Drought status is determined from stream flows based on exceedances rather than percentages. The various stages of drought watch, warning, and emergency conditions are indicated, respectively, by 75, 90, and 95 percent exceedances of 30-day average flows (PEMA 2018). NWS tracks stream gages throughout the Commonwealth and provides real-time information (https://water.weather.gov/ahps/region.php?state=pa).
- Groundwater Levels: Groundwater levels for each day are used to calculate the average level of the preceding 30 days. This 30-day value is compared to the values derived from historical records yielding a percentile indicating how much time the groundwater levels have been below the historical average levels. USGS also maintains a network of groundwater monitoring wells, recently upgraded to include at least one well in each county. Groundwater measurements are used to indicate drought status in a manner similar to stream flows. Groundwater level exceedances of 75, 90, and 95 percent are used to indicate watch, warning, and emergency status. In this case, the 30-day average depth to groundwater is measured and monitored, again in relation to long-term 30-day averages based on the period of record for each county well (PEMA 2018).
- Soil Moisture: Soil moisture is measured using an algorithm calibrated for relatively homogeneous regions that measures dryness based on temperature and precipitation in the area using information provided by NOAA. This generates a value called the Palmer Drought Severity Index (PDSI), which is compiled by the Climate Prediction Center of the National Weather Service on a weekly basis. A PDSI of -4.00 or less indicates a drought emergency; a value between -3.00 and -3.99 indicates a drought warning, and a value between -2.00 and -2.99 indicates a drought watch (PEMA 2018).
- Reservoir Storage Levels: Water level storage in several large public water supply reservoirs (especially three New York City reservoirs in the Upper Delaware River Basin) is the fifth indicator that PA DEP uses for drought monitoring. Depending on the total quantity of storage and the length of the refill period for the various reservoirs, PA DEP uses varying percentages of storage draw down to indicate the three drought stages for each of the reservoirs (PEMA 2018).

Table 4.3.2-4 lists PDSI classifications. The PDSI uses 0 to reflect normal status, and negative numbers indicate droughts. For example, 0 is no drought, -2 is moderate drought, and -4 is extreme drought. Positive numbers signify excess precipitation (NDMC 2013).

Table 4.3.2-4. Palmer Drought Severity Index (PDSI) Classifications

Severity Category	PDSI Value	Drought Status
Extremely wet	4.0 or more	None
Very wet	3.0 to 3.99	None
Moderately wet	2.0 to 2.99	None
Slightly wet	1.0 to 1.99	None
Incipient wet spell	0.5 to 0.99	None
Near normal	0.49 to -0.49	None
Incipient dry spell	-0.5 to -0.99	None
Mild drought	-1.0 to -1.99	None
Moderate drought	-2.0 to -2.99	Watch
Severe drought	-3.0 to -3.99	Warning
Extreme drought	-4.0 or less	Emergency

Source: NDMC 2013; PEMA 2019

Availability and management of water supply are discussed in the 2009 Pennsylvania State Water Plan PADEP 2009, a joint effort by the Statewide Water Resources Committee and PADEP. In 2009, the PADEP Secretary approved an updated State Water Plan to guide management of Pennsylvania's water resources over a 15-year planning horizon. As a functional planning tool for all Pennsylvania municipalities, counties, and regional planning partnerships, the State Water Plan profiles drought and resource constraints and encourages implementation of new technology and use policies to facilitate reduced water uses and resource demands at critical peak times. The State Water Plan provides inventories of water availability and an assessment of current and future water use demands and trends. It also offers strategies for improving management of water resources and waterway corridors that aim to reduce damage from extreme drought and flooding conditions (PADEP 2009b).

4.3.2.3 Past Occurrence

Historical information has been drawn from many sources regarding previous occurrences and losses associated with drought events throughout Pennsylvania and Chester County. Because so many sources were reviewed for the purpose of developing this plan, loss and impact information pertaining to many events could vary depending on the source. Therefore, accuracy of cited monetary values is based only on the available information identified during research for this plan.

According to NOAA's NCEI storm events database, Chester County did not undergo any drought events between January 1, 1950, and May 19, 2020. No Commonwealth-wide crop or property losses were reported because of the droughts, which would have also included damage in other counties.

Since 1930, the Commonwealth of Pennsylvania has undergone 12 significant droughts. Since 1955, the Commonwealth has undergone 12 drought events that resulted in a Governor's proclamation or a Federal Emergency Management Agency (FEMA)-declared disaster or emergency. Chester County was not included in any of the events. In addition to these events, between 1980 and 2017, PADEP indicated that Chester County has undergone 24 drought watch declarations, 17 drought warning declarations, and 15 drought emergency declarations (PADEP 2020).

According to FEMA, between 1954 and 2017, Pennsylvania underwent one drought-related disaster (DR) or emergency (EM) classified as one or a combination of the following disaster types: drought or water shortage. Because these disaster types generally cover a wide region of the Commonwealth, this single disaster may have impacted many counties. However, not all counties were included in the disaster declaration. FEMA, PEMA, and other sources indicate that Chester County has not been declared a disaster area as a result of a drought-related event (FEMA 2017). In 2019, it was reported that over 11.6 billion gallons of water were withdrawn

from seven surface water sources to provide public water supply to Chester County residents and businesses (Chester County Water Resources Authority 2019).

Based on all sources researched, drought events between 1980 and 2020 that have affected Chester County are identified in Table 4.3.2-5. However, not all sources have been identified or researched, and therefore Table 4.3.2-5 may not include all events that have occurred throughout the county.

Table 4.3.2-5. Past Occurrences of Drought Events from 1980 to 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts / PDSI Value
November 1980 – April 1982	Emergency	N/A	N/A	Not listed
November 1982- February 1983	Warning	N/A	N/A	Not listed
February - March 1983	Warning	N/A	N/A	Not listed
January - April 1985	Warning	N/A	N/A	Not listed
April - July 1985	Emergency	N/A	N/A	Not listed
July - October 1985	Emergency	DR-206	N/A	Not listed
October 22-29, 1985	Emergency	N/A	N/A	Not listed
October – December 1985	Emergency	N/A	N/A	Not listed
July- August 1998	Watch	N/A	N/A	Not listed
August- December 1988	Watch	N/A	N/A	Not listed
March- May 1989	Watch	N/A	N/A	Not listed
September- October 1991	Warning	N/A	N/A	Not listed
October 1991- January 1992	Warning	N/A	N/A	Not listed
January- April 1992	Warning	N/A	N/A	Not listed
April – June 1992	Warning	N/A	N/A	Not listed
July – September 1999	Emergency	N/A	N/A	Not listed
June- September, 1992	Watch	N/A	N/A	Not listed
September 1992- January 1993	Watch	N/A	N/A	Not listed
September 1-20, 1995	Warning	N/A	N/A	Not listed
September- November 1995	Emergency	N/A	N/A	Not listed
November – December 1995	Emergency	N/A	N/A	Not listed
October- November 1997	Warning	N/A	N/A	Not listed
November 1997- January 1998	Warning	N/A	N/A	Not listed
January- February 1998	Watch	N/A	N/A	Not listed
February- Spring 1998	Watch	N/A	N/A	Not listed
December 3-8, 1998	Watch	N/A	N/A	Not listed
December 8-14, 1998	Watch	N/A	N/A	Not listed
December 14-16, 1998	Warning	N/A	N/A	Not listed
December 1998- January 1999	Warning	N/A	N/A	Not listed
January- March 1999	Warning	N/A	N/A	Not listed
March-June 1999	Watch	N/A	N/A	Not listed
June 10-18, 1999	Warning	N/A	N/A	Not listed
June- July 1999	Warning	N/A	N/A	Not listed
July- September 1999	Emergency	N/A	N/A	Not listed
September- December 1999	Watch	N/A	N/A	Not listed
December 1999- February 2000	Watch	N/A	N/A	Not listed
February- May 2000	Watch	N/A	N/A	Not listed
August- November 2001	Watch	N/A	N/A	Not listed
November- December 2001	Warning	N/A	N/A	Not listed
December 2001- February 2002	Warning	N/A	N/A	Not listed
February- May 2002	Emergency	N/A	N/A	Not listed
May- June 2002	Emergency	N/A	N/A	Not listed
June- August 2002	Emergency	N/A	N/A	Not listed
August- September 2002	Emergency	N/A	N/A	Not listed
September- November 2002	Emergency	N/A	N/A	Not listed
November- December 2002	Emergency	N/A	N/A	Not listed
December 2002- January 2003	Watch	N/A	N/A	Not listed

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts / PDSI Value
April-June 2006	Watch	N/A	N/A	Not listed
October 2007- January 2008	Watch	N/A	N/A	Not listed
September- November 2010	Watch	N/A	N/A	Not listed
August- September 2011	Watch	N/A	N/A	Not listed
September- November 2016	Watch	N/A	N/A	Not listed
November- December 2016	Watch	N/A	N/A	Not listed
December 2016- February 2017	Watch	N/A	N/A	Not listed
February- April 2017	Watch	N/A	N/A	Not listed
April- May 2017	Watch	N/A	N/A	Not listed

Sources: PADEP 2020, NOAA NCEI 2020, FEMA 2020, USDA Disaster Declarations 2020

Notes:
FEMA Federal Emergency Management Agency
N/A Not applicable
PADEP Pennsylvania Department of Environmental Protection

Table 4.3.2-6 lists the crop loss insurance payments on claims from Chester County caused by drought events since 2012.

Table 4.3.2-6. Crop Loss Insurance Claims Due to Drought, 2012 to 2019

Crop Year	Total Claims	Crop Year	Total Claims
2012	$97,991	2016	$104,444
2013	$0	2017	$0
2014	$1,956	2018	$51,361
2015	$7,953	2019	$13,831

Source: U.S. Department of Agriculture (USDA) 2020

4.3.2.4 Future Occurrence

The frequency of droughts is difficult to forecast. Based on the drought conditions listed in Table 4.3.2-5, future occurrences of drought events are considered *likely*, as defined by the Risk Factor Methodology probability criteria (described in Section 4.4).

4.3.2.5 Vulnerability Assessment

To understand risk, a community must evaluate assets exposed and vulnerable within the identified hazard area. For the drought hazard, all of Chester County has been identified as the hazard area. Therefore, all assets (population, structures, critical facilities, and lifelines) described in the County Profile (Section 2) are potentially vulnerable to a drought. This section evaluates and estimates potential impacts of the drought hazard on Chester County in the following subsections:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impacts on (1) life, health, and safety; (2) general building stock; (3) critical facilities; (4) economy; and (5) future growth and development
- Effects of climate change on vulnerability
- Further data collections that will assist in understanding this hazard over time.

Overview of Vulnerability

Chester County is vulnerable to drought. Assets at particular risk include any open land or structures along the wildland/urban interface (WUI) that could become vulnerable to the wildfire hazard caused by extended periods of low rain and high heat, usually associated with drought. In addition, water supply resources could be impacted

by extended periods of low rain. Finally, vulnerable populations could be particularly susceptible to the drought hazard with cascading impacts because of age, health conditions, and limited ability to mobilize to shelter, cooling, and medical resources.

Data and Methodology

At the time this plan was updated, insufficient data were available to model long-term potential impacts of a drought on Chester County. Over time, additional data will be collected to allow better analysis of this hazard. Preliminary assessments based on available data are provided below.

Impact on Life, Health, and Safety

Drought conditions can cause a shortage of water available for human consumption and can reduce local firefighting capabilities. Commercial fires would be a great concern in the time of drought if water supplies are being impacted. The rural areas within the county lack fire hydrants and would have to pull water from ponds, creeks, or other water sources to put out fires, which is not feasible during droughts. Social impacts of a drought include mental and physical stress, public safety threats (increased threat from forest/grass fires), health threats, conflicts among water users, reduced quality of life, and inequities in distribution of impacts and disaster relief. The infirm, young, and elderly are particularly susceptible to drought and extreme temperatures (sometimes associated with drought conditions) because of their age, health conditions, and limited ability to mobilize to shelters or cooling centers, and the difficulty in identifying medical resources. Impacts on the economy and environment may have social implications as well (New York State Disaster Preparedness Commission [NYSDPC] 2011). For the purposes of this plan, the entire population of the county is considered vulnerable to drought events.

Impact on General Building Stock and Critical Facilities

A drought is not expected to directly affect any structures, and all are expected to be operational during a drought event. However, droughts contribute to conditions conducive to wildfires. Risk to life and property is greatest in regions where forested areas adjoin urbanized areas (high-density residential, commercial, and industrial), also known as the WUI. Therefore, all assets in and adjacent to the WUI zone, including population, structures, critical facilities, lifelines, and businesses, are considered vulnerable to wildfire.

Impact on the Economy

Drought events impact the economy, including loss of business function and damage and loss of inventory. Industries that rely on water for business may be impacted the hardest by drought (e.g., agriculture). Even though a majority of businesses will still be operational, they may be impacted aesthetically. A prolonged drought can exert serious direct and indirect economic impacts on a community or across the county. Economic impacts may include:

- Losses from crop, livestock, timber, and aquaculture production and associated businesses
- Losses from recreation providers and associated businesses
- Losses related to the increased costs resulting from increased energy demand and from shortages caused by reduced hydroelectric generation capacity
- Revenue losses for federal, state, and local governments from a reduced tax base and for financial institutions from defaults and postponed payments
- Long-term loss of economic growth and development

Loss estimates are based on lost agricultural revenues statewide. Table 4.3.2-7 below lists the county's farmland acreage exposure to the drought hazard as well as the annual market value of all agricultural products sold, as documented in the 2017 USDA Census of Agriculture. If the county would lose its agricultural yield because of a drought, total losses could amount to nearly $570,929,000. Table 4.3.2-8 details the potential losses associated with county livestock by providing livestock totals for the county and their associated market value. Livestock, poultry, and associated products have a potential loss value of more than $141,539,000 (USDA 2017).

Table 4.3.2-7. Estimated County Losses Relating to Agricultural Production

Impacted Farmland Acreage	Market Value of All Agricultural Products
150,514	$712,468,000

Source: USDA 2017

Table 4.3.2-8. Estimated County Losses Relating to Agricultural Production

Livestock and Poultry	Inventory	Market Value of All Livestock, Poultry, and Their Products
Layers	113,599	**$141,539,000**
Cattle and Calves	47,499	
Hogs and Pigs	21,550	
Sheep and Lambs	1,771	
Total	**184,419**	

Source: USDA 2017
Note: Market value of livestock and poultry is only provided by total value and not available by category.

Impact on the Environment

As summarized in the 2018 PA HMP, environmental impacts of drought include:

- Hydrologic effects – lower water levels in reservoirs, lakes, and ponds; reduced streamflow; loss of wetlands; estuarine impacts; groundwater depletion and land subsidence; effects on water quality, such as increases in salt concentration and water temperature
- Damage to animal species – lack of feed and drinking water; disease; loss of biodiversity; migration or concentration; and reduction and degradation of fish and wildlife habitat
- Reduced stream flow
- Loss of wetlands
- Increased groundwater depletion, land subsidence, and reduced groundwater recharge
- Water quality impacts, such as salinity, water temperature increases, pH changes, dissolved oxygen, or turbidity
- Loss of biodiversity

Future Growth and Development

Areas targeted for potential future growth and development within the next 5 to 10 years have been identified across the county (further discussed in Section 2.4 of this HMP). Any new development and all new residents will potentially be exposed to the drought hazard.

Effect of Climate Change on Vulnerability

Climate is defined not simply as average temperature and precipitation but also by type, frequency, and intensity of weather events. Both globally and at the local level, climate change can alter prevalence and severity of weather extremes such as droughts. While predicting changes in drought events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating effects of future climate change on human health, society, and the environment (U.S. Environmental Protection Agency [EPA] 2006).

PADEP was directed by the Climate Change Act (Act 70 of 2008) to initiate a study of potential impacts of global climate change on the Commonwealth. The June 2009 Pennsylvania Climate Impact Assessment's main findings indicated that Pennsylvania is very likely to undergo increased temperatures in the 21st century. Increases in temperature will likely lead to increased evapotranspiration, and thus an increase in soil-moisture-related droughts throughout late spring and early fall. Pennsylvania's precipitation climate is projected to

become more extreme in the future, with longer dry periods and greater intensity of precipitation. Most models project an increase in the maximum number of consecutive dry days in a year (Shortle et al. 2009).

Future improvements in modeling smaller-scale climatic processes can be expected and will lead to improved understanding of how the changing climate will alter temperature, precipitation, storm frequency, and intensity in Pennsylvania. Understanding this information can help provide better indications of future drought events (Shortle et al. 2009).