Hydrology

Chester County is comprised of over 760 square miles of land area lying within 21 watersheds that include nearly 2,300 miles of streams. These watersheds drain from Chester County downstream to six counties in three states (PA, DE, and MD).

The Schuylkill River forms the northeastern boundary of Chester County and is by far the largest stream affecting the County. The East Branch Octoraro Creek and Octoraro Reservoir form the southwestern boundary of the County. The largest watershed within Chester County is the Brandywine Creek watershed. Because of the size of their drainage areas and volume of flood flows, the Schuylkill River and Brandywine Creek present the most significant flood risks for the County. Smaller watersheds are also prone to localized flooding including French Creek, Red Clay Creek, (East) Valley Creek, Valley Run, and Trout Creek, among others. Across Chester County, over 250 locations of repeat flooding problems have been identified. Five flood control dams were constructed in Brandywine Creek watershed to reduce flood impacts to the Brandywine Creek communities.

The streams of Chester County are fed by groundwater from underlying aquifers and rainfall runoff. All geologic units in Chester County are considered to be aquifers and are recharged by infiltration of precipitation through their overlying soils. The groundwater resources and surface water resources within Chester County provide water supply for the County. Approximately 60% of the County's population relies on public water supplies (from groundwater and/or surface water sources) and 40% relies on individual domestic wells. Thus, protection of natural recharge and infiltration is essential to sustaining the availability of groundwater and stream flows for water supplies for humans and for aquatic and wildlife resources.

Because stream flows vary significantly based on weather conditions, public water suppliers rely on reservoirs to provide additional flows to support surface water withdrawals during periods of low stream flows. There are six water supply reservoirs in Chester County (Chambers Lake Reservoir, Marsh Creek Lake, Rock Run, Octoraro Reservoir, Pickering Creek Reservoir, and West Chester Reservoir).

Approximately 85% of the County is in watersheds that drain to Delaware Bay and the remaining 15% is in watersheds that drain to the Chesapeake Bay. *Figure 10* presents a map of the watersheds of Chester County.

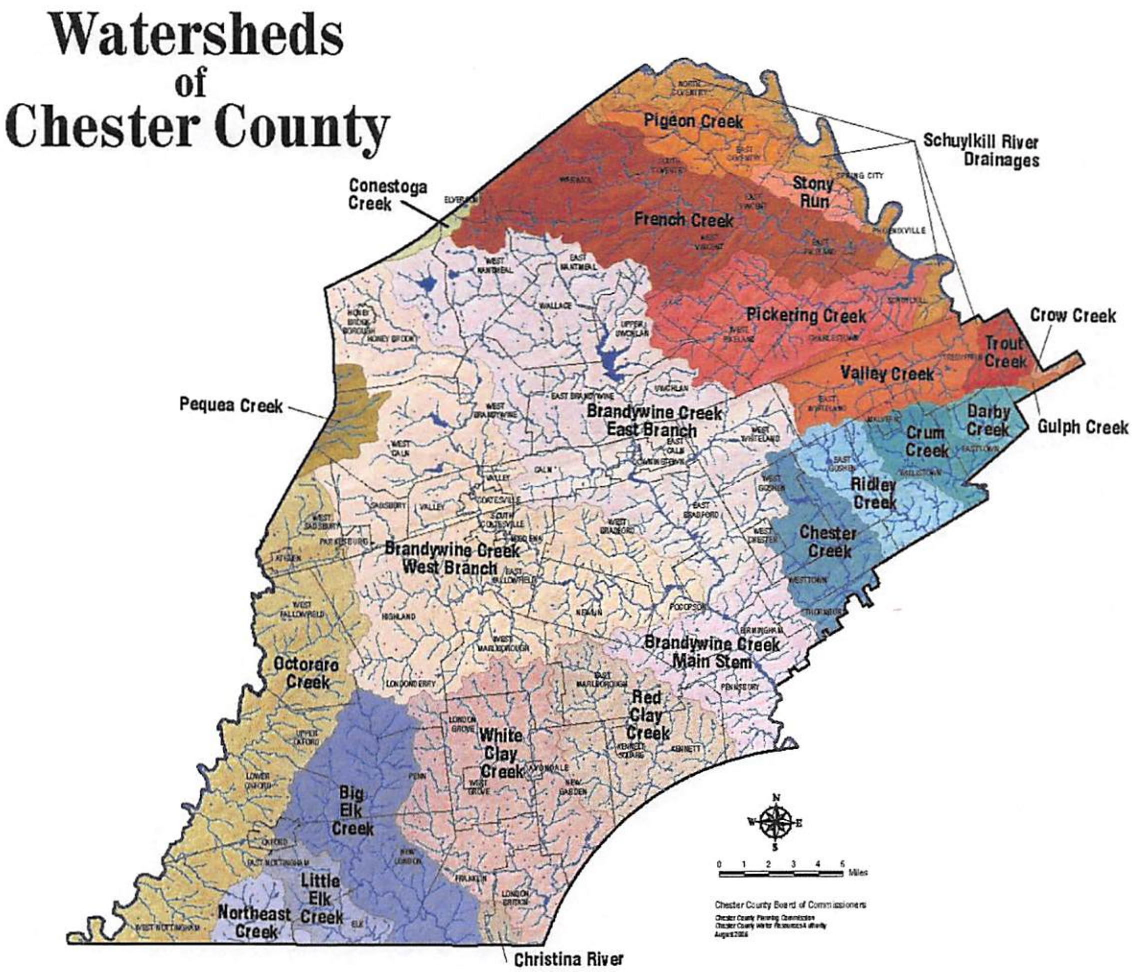

Figure 10: Watersheds of Chester County (CCWRA, 2006)

Climate

Looking at historical trends, Chester County is characterized by a humid continental climate that is modified by its proximity to both the Atlantic Ocean and the Appalachian Mountains (*Table 5*). Most low-pressure weather systems that affect the area develop in the Midwest and move eastward under the influence of the prevailingly westerly flow or form in the southeastern United States and track northward along the east coast. Due to the long overland trajectory, cold Canadian high-pressure air masses are usually considerably modified by the time they reach this portion of Pennsylvania, picking up warmth from the underlying land and moisture from the Gulf of Mexico and the Atlantic Ocean.

Chester County experiences moderately cold weather during the winter months (*Table 6*), which may include snowstorms, blizzards, freezing rain, and ice. The increased frequency of low-pressure systems and frontal passages give more cloudiness during the winter season with limited sunshine finding its way through the clouds and reaching the ground during this time of the year.

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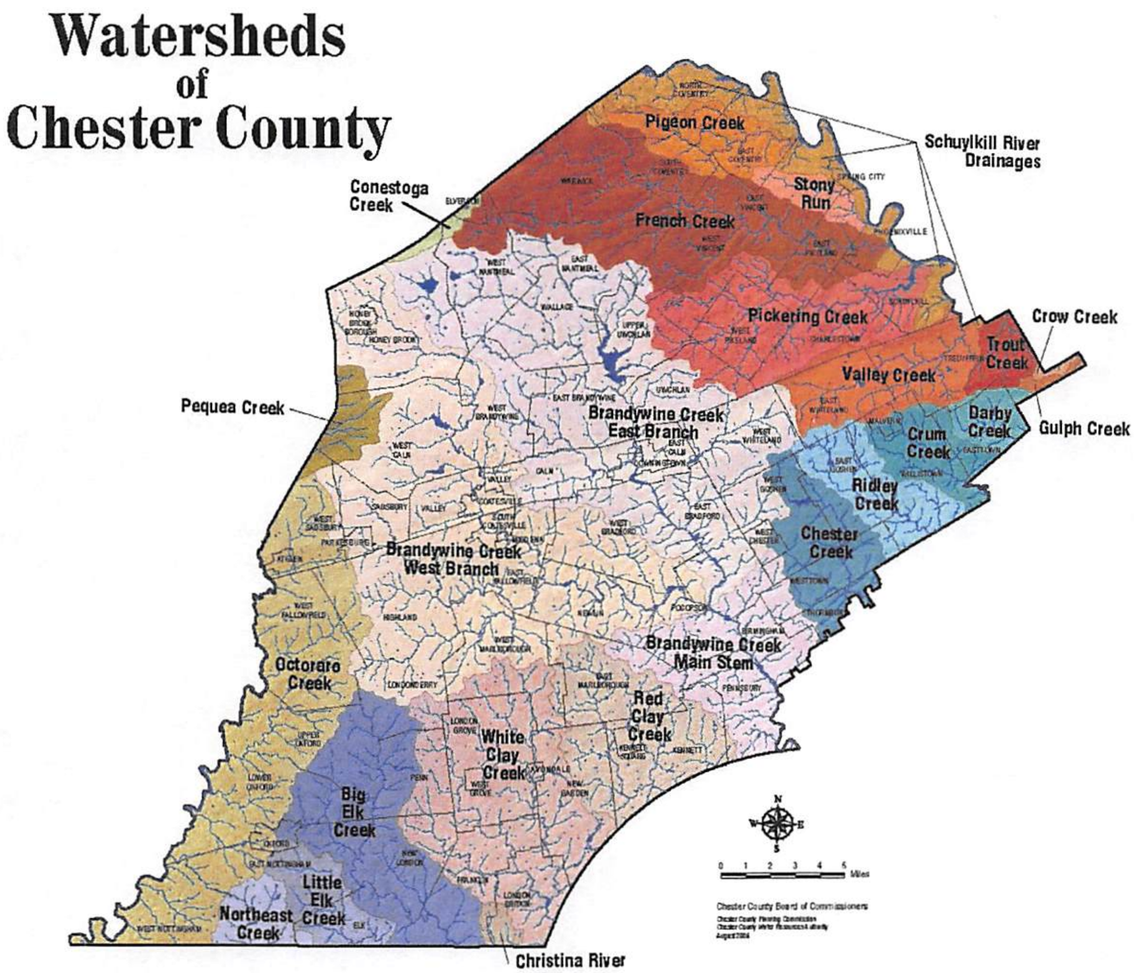

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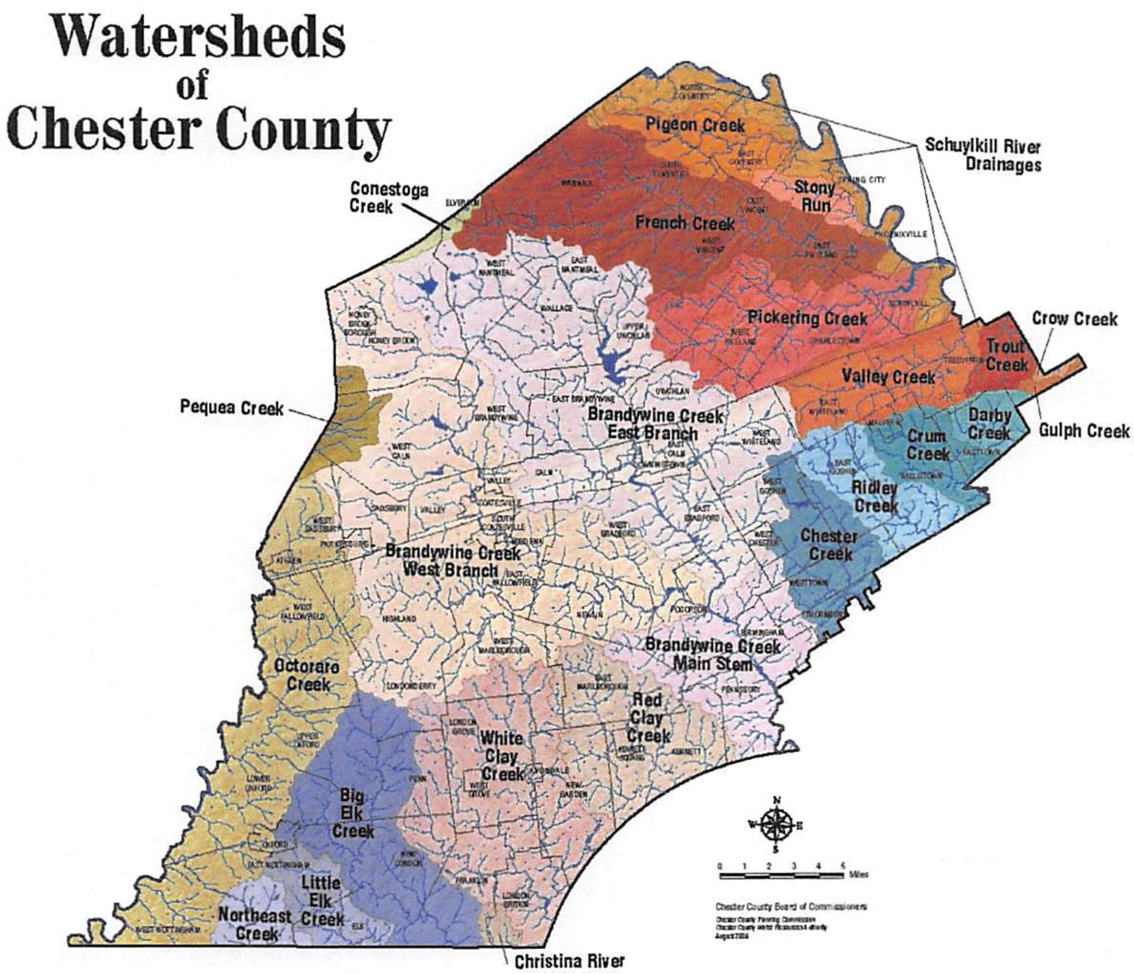

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Event		Declarations		
Type/Name	Date	County	State	Federal (For Chester County)
Winter Storms	Feb 1958	*	X	
Winter Storms	Jan 1966	*	X	
Winter Storms	Feb 1972	*	X	
Hurricane Agnes	Jun 1972	*	X	Presidential Major Disaster
Flood	July 1973	*	*	Presidential Major Disaster
Winter Storms	Feb 1978	*	X	
Drought	Nov 1980	X	X	
Fire	Feb 1989	*		SBA Physical Damage and Economic Injury
Flood	July 1989	*		SBA Physical Damage and Economic Injury
Fire	Aug 1992	*		SBA Physical Damage and Economic Injury
Winter Storms/Blizzard	Mar 1993	*	X	Presidential Major Disaster
Winter Storms	Jan 1994	*	X	Presidential Major Disaster
Drought	Sept 1995	*	X	
Flooding	Jan 1996	*	X	Presidential Major Disaster
Drought	July 1999	*	X	Agricultural Disaster
Hurricane Floyd	Sept. 1999	*	X	Presidential Major Disaster
Fires	May 2001	*		SBA
Drought & Water Shortage	Feb 2002	*	X	
Winter Snow Storm	Feb. 2003	*	X	Presidential Emergency Declaration
Tropical Storms Henri and Isabel	Sept. 2003	X	X	Presidential Major Disaster
Tropical Depression Ivan	Sept. 2004		X	Presidential Major Disaster
Severe Storms/Flooding	June 2006	X	X	Presidential Major Disaster
Fires	Nov 2007			SBA Physical Damage and Economic Injury
Coatesville Arson Fires	Jan 2009	X		SBA Physical Damage and Economic Injury
Flooding	Aug 2009	X		SBA Physical Damage and Economic Injury
Winter Snow Storm	Feb 2010	X	X	Presidential Major Disaster
Tropical Storm Nicole	Sept 2010	X	X	Presidential Major Disaster
Hurricane Irene	Aug. 2011	X	X	Presidential Major Disaster
Tropical Storm Lee	Sept. 2011	X	X	Presidential Major Disaster
Drought	April 2012			SBA: Agricultural Disaster
Hurricane Sandy	Oct. 2012	X	X	Presidential: Direct Federal Assistance
Winter Snow/Ice Storms	Feb. 2014	X	X	Presidential: Direct Federal Assistance - Power SBA: Economic Injury

Table 10: Declared Disasters (County, PEMA, FEMA, 2014) * unknown if a declaration was made

Flooding

Flooding is the most frequent and costly natural hazard in the United States. Floods are generally the result of excessive precipitation, and can be classified under two categories: general floods, precipitation over a given river basin for a long period of time; and flash floods, the product of heavy localized precipitation in a short time period over a given location. The severity of a flooding event is typically determined by a combination of several major factors, including: stream and river basin topography and physical geography; precipitation and weather patterns; recent soil moisture conditions; and the degree of vegetative clearing and impervious surface. Generally floods are usually long-term events that may last for several days. The primary types of general flooding include riverine, coastal, and urban flooding. Riverine flooding is a function of excessive precipitation levels and water runoff volumes within the watershed of a stream or river. Flooding can also occur from snow melt in the spring or ice jamming on the rivers in the winter. Urban flooding occurs where manmade development has obstructed the natural flow of water and decreased the ability of natural groundcover to absorb and retain surface water runoff.

Most flash flooding is caused by slow-moving thunderstorms in a local area or by heavy rains associated with hurricanes and tropical storms. However, flash flooding events may also occur from a dam or levee failure within minutes or hours of heavy amounts of rainfall, or from a sudden release of water held by a retention basin or other stormwater control facility.

The periodic flooding of lands adjacent to rivers, streams and shorelines (land known as floodplain) is a natural and inevitable occurrence that can be expected to take place based upon established recurrence intervals. The recurrence interval of a flood is defined as the average time interval, in years, expected between a flood event of a particular magnitude and an equal or larger flood. Flood magnitude increases with increasing recurrence intervals, and floodplains are designated by the percent chance per year that a flood is large enough to cover them. For example, the 100-year flood has a 1 percent chance of occurring in any given year. The 500-year flood has a 0.2 percent chance of occurring in any given year.

Location and Extent

Approximately 80 percent of Chester County is located in the Lower Delaware River Basin. Flooding in this basin has been a result of extensive development in floodplain areas. The remainder of Chester County is located in the Susquehanna River Basin. This basin is represented mainly by the Octorara Creek Watershed which has been subject to less developmental pressure.

Seventy-two of the 73 municipalities in Chester County are in floodplains; Honey Brook Borough is the only municipality without a 100-year or 500-year floodplain. *Figure 13* shows the floodplain in Chester County.

While this plan was in development, FEMA was in the process of updating the flood maps for Chester County. The new flood maps include depth grids for the base flood elevation throughout the County. Once the final maps are released, they will be made available on the FEMA Region III Risk Map webpage at http://www.riskmap3.com/maps

Severity, Warning Time, and Duration
Due to the rolling landscape and low water capacity of the soils and underlying rocks, flooding due to runoff from a heavy rainfall may be more severe in a stream valley. Floods may occur during any month of the year, although they occur with greater frequency in the spring months of March and April due to a combination of rainfall and snowmelt. In addition to local flooding from severe thunderstorms during the summer and fall, storms of tropical origin sometimes deposit flood-producing rains. Flooding associated with snow melt has a greater warning time than flooding associated with thunderstorms.

Monitoring of National Weather Service products allows for a day or more lead time for traditional riverine flooding. The forecasts have the potential for making an error in the exact path or amount of water that is going to fall in a particular area, which can drastically change the effects seen from flooding. Riverine flooding typically starts hours after the storm has left the area and can last for hours up to a day. The water rise and fall associated with riverine flooding is typically a slower process.

Flash flooding has less warning time since is it usually associated with small pop up thunderstorms. Flash flooding usually will subside shortly after the storm has passed and the stormwater systems are able to catch up with diverting the large amount of water.

Past Occurrences
Chester County has been affected by flooding relatively frequently in the past. Specific areas where flooding has caused problems in the past are those locations abutting the Schuylkill and Brandywine Rivers, as well as several creeks within the County (e.g. White Clay, French, Octorara, Red Clay and Elk). Flash flooding has been seen in the more urbanized areas of the County predominantly due to large amounts of water falling that are greater than the stormwater systems are designed to handle at once.

Probability of Future Frequency
Within the flood susceptible areas of Chester County, it is expected that the character of flooding will not diminish over the coming years. Protection against flood damage and loss can be greatly decreased by monitoring weather patterns, forecasts, stream and rain gauges, and historical statistics.

Potential Impact
Life, Property and Safety. Flood related injuries or facilities are a possibility with the cause generally relating to residents being caught in flood prone areas and being unable to safely get out of the flood waters. Within Chester County there are approximately 4,900 buildings on 3,000 parcels that are within the 100-year floodplain and 1,100 buildings on 800 parcels in the 500-year floodplain. The assessed value of the structures within the floodplain is $900 Million and $400 Million respectively. If a flood event occurs outside of the floodplain the potential loss to property would increase. There is a

risk of sewage ending up in flood water and after a flood event there is a risk of mold build up in flooded homes that are not properly cleaned out; both posing a health risk to residents.

Flooding puts a strain on emergency personnel as well. Impacted roads may affect the routing of emergency vehicles during flood events. Swift water rescues require specialty training which might require out of county swift water rescue teams.

Facilities and Infrastructure. With any flood event there is the likelihood of damage to facilities and infrastructure. The majority of the critical infrastructures in the floodplains are transportation networks such as roadways. The forces behind flood waters can easily damage roadways and their foundations. Very few critical facilities are located within the 100 year or 500 year floodplain. There are a total of 12 critical facilities that are located in a 100 year floodplain. These include 2 day cares, 1 police station, 1 ambulance station, 1 fire station, 6 churches and 1 major industrial plant. Flash flooding and urban flooding have the potential to bring flood waters into an area that is not as well mapped out and pose a slight risk to impacting other infrastructure. Gaining access to these areas during a flood will be effected by transportation networks.

Economy. The economy is impacted by businesses that have their facility flooded and transportation routes that are closed due to flooding. The rail and air transportation networks are usually not impacted by flooding. While most of the flooded roadways will re-open in a short period, damaged road infrastructure from the forces of water can last for a long period of time.

Environment. Floods are naturally occurring events that benefit riparian systems that have not been disrupted by human actions. Such benefits include groundwater recharge and the introduction of nutrient rich sediment improving soil fertility. However, the destruction of riparian buffers, changes to land use and land cover through a watershed, and introduction of chemical or biological contaminants that often accompany human sources cause environmental harm when floods occur. Hazardous material facilities are potential sources of contamination during flood events. Other environmental impacts of flooding include: water-borne diseases, heavy siltation, erosion or streambanks and riverbeds, destruction of aquatic habitat, damage to water and sewer infrastructure located in floodplains, damage or loss of crops and drowning of both humans and animals.

<u>Repetitive and Severe Repetitive Loss</u>

Several federal government programs encourage communities to identify and mitigate "repetitive loss" and "severe repetitive loss" properties. Nationwide, repetitive loss properties make up only 1 to 2 percent of the flood insurance policies currently in force, yet they account for 40 percent of the flood insurance claim payments.

FEMA identifies repetitive loss and severe repetitive loss structures based on flood insurance payments. A repetitive loss property is one in which two or more paid out National Flood Insurance Program (NFIP) claims of at least $1,000 each are made within

10 years of each other. A severe repetitive loss property is one that has at least four paid out claims over $5,000 each or two payments which the cumulative amount exceeds the market value of the building.

According to the list of repetitive loss properties maintained by FEMA, as of June 2012, Chester County has 136 identified repetitive loss and 23 severe repetitive loss properties. These properties are outlined within each of the municipal specific sections of this plan. All of the repetitive loss and severe repetitive loss properties are on the list of potential hazard mitigation action to either elevate the structure out of the floodplain or to acquire the property and demolish the structure.

Sixty-nine of the seventy-three Chester County's municipalities participates in the National Flood Insurance Program. All of those municipalities have adopted the minimum standards required by the NFIP, however many of them have implemented stricter ordinances when it comes to building in the floodplain. There are municipalities within the County that have ordinances prohibiting any building within the floodplain at all.

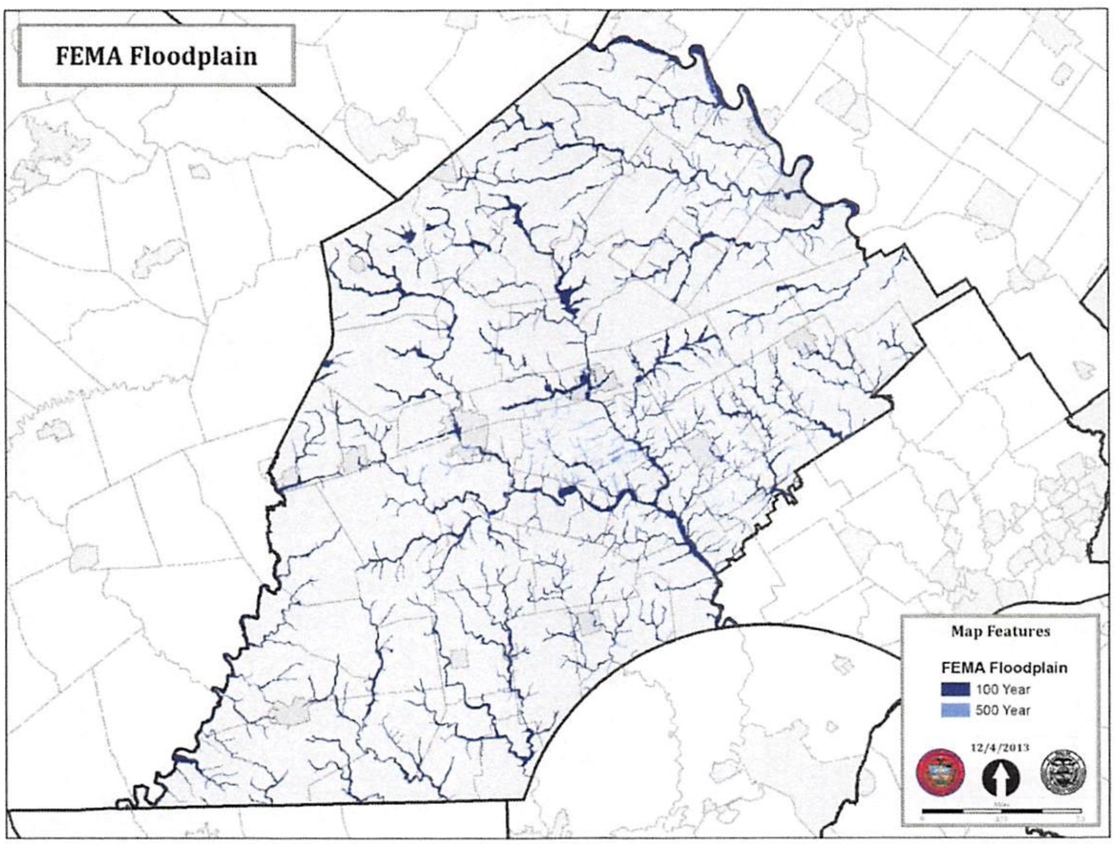


Figure 13: FEMA Floodplains in Chester County. (FEMA, 2014)

Hurricane and Tropical Storm

Hurricanes and tropical storms are defined as any closed circulation developing around a low-pressure center in which the winds rotate counter-clockwise in the Northern Hemisphere (or clockwise in the Southern Hemisphere). The primary damaging forces associated with these storms are high-level sustained winds, heavy precipitation that causes inland flooding, and tornados.

The majority of hurricanes and tropical storms form in the Atlantic Ocean, Caribbean Sea and Gulf of Mexico during the official Atlantic hurricane season, which encompasses the months of June through November. The peak of the Atlantic hurricane season is in early to mid-September.

As a hurricane develops, barometric pressure at its center falls and winds increase. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed 39 mph, the system is designated a tropical storm, given a name, and is closely monitored by the National Hurricane Center. When sustained winds reach or exceed 74 mph the storm is deemed a hurricane. Hurricane intensity is further classified by the Saffir-Simpson Scale, which rates hurricane intensity in categories on a scale of 1 to 5, with category 5 being the most intense. The Saffir-Simpson Scale categorizes hurricane intensity linearly based upon maximum sustained winds, barometric pressure and storm surge potential, which are combined to estimate potential damage.

Categories 3, 4, and 5 are classified as "major" hurricanes, and while hurricanes within this range comprise only 20 percent of total tropical cyclone that make landfall, they account for over 70 percent of the damage in the United States. Damage during hurricanes might also result from spawned tornados, storm surge, and inland flooding associated with heavy rainfall that usually accompanies these storms.

Location and Extent

The entirety of Chester County becomes impacted when a tropical event comes into the area. The low lying areas are more vulnerable to the flooding caused by the storm and the wooded areas are more vulnerable to the high winds causing tree damage. The vast amount of the commercial power network is above ground, which makes the entire county vulnerable to power outages due to falling trees and wires. The amount of damage that is sustained is directly related to the size and the intensity of the storm when it reaches the County. The intensity has usually decreased due to the distance the storm has to travel across land prior to impacting the county.

Severity, Warning Time, and Duration

In regards to hurricanes, by the time most storms reach Pennsylvania they fail to satisfy the definition of a hurricane (75 mph winds). However, Chester County has been affected by the secondary effects (mainly heavy rainfall) of more than 20 hurricanes in the last 80 years. Winds from hurricanes and tropical storms seldom reach destructive speeds in Chester County, although widespread minor damage sometimes results from a combination of heavy rain and strong winds.

The hurricane developing in the tropical area of the Atlantic Ocean gives emergency management staff plenty of time to see tropical weather develop along with potential tracks of the storm. The forecasting of tracks has improved, so it is easy to see 3 to 4 days out if there is a possibility of tropical storm impact to the area. Once it is determined that a storm will impact our area, the exact track contains some assumptions built into the models which causes some error so it is hard to determine the anticipated amount of damages based on that track. However, once it is determined that a tropical storm is going to impact our area there is time to plan and prepare for the storm. Once a tropical storm begins to impact the County, the duration of the storm itself is usually less than 24 hours. The effects of flooding as a result of the storm can last for a few days.

Past Occurrences
The most severe impact from tropical storms/hurricanes occurs in the Delaware River Basin. In the past Chester County has felt the effect of multiple tropical storms including Hurricane Agnes (1972), Hurricane Floyd (1999), Hurricane Irene (2011), Tropical Storm Lee (2011). Another recent hurricane that impacted Chester County was Hurricane Irene in 2011. *Figure 14* depicts historical tropical storm tacks that came near Chester County

Probability of Future Frequency
From 2010 through 2014, Chester County has felt the impact from three tropical events, Hurricane Irene, Tropical Storm Lee, and Super Storm Sandy. The recent increase in tropical events shows that there is a high probability that Chester County will feel the impact of additional tropical events in the future. The size and severity of the damage caused by those events is the unknown factor.

Potential Impact
Life, Property and Safety. The entire county has the potential to be impacted by a tropical event. Certain locations within the county are more prone to having wind damage from such a storm and certain properties within the county are more prone to being impacted by floods created by the rain from that type of event. The impact to structures can be seen in the flooding and the thunderstorm hazard profiles.

Hurricanes and tropical storms bring numerous hazards for emergency personnel. Based on the inland location of the County, the greatest impact to emergency responders would be from wind and rain. The high winds and air speeds of a hurricane or any severe storm often result in power outages, disruptions to transportation corridors and equipment, significant property damage, injuries and loss of life and the need to shelter and care for individuals affected by the event, all of which create a strain to emergency responders.

Facilities and Infrastructure. In addition to the wind and flood hazards, county facilities and critical infrastructure has the potential to lose power. The loss of power would force these buildings onto generator power and make them more vulnerable to a disruption of the supply chain (such as fuel) and other impacts from the event. Transportation networks could be impacted by a tropical event, compounding the issues for those facilities that are not on commercial power.

Economy. The economy is impacted from the loss of services due to closed transportation networks from flooded roads and downed trees and wires. The services provided by the businesses can be interrupted due to a loss of power.

Environment. The environmental impacts associated with coastal storms are consistent with flood events, including the destruction of riparian buffers, changes to land use and land cover through watersheds and introductions of chemical and/or biological contaminants. Hazardous material facilities are potential sources of contamination during hurricane and tropical storm events. Other environmental impacts from coastal storms include: water-borne diseases, heavy siltation, erosion or streambanks and riverbeds, destruction of aquatic habitat, damage to water and sewer infrastructure located in floodplains, damage or loss of crops and drowning of both humans and animals.

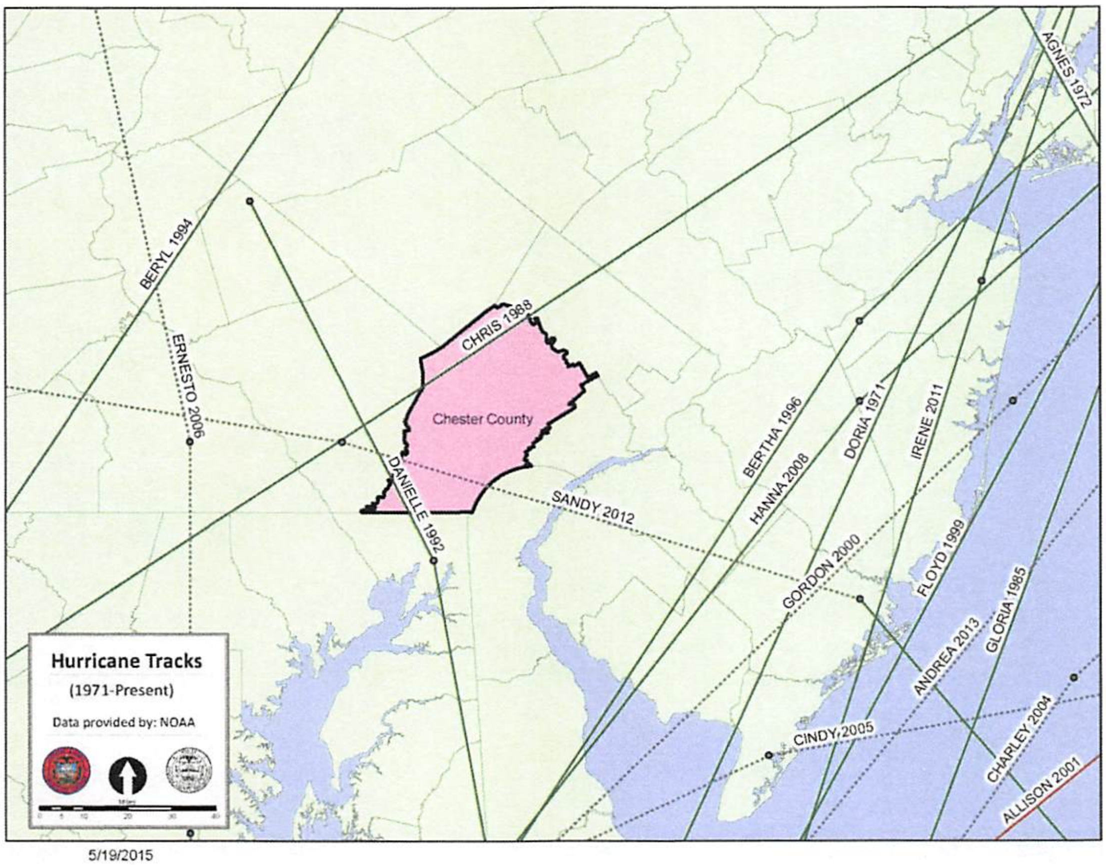


Figure 14: Historical Hurricane Tracks around Chester County. (NOAA, 2015)

Radon

Radon is a naturally occurring, colorless, odorless gas that is soluble in water. When uranium and radium exist naturally in places such as in soil or in minerals from bedrock, they produce radon as they go through a radioactive decaying process. Radon is radioactive, meaning that it breaks down and materializes into different elements. As radon decays, it produces several short-lived elements that also are radioactive. Radon, along with these decay products, emits alpha particles which can damage lung tissue. The half-life of radon, which is defined by the time it takes one half of the amount of radon to break down into other elements, is 3.8 days.

Commonly, radon enters into your house through the basement. Groundwater absorbs some of the radon while the rest floats to the surface and dissipates easily into the air. Problems arise when radon rises into the underside of a building. Any cracks, seams or other type of openings beneath the structure will allow the lower air pressure within a building to suck the radon inside, much like that of a vacuum. As a result, dense gas pockets may build up to quite high levels in low-lying sections of a house such as in basements or cellars. As these dense gas pockets build up more and more, they may leak into other rooms causing an even higher exposure.

Radon found within water sources is a common concern as well, especially for those who rely on well water for their supply of water. For houses that have high concentrations of radon in their water supply, most of the gas escapes from the water at the faucet or anywhere else water is entering the home thus leaving small amounts of radon in the water itself. Unfortunately, the radon that escapes from the water contributes to the concentrations of radon which have already entered the home through the bottom of the structure. In particular cases which have been studied in Chester County by the USGS, EPA, Chester County Water Resources Authority, and the Chester County Health Department, the radon found in the water supply has been shown to contribute a large portion of the radon which is present in the home.

Location and Extent

The underlying geologic unit that composes Chester County plays an important role in approximating how much radon will exist in different areas. When you look at a geological map of Chester County, schist accounts for roughly one third of our geologic composition. Rocks such as schist normally contain higher amounts of uranium compared to other rocks such as limestone. Thus we can infer that buildings built over schist may have higher amounts of radon rising from below. The same applies when looking for the amounts of radon in groundwater. Several factors affect the formation and movement of radon in groundwater, such as uranium content, grain size, permeability, and the nature and extent of fracturing in the host rock which are all functions of rock type. Thus, the groundwater associated with the schist rock formations may also have higher concentrations of radon. With that being said, tests have shown that homes over the same geological formation and only 100 feet away from one another may have drastically different levels of radon in their home. Because of this, we may have a good idea where concentrations could be high, but it is still important to have your home tested for radon levels, regardless of where you live.

Severity, Warning Time, and Duration

Pennsylvania has one of the most serious radon problems in the country. An estimated 40 percent of Pennsylvania homes have radon levels above Environmental Protection Agency's action guideline. The US EPA determined an action level of 4 picocuries per liter, meaning that if your home or workplace has radon levels exceeding that, corrective measures should be taken. Perhaps one of the most dangerous aspects of radon gases within homes is that because of its tasteless and odorless qualities, humans cannot detect its presence without professional help or home test kits. As a result, without testing for current levels nor taking any corrective measures, there is no warning time and it could be a problem which has been ongoing in a large multitude of buildings for quite a while. *Figure 19* shows the average radon level per zip code in Chester County.

Past Occurrences

In the 1980s, a rising awareness for high indoor radon levels occurred and states began to test the levels at different buildings. As a result, it was found that several buildings indeed contained high concentrations of radon and awareness since then has increased tremendously. As more and more studies are completed, it has been discovered that the problem is still occurring and buildings contain even higher levels than initially thought. This shows that the problem has been occurring most likely since homes were even first established but only now are we beginning to take corrective actions.

Probability of Future Frequency

Unless all buildings are tested and radon mitigation systems installed where appropriate, high concentrations of radon will remain in improperly sealed buildings and wells that do not contain water treatment systems. Exposure is a risk that is prevalent year round; however winter tends to be the most dangerous time of the year simply because people trap more of this toxic gas inside their homes by keeping their doors and windows closed.

Potential Impact

Life, Property and Safety. The Surgeon General of the United States has recognized exposure to radon gas as being second only to cigarette smoking as a cause of lung cancer. Radon gas can cause lung cancer if inhaled because its decay products can accumulate in the lungs and damage lung tissue. It is estimated that nearly 21,000 people in the United States will develop lung cancer as a result of exposure to radon gas each year. Radon in water is another concern as it may lead to stomach cancer when it is ingested, but the main threat lies in the process of inhalation. Radon by itself does not pose a threat to property; however, high concentrations of the gas within a home may indicate issues with the bottom of a structure where the gas is entering.

The entire population of the county is exposed to the risk of radon exposure, including emergency responders.

Facilities and Infrastructure. Radon does not pose a threat to facilities and infrastructure within the County.

Economy. There would be no major impacts to the economy from the presence of radon. The building owners would have to install a radon remediation system if determined their building is above the action level. The average cost of radon reduction systems being around $1,200. This price would obviously fluctuate depending on the size of the building.

Environment. Radon exposure has minimal environmental impacts. Due to the relatively short half-life or radon, it tends to only affect living and breathing organisms such as humans or pets which are routinely in contained areas (i.e. basement or house) where the gas is released.

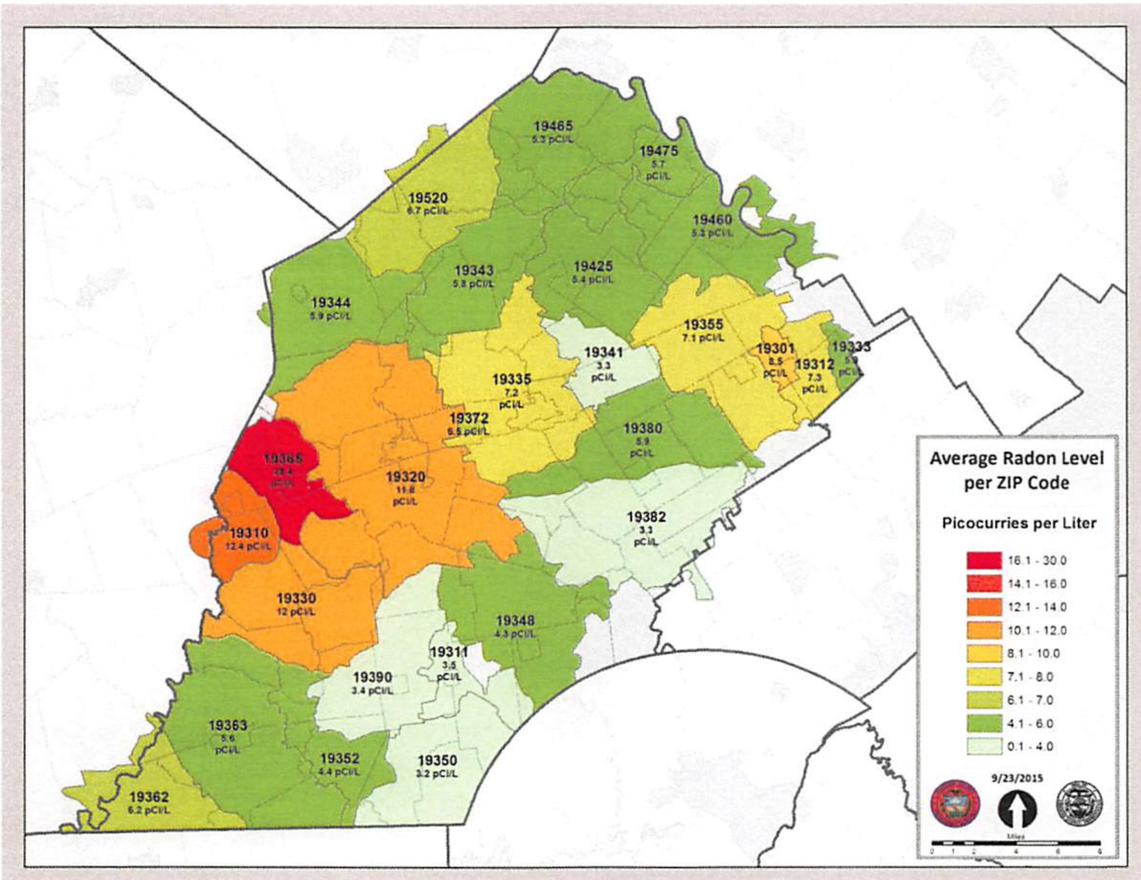


Figure 15: Average Radon Level per Zip Code (Pa DEP, 2015)

Thunderstorms

A thunderstorm, also known as an electrical storm, a lightning storm, or a thundershower, is a type of storm characterized by the presence of lightning and its acoustic effect on the Earth's atmosphere known as thunder. Thunderstorms are usually accompanied by strong winds, heavy rain and sometimes snow, sleet, hail, or no precipitation at all.

One of the main hazards with thunderstorms is lightning. Lightning is a discharge of electrical energy resulting from the buildup of positive and negative charges within a thunderstorm, creating a "bolt" when the buildup of charges becomes strong enough. While most often affiliated with severe thunderstorms, lightning often strikes outside of heavy rain and might occur as far as 10 miles away from any rainfall.

Hail develops when a super cooled water droplet collects a layer of ice and continues to grow, sustained by the updraft. Once the hail stone cannot be held up any longer by the updraft, it falls to the ground. Hail up to 2.75 inches in diameter, nearly the size of a baseball, was reported in northern Chester County in 1995, according to the NCDC.

Location and Extent

The entire County is susceptible to thunderstorms. Thunderstorms historically move across the county from the southwest to the northeast and are more common in the spring and summer months.

Severity, Warning Time, and Duration

There is moderate warning time for thunderstorms. The National Weather Service is good at predicting when a thunderstorm will impact the region. There is some uncertainty as to the exact timing and the intensity of the storm when it hits a specific town. That uncertainty is what makes it hard to plan for when and where the damages will occur. Thunderstorms are capable of bringing localized damage due to strong winds and hail as well as wide spread damage from downed trees and flash flooding. The duration of the storm itself is usually short lived in any area of the County, but the effects from the storm can be felt for one to three days after the storm depending on its severity.

Past Occurrences

Multiple thunderstorms every year impact Chester County. Thunderstorms have caused power outages across the county and others have caused major localized damages. Due to the nature of thunderstorms there has not been widespread major damage seen across the entire county from one storm. No thunderstorm has ever created the need to declare a disaster, but they have caused the Emergency Operations Center to open to support the needs of the public and municipalities following the storm.

Probability of Future Frequency

Thunderstorms will continue to occur in Chester County. The size and the intensity of the storm as well as the portion of the county that is impacted will determine the amount of damage and the disruption felt from those storms.

nuclear power plant or the power grid could have detrimental impacts on services and functions.

Economy. The economy could be majorly impacted by a cyber-attack. Financial records, order processing, and many other systems that keep the economy running are computer based. If those systems are impacted by a cyber-attack or if there is a loss of services from critical infrastructure, the economy could be severely impacted.

Environment. There would be a limited impact to the environment with regards to a cyber terrorism event. However, the environment may be affected if a hazardous materials release occurred because of critical infrastructure failure as a result of cyber terrorism. Similarly, an act of cyber terrorism on a nuclear power plant could have devastating environmental consequences if the plant suffered an intentional catastrophic failure.

Dam Breaches

Dam failure is the breakdown, collapse, or other failure of a dam structure characterized by the uncontrolled release of impounded water that results in downstream flooding. In the event of a dam failure, the energy of the water stored behind even a small dam is capable of causing loss of life and severe property damage if development exists downstream. There are varying degrees of failure; an unexpected or unplanned dam breach is considered one type of failure. A breach is an opening through a dam which drains the water impounded behind it. A controlled breach is a planned, constructed opening and not considered a dam failure event.

Dam failure can result from natural events, human-induced events, or a combination of the two. Natural occurrences that may cause dam failure include hurricanes, floods, earthquakes, and landslides; human induced actions may include the deterioration of the foundation or the materials used in dam construction or malicious attacks.

Dam failure presents a significant potential for disaster, in that significant loss of life and property would be expected in addition to the possible loss of power and water resources. The most common cause of dam failure is prolonged rainfall that produces flooding. Failures due to other natural events such as earthquakes or landslides are significant because there is generally little or no advance warning. The best way to mitigate dam failure is through the proper construction, inspection, maintenance, and operation of dams, as well as maintaining and updating Emergency Action Plans.

Location and Extent

Any dam has the potential for creating a major disaster. There are a number of potentially hazardous dams in the Commonwealth. Rapid thaw in the spring, poor maintenance, severe thunderstorms, or rain are factors that may facilitate an actual dam break. Within Chester County there are 36 dams that meet the state's definition of a high hazard dam. Of those there are thirteen that meet the category 1 criteria meaning there is a substantial population at risk (numerous homes or small businesses or a large business or school) in the inundation zone. In addition, two dams in neighboring Berks County present a potential for impacting Chester County if they fail. *Figure 17* shows the dam inundation zones for the dams within Chester County.

Severity, Warning Time, and Duration

Vulnerability of any community is increased by the mere existence of a dam. Proper maintenance and extensive planning for a potential break greatly reduces the risk factors involving dam disasters. Dam failures usually occur with little or no notice, wreaking havoc on an unsuspecting community. After a dam failure, the water would flow downstream, so the duration of water present in any one area would be short. The amount of water behind the dam when it breached would determine how far downstream the water would travel before being able to be held by the stream banks and the amount of time it would take for the water to reach that point.

Past Occurrences

There have been no dam failures in the history of Chester County.

Probability of Future Frequency

Because of the tremendous dangers resulting from any dam break, measures are being taken to keep probability to a minimum. Chester County is always in the process of evaluating dam data and updating Emergency Action Plans (EAP) which include evacuation plans for the areas potentially affected by a dam breach. Currently, there are no dams that do not have an EAP. There is a constant five-year update cycle to the EAPs, so at any time there might be a handful of dams that do not have a "current" plan which is one that is less than five years old.

The nature of having dams present within the county allows time for pre-planning of worse case scenarios. The purpose of the EAP is to outline the agencies that would be involved in responding to a dam breach, their roles, and the trigger points in which those agencies would be notified. The plan also establishes requirements when the dam owner must begin 24 hour surveillance of the dam and thresholds that the County must be notified to give advanced warning to the potential for a dam failure.

Potential Impact

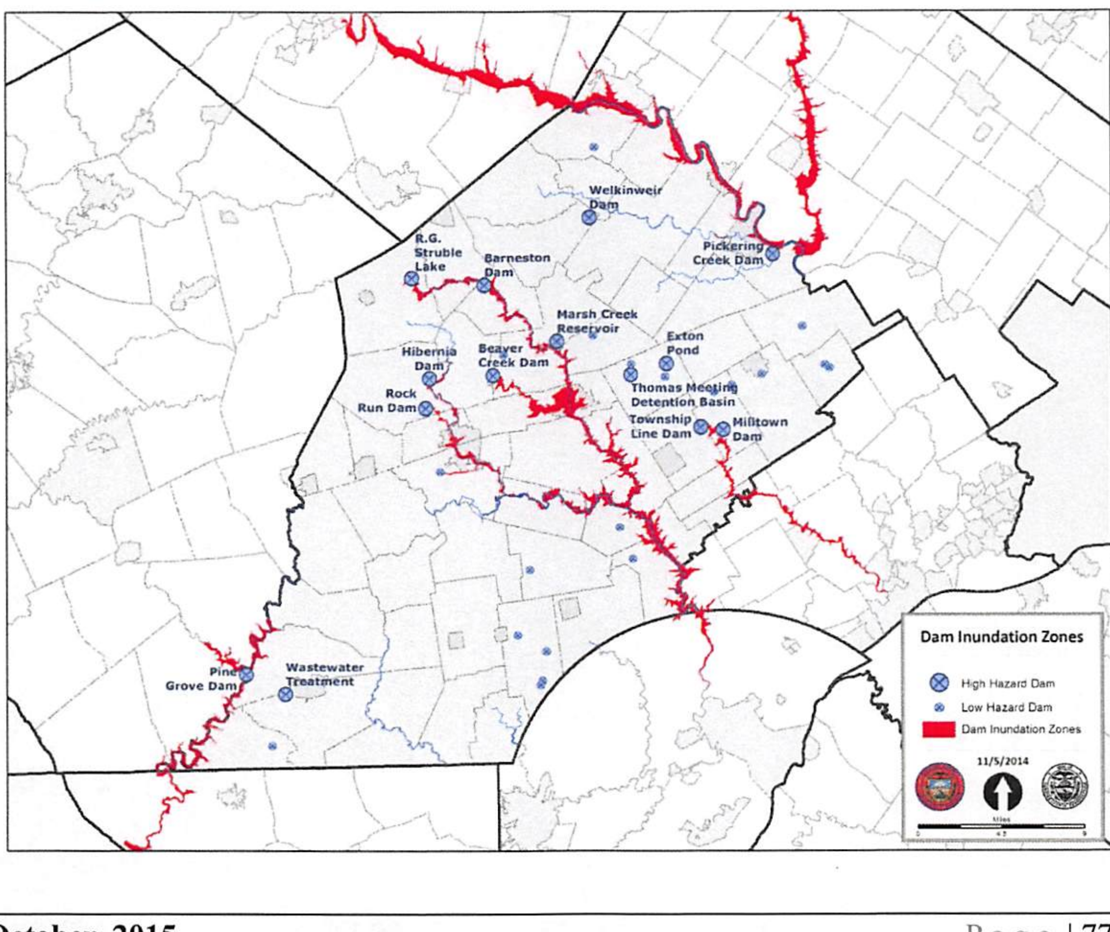
Life, Property and Safety. The largest impact to the community will be if there is a breach of one of the "Category 1" dams within the county. There is a chance for loss of life and injuries as well as major property damage to the structures that are within the inundation zone. The amount of warning time and the ability to evacuate the pre-identified inundation zone would directly correlate to any injuries and fatalities that occurred.

Dam failures also put a strain on emergency personnel. Impacted roads may affect the routing of emergency vehicles during a dam failure as well as evacuation routes. Swift water rescues require specialty training which might require out of county swift water rescue teams.

Facilities and Infrastructure. The only infrastructure that would be impacted would be those within the inundation zone. Also, any roads or bridges that are within the inundation area have the potential to become damaged.

Economy. The largest impact would be loss of function of the dam. If the dam was created for recreation, power generator, or water treatment purposes, those functions could cease to exist. After a dam breach, the water that was behind the dam would pass downstream; the only long term road closures would be related to any roads or bridges that were washed out from the inundation waters. In addition, any businesses that were lost as a result of the water released would incur costs due to loss of function and rebuilding.

Environment. The environmental impacts of a dam breach result in significant water quality and debris disposal issues. Flood waters will back-up sanitary sewer systems and inundate wastewater treatment plants, causing raw sewage to contaminate residential and commercial buildings and the flooding waterway. The contents of unsecured containers of oil, fertilizers, pesticides, and other chemicals get added to flood waters. Water supplies and waste water treatment could be off-line for weeks. After the flood waters subside, contaminated and flood-damage building materials and contents must be properly disposed. Contaminated sediment must be removed from buildings, yards, and properties.



Downingtown Borough

Background Information
The borough is 2.2 square miles in area. The 2010 Census counted 7,923 people within the municipality.

Buildings in the 1% (100 year) and 0.2% (500 year) chance floodplain

Total		1% Annual flood chance			0.2% Annual flood chance		
Parcel Count	Building Count	Parcel Count	Building Count	Structure Value	Parcel Count	Building Count	Structure Value
2,566	2,652	277	344	$51,750,880	69	78	$7,450,190

Utility Providers

Electric	Natural Gas	Water
PECO	PECO	Downingtown Municipal Water Authority

Capabilities

Planning and Regulatory Capabilities		Administrative and Technical Capabilities	
Building Code	IBC	Emergency Management Coordinator	✓
Capital Improvement Plan	✓	Engineer on Staff or Contracted	✓
Comprehensive Plan (Last Updated)	9/4/2013	Environmental Preservation Committee	
Emergency Operations Plan	✓	GIS Capabilities on Staff or Contracted	✓
Floodplain Ordinance	✓	Historical Preservation Committee	✓
NFIP Participant	✓	Municipal Planning Commission	✓
Stormwater Management Ordinance	✓	Municipal Road Crew	✓
Subdivision or Land Development Ordinance (Last Updated)	12/1/1999	Municipal Sewer Authority	✓
		Municipal Water Authority	✓
Zoning Ordinance (Last Updated)	7/18/2012	Municipal Zoning Board	✓
Restrictions on building in the floodplain	Restriction on use	Require Radon Testing during real estate transaction	

These capabilities are in addition to the countywide capabilities outlined in the capability section of the plan.

Emergency Services Providers

	Agency(ies)
ALS	Downingtown Fire Department
BLS	Downingtown Fire Department
Fire	Downingtown Fire Department
Police	Downingtown Police Department

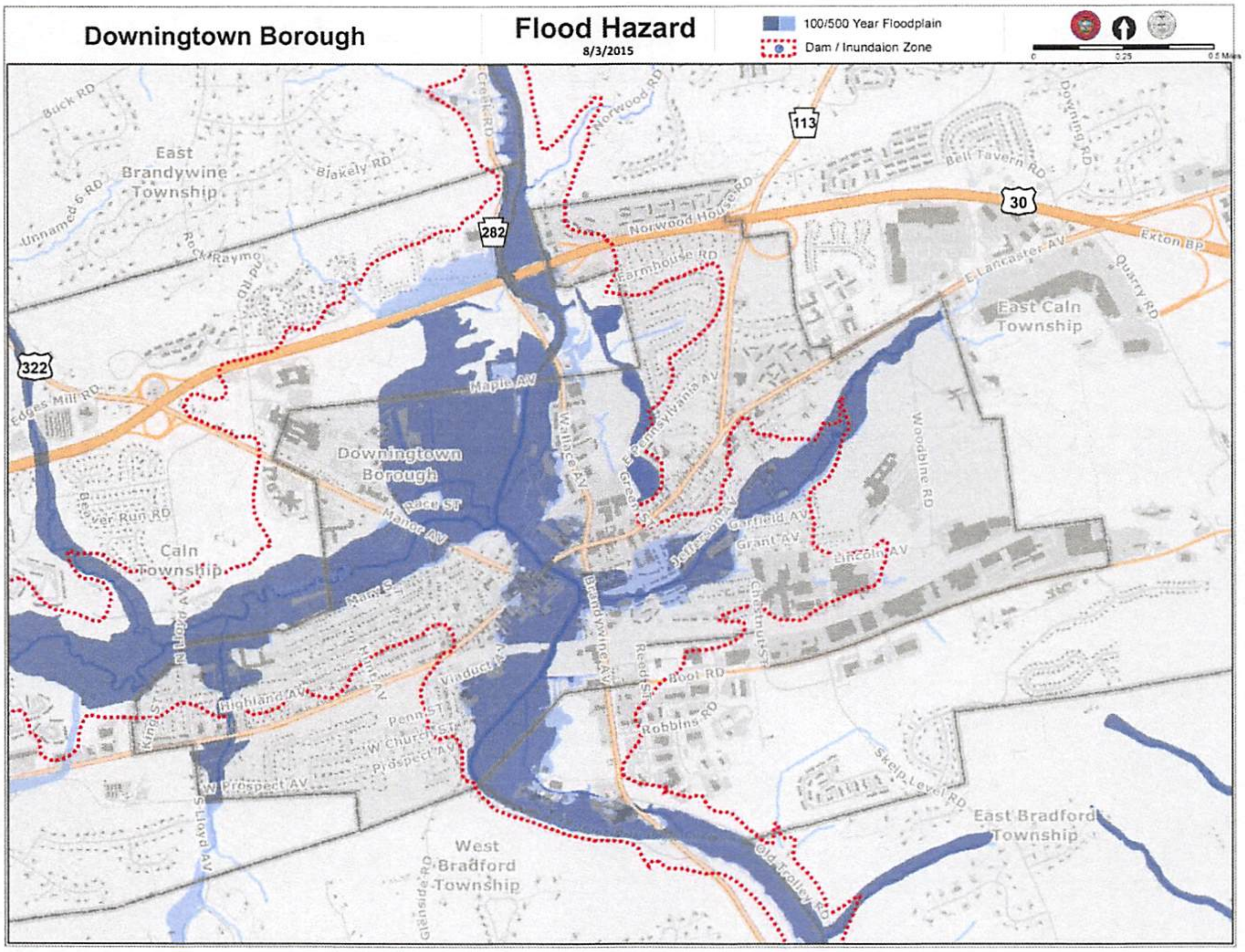
Risk Assessment
Downingtown Borough considers their top three hazards to be floods, sinkholes, and thunderstorms in that order. Municipal specific risk information supplements the countywide risks as outlined in the Risk Assessment section of the plan.

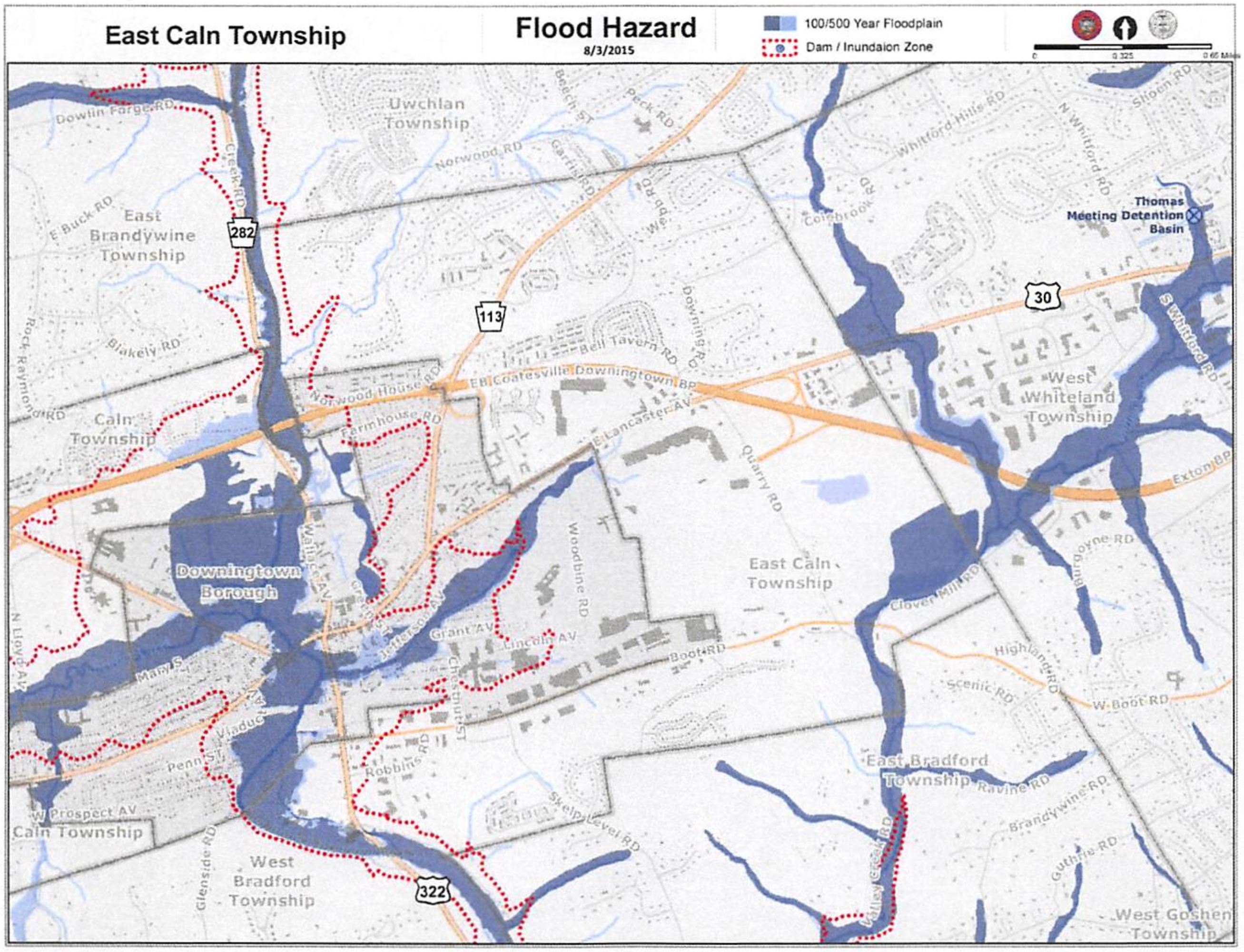
Exposure to Flood Hazard
According to the NFIP records, residents within Downingtown Borough have received $1,730,148 in total payouts from a total of 233 flood claims since 1978. There are 228 flood insurance policies currently in effect within the borough. There are 37 repetitive loss properties, and no severe repetitive loss properties.

Potential Hazard Mitigation Actions

Location	Mitigation Measure	Comments
Borough wide	Public Information Programs	
Borough wide	Emergency alerting systems	
Borough wide	Install battery backup for 13 traffic signals	
410 Acorn Ln	Property Protection	Non-residential, Repetitive Loss Property
110 Brandywine Ave	Acquire/Elevate Structure	Repetitive Loss Property
112 Brandywine Ave	Acquire/Elevate Structure	Repetitive Loss Property
114 Brandywine Ave	Acquire/Elevate Structure	Repetitive Loss Property
119 Brandywine Ave	Acquire/Elevate Structure	Repetitive Loss Property
121 Brandywine Ave	Acquire/Elevate Structure	Repetitive Loss Property
123 Brandywine Ave	Acquire/Elevate Structure	Repetitive Loss Property
125 Brandywine Ave	Acquire/Elevate Structure	Repetitive Loss Property
127 Brandywine Ave	Acquire/Elevate Structure	Repetitive Loss Property
128 Brandywine Ave	Acquire/Elevate Structure	Repetitive Loss Property
132 Brandywine Ave	Acquire/Elevate Structure	Repetitive Loss Property
209 Brandywine Ave	Acquire/Elevate Structure	Repetitive Loss Property
118 Green St	Acquire/Elevate Structure	Repetitive Loss Property
120 Green St	Acquire/Elevate Structure	Repetitive Loss Property
124 Green St	Acquire/Elevate Structure	Repetitive Loss Property
126 Green St	Acquire/Elevate Structure	Repetitive Loss Property
128 Green St	Acquire/Elevate Structure	Repetitive Loss Property
113 Jefferson Ave	Acquire/Elevate Structure	Repetitive Loss Property
119 Jefferson Ave	Acquire/Elevate Structure	Repetitive Loss Property
121 Jefferson Ave	Acquire/Elevate Structure	Repetitive Loss Property
123 Jefferson Ave	Acquire/Elevate Structure	Repetitive Loss Property
125 Jefferson Ave	Acquire/Elevate Structure	Repetitive Loss Property
127 Jefferson Ave	Acquire/Elevate Structure	Repetitive Loss Property
155 Jefferson Ave	Acquire/Elevate Structure	Repetitive Loss Property
309 Jefferson Ave	Acquire/Elevate Structure	Repetitive Loss Property
311 Jefferson Ave	Acquire/Elevate Structure	Repetitive Loss Property
315 Jefferson Ave	Acquire/Elevate Structure	Repetitive Loss Property
317 Jefferson Ave	Acquire/Elevate Structure	Repetitive Loss Property

Location	Mitigation Measure	Comments
319 Jefferson Ave	Acquire/Elevate Structure	Repetitive Loss Property
34 W Lancaster Ave	Acquire/Elevate Structure	Repetitive Loss Property
309 Mary St	Acquire/Elevate Structure	Repetitive Loss Property
311 Mary St	Acquire/Elevate Structure	Repetitive Loss Property
313 Mary St	Acquire/Elevate Structure	Repetitive Loss Property
401 Mary St	Acquire/Elevate Structure	Repetitive Loss Property
337 Stuart Ave	Acquire/Elevate Structure	Repetitive Loss Property
21 Viaduct Ave	Acquire/Elevate Structure	Repetitive Loss Property
521 Whiteland Ave	Acquire/Elevate Structure	Repetitive Loss Property
Jefferson Ave	Acquire/Elevate Structures	104 properties with buildings in the 100 yr or 500 yr floodplain
Mary St	Acquire/Elevate Structures	63 properties with buildings in the 100 yr or 500 yr floodplain
Brandywine Ave	Acquire/Elevate Structures	42 properties with buildings in the 100 yr or 500 yr floodplain
Cherry St	Acquire/Elevate Structures	31 properties with buildings in the 100 yr or 500 yr floodplain
Viaduct Ave	Acquire/Elevate Structures	29 properties with buildings in the 100 yr or 500 yr floodplain
Roosevelt Ave	Acquire/Elevate Structures	28 properties with buildings in the 500 yr floodplain
Washington Ave	Acquire/Elevate Structures	25 properties with buildings in the 100 yr or 500 yr floodplain


Downingtown Borough
Flood Hazard
8/3/2015
100/500 Year Floodplain
Dam / Inundaion Zone
East Brandywine Township
Downingtown Borough
Caln Township
East Caln Township
West Bradford Township
East Bradford Township
Buck RD
Blakely RD
Norwood RD
Bell Tavern RD
Downing RD
Norwood House RD
Farmhouse RD
E Lancaster AV
Exton BP
Quarry RD
Maple AV
Wallace AV
Pennsylvania AV
Green ST
Woodbine RD
Race ST
Manor AV
Jefferson AV
Garfield AV
Grant AV
Lincoln AV
Beaver Run RD
Edges Mill RD
Main ST
Highland AV
Viaduct AV
Brandywine AV
Chestnut ST
Boot RD
Reeds ST
Robbins RD
Penn ST
W Church ST
Prospect AV
W Prospect AV
S Lloyd AV
N Lloyd AV
King ST
Skelp Level RD
Old Trolley RD
Glenside RD
113
30
282
322


East Caln Township
Flood Hazard
8/3/2015
100/500 Year Floodplain
Dam / Inundaion Zone
Uwchlan Township
East Brandywine Township
Caln Township
Downingtown Borough
East Caln Township
West Whiteland Township
East Bradford Township
West Bradford Township
West Goshen Township
Thomas Meeting Detention Basin