## 4.3.4 Drought and Water Supply Deficiencies

This section provides a profile and vulnerability assessment of the drought and water supply deficiencies hazard in Dauphin 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 supply, 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 particular 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.

### 4.3.4.1 Location and Extent

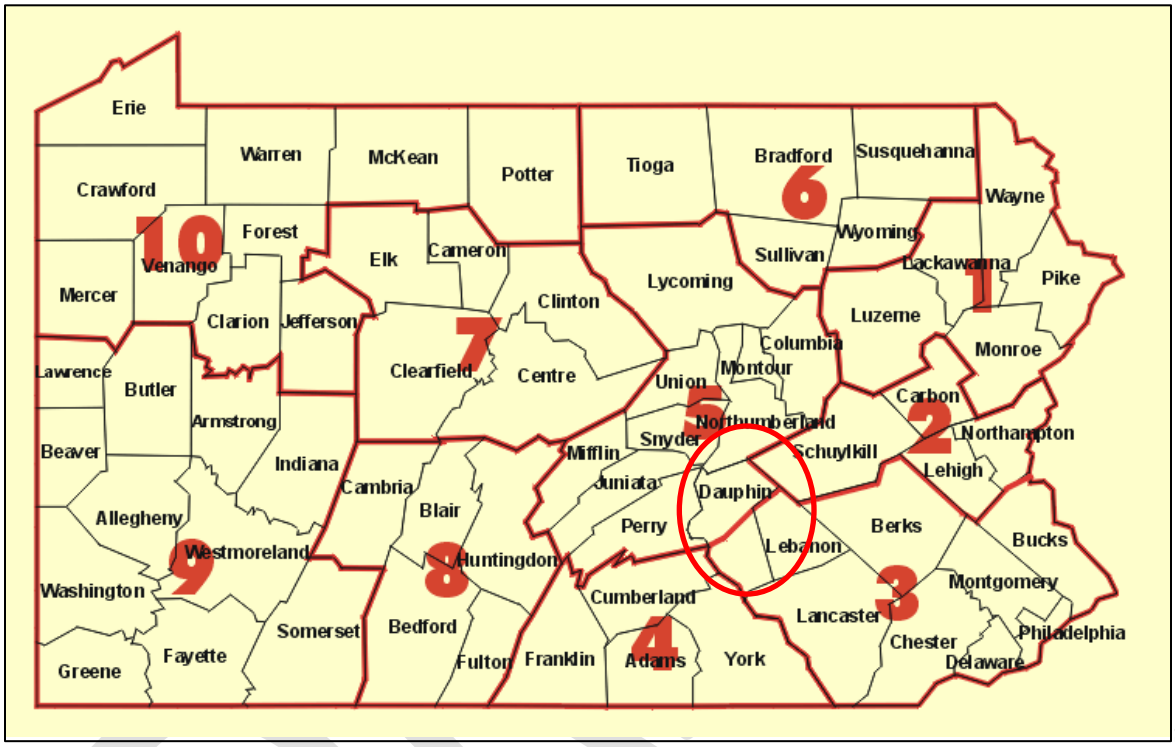
Droughts and water supply deficiencies are regional in scope and may affect the entirety of Dauphin County rather than only individual municipalities within the county. Droughts and water supply deficiencies may also concurrently affect counties near Dauphin County, or even the entire Commonwealth. Generally, 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 (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 Climatic Data Center [NCDC] 2012). Figure 4.3.4-1 shows the climate divisions of Pennsylvania. Dauphin County is within the Southeastern Piedmont and Middle Susquehanna climate divisions.

**Figure 4.3.4-1. 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

Particularly at locations where citizens rely on wells for drinking water, water supplies are vulnerable to effects of drought and thus can impact the severity of a drought. 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. Dauphin 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 average daily domestic self-supplied groundwater withdrawals of fresh water in Pennsylvania was 501 million gallons per day (Mgal) to 1 billion gallons per day in 2015 (USGS n.d.).

Table 4.3.4-1 lists the number of reported domestic wells within each municipality of Dauphin 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 4.3.4-1. Domestic Wells in Dauphin County**

| Municipality | Number of Reported Domestic Wells | Municipality | Number of Reported Domestic Wells |
|---|---|---|---|
| Berrysburg Borough | 13 | Middletown Borough | 6 |
| Conewago Township | 372 | Mifflin Township | 52 |
| Dauphin Borough | 12 | Millersburg Borough | 13 |
| Derry Township | 504 | Paxtang Borough | 0 |
| East Hanover Township | 738 | Penbrook Borough | 4 |
| Elizabethville Borough | 19 | Pillow Borough | 3 |
| Gratz Borough | 16 | Reed Township | 44 |
| Halifax Borough | 18 | Royalton Borough | 0 |
| Halifax Township | 184 | Rush Township | 30 |
| Harrisburg City | 58 | South Hanover Township | 545 |
| Highspire Borough | 15 | Steelton Borough | 20 |
| Hummelstown Borough | 9 | Susquehanna Township | 339 |
| Jackson Township | 146 | Swatara Township | 140 |
| Jefferson Township | 46 | Upper Paxton Township | 129 |
| Londonderry Township | 551 | Washington Township | 123 |
| Lower Paxton Township | 1053 | Wayne Township | 88 |
| Lower Swatara Township | 185 | West Hanover Township | 662 |
| Lykens Borough | 1 | Wiconisco Township | 33 |
| Lykens Township | 45 | Williams Township | 23 |
| Middle Paxton Township | 560 | Williamstown Borough | 1 |

Source: PA DCNR 2017

In addition to domestic wells in the county, residents may also receive their water from municipal water providers. The primary water source is the DeHart Reservoir and the secondary source is the mainstream of the Susquehanna River. The systems serve a population of approximately 67,000 people (Capital Region Water n.d.). The municipal water provider for the City of Harrisburg, Paxtang, Penbrook, and Steelton Boroughs, and Lower Paxton, Susquehanna, and Swatara Townships is Capital Region Water. Pennsylvania American Water serves portions of Derry, Londonderry, South Hanover, and West Hanover Townships. Loyalton Water Association serves Washington Township, Harrisburg International Airport Water Co serves Lower Swatara Township, and Lykens Borough Authority covers Lykens Borough and Wiconisco Township. Middletown Borough Authority serves Middletown Borough, a portion of Lower Swatara Township, and Royalton Borough. Millersburg Borough Authority serves Millersburg Borough and Upper Paxton Township, Pillow Borough Authority serves Pillow Borough, Steelton Borough Authority serves Steelton Borough, and Williamstown Borough Authority serves a portion of Williams Township and Williamstown Borough.

Jurisdictions that are designated for agricultural use are particularly vulnerable to drought. As of 2017, 81,252 acres of farmland were recorded in Dauphin County with 375 total acres of land in the county that need to be irrigated (Agricultural Census 2017). In Dauphin County, agricultural land is particularly prevalent in the northern portion of the county, but also in portions of the more urbanized southern region (Dauphin County

Comprehensive Plan "Growing Together" 2020). Areas designated for agricultural use are illustrated in Figure 2-5 in Section 2.

### 4.3.4.2 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 2018 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. Drought watches are invoked when three or more drought indicators are present for a county or group of counties. 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. The objective of voluntary water conservation measures during a drought watch is to reduce 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 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 water supply 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 2018).

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 National Weather Service (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 4.3.4-2 lists the drought conditions (defined in the PA HMP and noted above) that are indicated by various precipitation deficit percentages (PEMA 2018).

**Table 4.3.4-2. 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 2018

Table 4.3.4-3 lists normal monthly and annual precipitation from 1981 to 2010 (the most current three-decade data available) at the three NOAA weather stations in Dauphin 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 4.3.4-3. Normal Monthly and Annual Precipitation (total in inches) from 1981 to 2010 at NOAA Weather Stations in Dauphin County**

| Station Name | January | February | March | April | May | June | July | August | September | October | November | December | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dehart Dam | 3.50 | 2.65 | 3.88 | 3.99 | 4.39 | 5.04 | 4.75 | 4.20 | 5.19 | 4.09 | 3.60 | 3.86 | 49.14 |
| Harrisburg 1NE | 2.93 | 3.06 | 3.54 | 3.49 | 4.15 | 4.04 | 4.26 | 3.61 | 4.36 | 3.40 | 3.45 | 3.34 | 43.63 |
| Middletown Harrisburg International Airport | 2.93 | 2.73 | 3.30 | 3.41 | 4.05 | 3.67 | 3.63 | 3.69 | 3.64 | 3.33 | 3.37 | 3.17 | 40.92 |

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. PADEP 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 percent, 90 percent, and 95 percent exceedances of 30-day average flows (PEMA 2018). The National Weather Service tracks stream gauges throughout the Commonwealth and provides real-time information. Detailed descriptions of these data collection methods appear in the PA HMP.
- 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 the 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).
- 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. The USGS also maintains a network of groundwater monitoring wells. Groundwater is used to indicated 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. The 30-day average depth to groundwater is measured and monitored 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 homogenous regions) that measures dryness based on temperature and precipitation in the area according to information provided by the National Oceanic and Atmospheric Administration (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).

Table 4.3.4-4 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 4.3.4-4. 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 2018

The availability and management of water supply are discussed in the 2009 Pennsylvania State Water Plan (PADEP 2009b), 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).

### 4.3.4.3 Past Occurrence

Historical information has been drawn from many sources regarding previous occurrences and losses associated with drought events throughout Pennsylvania and Dauphin 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 National Centers for Environmental Information storm events database, Dauphin County underwent four drought events between January 1, 1950, and July 30, 2020. No Commonwealth-wide crop or property losses were reported because of the droughts; statewide losses would have included damages in other counties.

Since 1930, the Commonwealth of Pennsylvania has undergone 10 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. Dauphin County was not included in any of the events. In addition to these events, between 1980 and 2017, PADEP indicated that Dauphin County has undergone 34 drought watch declarations, 12 drought warning declarations, and 9 drought emergency declarations (PADEP 2020).

According to FEMA, between 1954 and 2020, 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 Dauphin County has not been declared a disaster area as a result of a drought-related event (FEMA 2017).

Based on all sources researched, drought events between 1980 and 2020 that have affected Dauphin County are identified in Table 4.3.4-5. However, not all sources have been identified or researched, and therefore Table 4.3.4-5 may not include all events that have occurred throughout the county.

**Table 4.3.4-5. 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 |
| April-July 1985 | Water | N/A | N/A | Not listed |
| July-October 1985 | Watch | N/A | N/A | Not listed |
| October 1985 | Watch | N/A | N/A | Not listed |
| October-December 1985 | Watch | N/A | N/A | Not listed |
| July-August 1988 | Watch | N/A | N/A | Not listed |
| August-December 1988 | Watch | N/A | N/A | Not listed |
| June-July 1991 | Warning | N/A | N/A | Not listed |
| July-August 1991 | Emergency | N/A | N/A | Not listed |
| August-September 1991 | Emergency | N/A | N/A | Not listed |
| September-October 1991 | Emergency | N/A | N/A | Not listed |
| October 1991-Janauray 1992 | Warning | N/A | N/A | Not listed |
| January-April 1992 | Emergency | N/A | N/A | Not listed |
| April-June 1992 | Warning | N/A | N/A | Not listed |
| September 1995 | Warning | N/A | N/A | Not listed |
| September-November 1995 | Warning | N/A | N/A | Not listed |
| November-December 1995 | Watch | N/A | N/A | Not listed |
| July-October 1997 | Watch | N/A | N/A | Not listed |
| October- November 1997 | Watch | N/A | N/A | Not listed |
| November 1997-January 1998 | Watch | N/A | N/A | Not listed |
| December 1998 | Watch | N/A | N/A | Not listed |
| December 1998 | Warning | N/A | N/A | Not listed |
| December 1998-January 1999 | Waring | 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 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 2001 | 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 | Watch | N/A | N/A | Not listed |
| August-September 2002 | Watch | N/A | N/A | Not listed |
| September-November 2002 | Emergency | N/A | N/A | Not listed |
| November-December 2002 | Watch | N/A | N/A | Not listed |
| April-June 2006 | Watch | N/A | N/A | Not listed |
| August-September 2007 | Watch | N/A | N/A | Not listed |
| September-October 2007 | Watch | N/A | N/A | Not listed |
| October 2007-Janaury 2008 | Watch | N/A | N/A | Not listed |
| January-February 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 |
| August - September 2016 | Watch | N/A | N/A | Not listed |
| September-November 2016 | Watch | N/A | N/A | Not listed |

| Dates of Event | Event Type | FEMA Declaration Number | County Designated? | Losses / Impacts / PDSI Value |
|---|---|---|---|---|
| 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, Drought Reporter 2020

Notes:
FEMA Federal Emergency Management Agency
N/A Not applicable
PDSI Palmer Drought Severity Index

Table 4.3.4-6 lists the crop loss insurance payments on claims in Dauphin County caused by drought events since 2012.

**Table 4.3.4-6. Crop Loss Insurance Claims Due to Drought, 2012 to 2020**

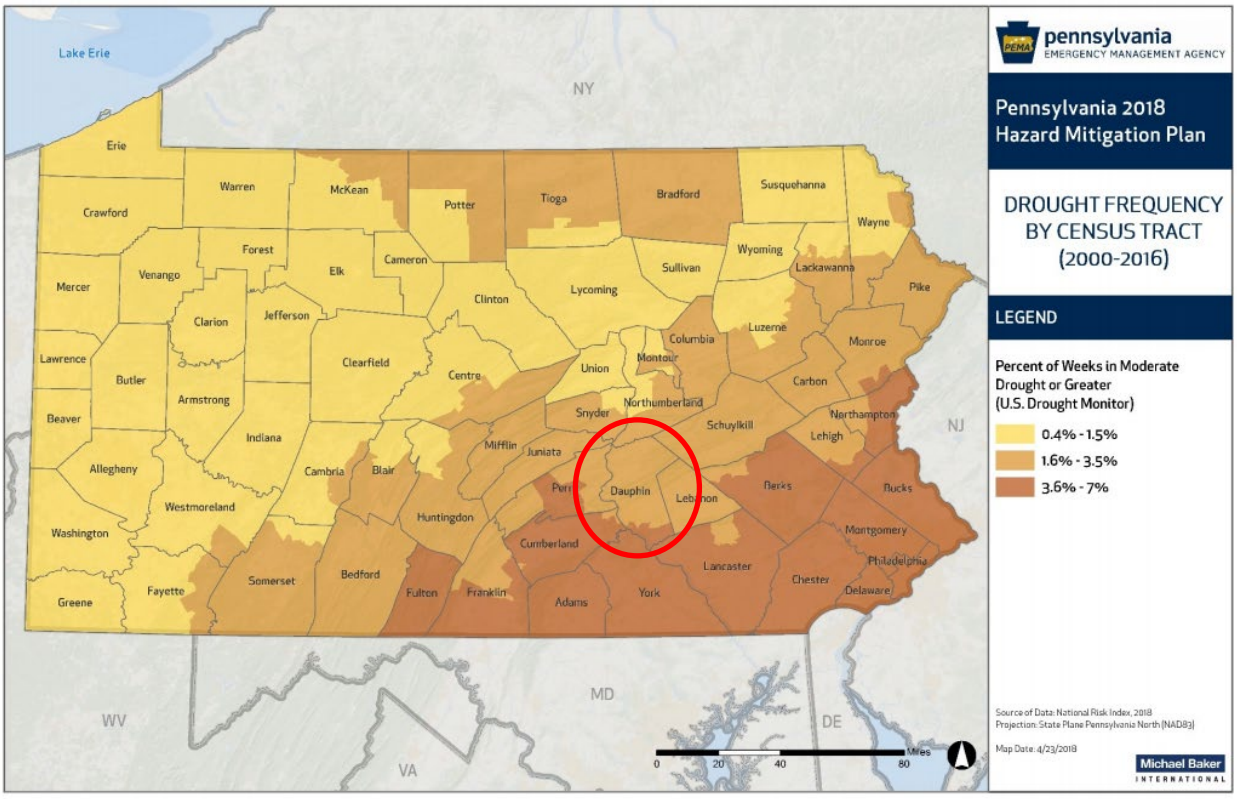
| Crop Year | Total Claims | Crop Year | Total Claims |
|---|---|---|---|
| 2012 | $479,943 | 2017 | $0 |
| 2013 | $32,123 | 2018 | $0 |
| 2014 | $10,950 | 2019 | $29,384 |
| 2015 | $34,903 | 2020 | $501,956 |
| 2016 | $798,780 | | |

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

### 4.3.4.4 Future Occurrence

Frequency of droughts is difficult to forecast. Based on data from a 16-year period, the majority of Dauphin County underwent severe or extreme drought conditions less than 3.5 percent of the time, whereas the southern portion of the county underwent severe or extreme drought conditions less than 7 percent of the time (illustrated on Figure 4.3.4-2). Based on the drought conditions listed in Table 4.3.4-5, future occurrences of drought events are considered *likely*, as defined by the Risk Factor Methodology probability criteria (described in Section 4.4).

**Figure 4.3.4-2. Percentage of Weeks with Moderate Drought or Greater**




Source: PEMA 2018
Note: Dauphin County circled in red

### 4.3.4.5 Vulnerability Assessment

To understand risk, a community must evaluate assets exposed and vulnerable within the identified hazard area. For the drought hazard, all of Dauphin 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 Dauphin 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

Dauphin 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 and cascading impacts because of age, health conditions, and limited ability to mobilize to shelter, cooling, and medical resources.

## Data and Methodology

At the time of this plan update, insufficient data were available to model long-term potential impacts of a drought on Dauphin 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. 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, cooling centers, and medical sources. 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

A prolonged drought can exert serious direct and indirect economic impacts on a community or across the county. A summary of impacts on the economy is presented in Table 4.3.4-7.

**Table 4.3.4-7. Impacts on the Economy**

| Losses to Agricultural Producers | Losses to Livestock Producers | Losses of Timber Production |
|---|---|---|
| Annual and perennial crop losses | Reduced productivity of rangeland | Wildland fires |
| Damage to crop quality | Reduced milk production | Tree disease |
| Income loss for farmers because of reduced crop yields | Forced reduction of foundation stock | Insect infestation |
| Reduced productivity of cropland (wind erosion, long-term loss of organic matter, etc.) | High cost/unavailability of water for livestock | Impaired productivity of forest land |
| Insect infestation | Cost of new or supplemental water resource development (wells, dams, pipelines) | Direct loss of trees, especially young ones |
| Plant disease | High cost/unavailability of feed for livestock | **Losses to Transportation Industry** |
| Wildlife damage to crops | Increased feed transportation costs | Loss from impaired navigability of streams, rivers, and canals |
| Increased irrigation costs | High livestock mortality rates | **Decline in Food Production/Disrupted Food Supply** |
| Cost of new or supplemental water resource development (wells, dams, pipelines) | Disruption of reproduction cycles (delayed breeding, more miscarriages) | Increase in food prices |
| **Losses of Fishery Production** | Decreased stock weights | Increased importation of food (higher costs) |
| Damage to fish habitat | Increased predation | **Losses to Water Suppliers** |

| Losses to Agricultural Producers | Losses to Livestock Producers | Losses of Timber Production |
|---|---|---|
| Loss of fish and other aquatic organisms because of decreased flows | Grass fires | Revenue shortfalls and/or windfall profits |
| **Losses to Recreation and Tourism Industry** | **Energy-Related Effects** | Cost of water transport or transfer |
| Loss to manufacturers and sellers of recreational equipment | Increased energy demand and reduced supply because of drought-related power curtailments | Cost of new or supplemental water resource development |
| Losses related to curtailed activities: hunting and fishing, bird watching, boating, etc. | Costs to energy industry and consumers associated with substituting more expensive fuels (oil) for hydroelectric power | |

Source: NYSDPC 2011

Loss estimates are based on lost agricultural revenues throughout Pennsylvania. Table 4.3.4-8 below enumerates 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 loses its agricultural yield because of drought, total losses could amount to nearly $93 million. Table 4.3.4-9 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 nearly $66 million (USDA 2017).

### Table 4.3.4-8. Estimated County Losses Relating to Agricultural Production

| Impacted Farmland Acreage | Market Value of All Agricultural Products |
|---|---|
| 81,252 | $93,074,000 |

Source: USDA 2017

### Table 4.3.4-9. Estimated County Losses Relating to Agricultural Production

| Livestock and Poultry | Inventory | Market Value of All Livestock, Poultry, and Their Products |
|---|---|---|
| Broilers and other meat-type chickens | 847,299 | **$65,913,000** |
| Cattle and Calves | 15,335 | |
| Hogs and Pigs | 4,744 | |
| Layers | 636,663 | |
| Horses and ponies | 1,821 | |
| Goats | 1,451 | |
| Pullets | 262,567 | |
| Sheep and Lambs | 1,103 | |
| **Total** | **1,770,893** | |

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 PA HMP (2018), 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; and 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 like 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). Exposure of any new development and new residents to the drought hazard is anticipated.

### 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).

According to the Pennsylvania Climate Impacts Assessment 2015 Update, the likelihood for drought will decrease by the middle of the 21st century as months with above-normal precipitation increase; however, drying of surface soil across the coterminous United States in all seasons is still projected because of enhanced evapotranspiration. Soil moisture at root depth of crops is more useful for estimating agricultural drought. Resolution constraints and lack of detailed evapotranspiration process representation will lead to lower confidence in projections with the soil moisture budget being less constrained (Wehner et al. 2017).