The Pearl of the Bayshore SM

Keyport

NEW JERSEY

# Hazard Mitigation Plan

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2007 Keyport Natural Resource Inventory
Multi-Jurisdictional Natural Hazard Mitigation Plan Monmouth County, New Jersey 2015 Update
State of New Jersey 2014 Hazard Mitigation Plan
Keyport Borough 2017 Master Plan
Keyport Borough Post Sandy Planning Neighborhood Plans
Keyport Borough Coastal Vulnerability Assessment

# Introduction

## Purpose

A Hazard Mitigation Plan is typically used as a major effort to reduce the loss of property and life by lessening the impacts of natural disasters. The key to lessening any impact of natural disasters lies in understanding them through past experiences, future modeling, and estimations. The more a municipality understands, the more it can do to implement proper mitigation strategies to reduce loss of property and life. This Plan will help identify risks and vulnerabilities associated with natural disasters, and develop long-term strategies for protecting the people and property of Keyport from future hazard events. The Keyport Borough Hazard Mitigation Plan is being funded through the New Jersey Department of Community Affairs Post-Sandy Planning Assistance Grant (PSPAG) program. This planning effort is being completed in conjunction with other PSPAG projects such as an Updated Master Plan, Coastal Vulnerability Assessment, Capital Improvement Plan, and Neighborhood Plans. Additionally, this Plan builds upon past planning efforts of the Borough such as the Strategic Recovery Planning Report (SRPR), Master Plan Reexamination, and ongoing hazard mitigation projects in the Borough. It should be noted that the Borough's recently adopted 2017 Master Plan shall take precedent if any content herein conflicts with the Borough's Master Plan.

### *Key Terms*[1]

For the purpose of clarity throughout this document, the following definitions are briefly outlined:

- A natural hazard is any hazard that occurs or results from acts of nature such as floods, earthquakes, hurricanes, tornadoes and coastal storms, to name a few. This plan addresses natural hazards only. It does not assess manmade hazards, technological hazards, or terrorism.
- A disaster is any catastrophic event that causes loss of life, injuries and widespread destruction to property. For the purpose of this document, a disaster is the result of a natural hazard, whether anticipated (such as flash floods with warnings) or fortuitous (such as earthquakes).
- Hazard mitigation is the method by which measures are taken to reduce, eliminate, avoid or redirect natural hazards in order to diminish or eradicate the long-term risks to human life and property.
- Mitigation is the effort to reduce loss of life & property by reducing the impact of disasters.
- A Hazard mitigation plan is a well-organized and well documented evaluation of the natural hazards and the extent that the events will occur. In addition, the plan identifies the vulnerability to the effects of the natural hazards typically present in a certain area, as well as the goals, objectives and actions required for minimizing future loss of life and property damage as a result of natural hazards.
- Hazard mitigation planning is the process of managing actions taken by individual citizens and professional organizations involved in mitigation activities. The process involves carrying out plans to reduce loss of life, injuries and damage to property, as well as reducing the costs associated with losses from natural hazards. It is a long-term process with benefits best realized over time.

## Planning Area

Located within Monmouth County in east-central New Jersey, the Borough of Keyport is a Bayfront community known as "The Pearl of the Bayshore", that was originally established in 1908. Keyport is one of the most northern municipalities within the County and is situated along the southern side of Raritan Bay across from Staten Island, NY. The Borough is approximately 1.469 square miles, of which 1.395 square miles is land and 0.074 square miles is water. It borders the Boroughs of Keansburg and Union Beach to the east, the Township of Hazlet to the south, and the Township of Aberdeen and Cliffwood Beach to the southwest, west, and northwest respectively.

[1] *Multi-Jurisdictional Natural Hazard Mitigation Plan – Monmouth County, New Jersey Draft – 2014 Plan Update.*

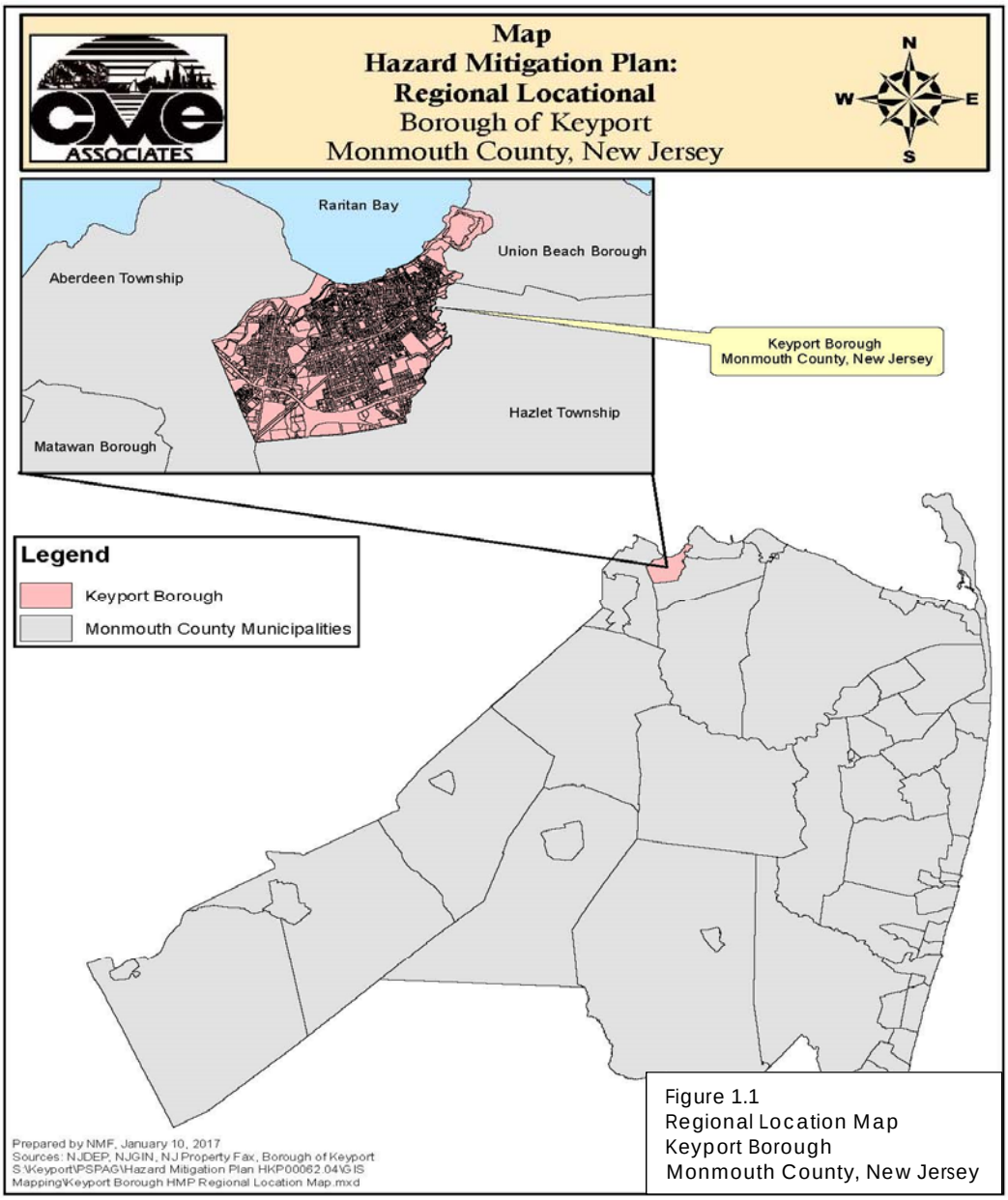



Figure 1.1
Regional Location Map
Keyport Borough
Monmouth County, New Jersey

Keyport contains a wide variety of natural resources and landscapes including beaches and dunes, deciduous forest, deciduous wooded wetlands, open tidal bays, saline marshes, tidal rivers, inland bays and other tidal waters/transitional areas. The Borough lies entirely within the Atlantic Coastal Plain, which is characterized by low lying terrain with open stream valleys and broad, gently sloping divides. This topography is a result of the differential erosion of unconsolidated, gently dipping strata of gravel, sand, silt, and clay. The majority of Keyport is at an elevation less than 50 feet, with the lowest areas located along the northern boundary of the Borough at sea level looking out over the Raritan Bay and the low lying area surrounding the Luppatatong Creek. The highest point of the Borough is situated to the south on Route 35 near its intersection with Clark Street which is at an elevation of 47 feet above mean sea level. Steep slopes are found along the Luppatatong Creek near the southern border of the Borough and near the confluence of the Matawan Creek and Raritan Bay near the north end of Broadway. Coastal bluffs are also considered a type of steep slope, which are

located in various sections along the Raritan Bay at the northern border of the Borough[2].

From the 1930's to the 1970's the Borough encountered a significant increase in population with a total increase of 31.4 percent over that time period. Over the next two decades there would be a slight increase in population, but since the 1990's the total population of Keyport has declined. From 1990 to 2000 the Borough saw a 0.2 percent decrease and from 2000 to 2010 the Borough saw a 4.5 percent decrease in total population. Table 1.1 below displays the population changes within the Borough and the County from 1980 to 2010 as well as the estimated total population for 2040 along with its percent change. The 2040 estimated population was derived from the North Jersey Transportation Authority's Plan 2040 Forecasts dated April 26, 2013. As shown in the table, it is believed that Keyport Borough will have a population increase of 3 percent or 220 residents by 2040. It should be noted that this projection does not take into account recent redevelopment projects that will likely raise the population beyond 7,460 assuming no population reduction.

According to the 2010 US Census, the population density of the Borough was 5,188.4 persons per square mile. The Borough contained 3,272 housing units at an average density of 2,344.8 houses per square mile. These numbers compared to the 2000 US Census were slightly lower compared to 2010 figures with a population density of 5,358.4 persons per square mile and 2,407.3 houses per square mile.

The figure below represents population density in the Borough using 2010 Census Data. No data was available for existing buildings that could be mapped.

**Table 1.1**

**Keyport Borough/ Monmouth County Population Change and Projections**

| | 1980 Census | 1990 Census | 2000 Census | 2010 Census | 2040 Estimate | Absolute Change 2010 - 2040 | Percent Change 2010 - 2040 |
|---|---|---|---|---|---|---|---|
| Keyport Borough | 7,413 | 7,586 | 7,568 | 7,240 | 7,460 | 220 | 3.00% |
| Monmouth County | 503,173 | 553,124 | 615,301 | 630,380 | 696,920 | 66,540 | 10.60% |

Figure 1.2
Population Density Map
Keyport Borough
Monmouth County, New Jersey


[2] *Natural Resource Inventory Borough of Keyport Monmouth County, New Jersey, August 2007.*

Figure 1.3
Neighborhood Boundaries
Keyport Borough
Monmouth County, New Jersey


The Strategic Recovery Planning Report (SRPR) specifically created for the Borough four neighborhoods that have experienced flood issues and hazards in the past and continue to be vulnerable to flood hazards or storm disasters such as Hurricanes, storm surge, or Sea Level Rise. These four neighborhoods include the Beers Street Basin, Division Street Basin, Walnut-Oak Street Basin, and the First Street Basin Neighborhoods. The First Street Basin Neighborhood is one of the more significant areas of vulnerability because it includes the Borough's downtown commercial corridor, the Borough's Historic District, and also provides possibly the single largest attractor in the Borough, public waterfront access to the Raritan Bay. This section of Keyport is vital to the community since it encompasses a large portion of Borough businesses, Marina's, Parks, Open Space, the Waterfront Promenade, the municipal boat launch, and residential complexes, apartments, and single family homes along or near the Raritan Bay.

**Neighborhoods**

The First Street Basin Neighborhood is the biggest Neighborhood within the Borough. It is located in the most northern part of Keyport along the Raritan Bay, which acts as its northern border. The Neighborhood's eastern and western borders range from Broadway up to Cedar Street with four different streets creating its southern border including West Front Street, East Front Street, a small segment of Church Street, and finally 1st Street.

The Beers Street Basin Neighborhood is one of the smaller neighborhoods in Keyport. This Neighborhood is located near the center of the Borough just west of Borough Hall. The Luppatatong Creek acts as its natural western border with West Front Street acting as the northern border, Elizabeth Street acting as the southern border, and the eastern border being Kearney Street. The Neighborhood is mostly residential with some commercial establishments situated along West Front Street. The Sandpiper development, the 50 Beers Street Senior Apartment Complex, and the 15 unit townhouse development know as 45 Beers Street (currently under construction to above BFE) are some of the larger residential developments within this portion of the Borough. The Beers Street Neighborhood also encompasses some vacant land along the Luppatatong Creek. One of the defining features of the Neighborhood is the Luppatatong Creek which regularly floods the Neighborhood, specifically along Beers Street, frequently during normal storm events or during moon tides. The flooding that occurs quite regularly inhibits pedestrian and vehicular traffic. Past major storm events such as the 1991 and 1992 Nor-Easters, Hurricane Irene, and Superstorm Sandy caused severe flooding to the Neighborhood.

The Division Street Basin Neighborhood is the smallest neighborhood within the Borough and is located near the center of Keyport. The Neighborhood's northern and southern borders are small portions of East Front Street (north border) and 3rd Street (south border) with its eastern border running along Church Street and its western border running along Broad Street. The Division Street Neighborhood consists mainly of commercial establishments including the eastern end of the downtown commercial district. The defining feature of this Neighborhood is its low lying area that acts as a basin. This area, or basin, was created by a significant dip along Division Street between 3rd Street and East Front Street, which used to be a pond. This basin is the culprit for common flooding during heavy rain fall and major flood damage during Nor'easters or Hurricanes. During Superstorm Sandy, approximately eight (8) business were subject to flooding along with a handful of single family home owners.

The Walnut-Oak Street Basin Neighborhood is situated in the eastern portion of the Borough along the Bayfront and bordered by the Chingarora Creek. The Neighborhood consists of the developed portion of the Aeromarine site which is a critical area due to the presence of brownfields. The open space located to the northeast of the Aeromarine Site is included outside of the Neighborhood and is designated Vulnerable Area 4 according to the Keyport CVA. The Neighborhood's borders consist of the Raritan Bay to the north, the Chingarora Creek to the east, Cedar Street and Fulton Street to the west, and 2nd Street to the south. This section of the Borough is defined by the Cedar Street Park, the Bay frontage, the Chingarora Creek, and the former Aeromarine Redevelopment Area. Mainly residential uses, the Aeromarine site, open space, and wetlands along the Chingarora Creek make up the Walnut-Oak Street Basin Neighborhood. This area of Keyport is susceptible to flooding due to its low elevation and proximity to the Raritan Bay and Chingarora Creek. During Superstorm Sandy approximately thirty (30) properties experienced damage. Poor stormwater management facilities also cause the Neighborhood to be prone to flooding along the creek.

**Vulnerable Areas**

In addition to the four neighborhoods, the Borough's Coastal Vulnerability Assessment (CVA) introduced four vulnerable areas. These additional areas of vulnerability were added after reviewing Keyport's storm surge and Sea Level Rise maps which found these areas to have vulnerabilities outside of the original four neighborhoods. These areas are described in the following sections below.

The first vulnerable area envelops a large range of land located within the western portion of the Borough. This area includes land north of Route 35 and/or the Henry Hudson Trail and west of the First Street Basin Neighborhood, Beers Street Basin Neighborhood, and Kearney Street. This area mainly consists of residential single family homes and marinas along the Matawan Creek with a few commercial structures along Route 35. There are two redevelopment areas within this first vulnerable are known as the Brown's Point Marina Redevelopment Area and the Longview/Boatworks Redevelopment Area.

The second vulnerable area is located to the east of the first vulnerable area almost directly in the center of the Borough. This area is mainly comprised of residential uses with commercial uses spread throughout key intersections closer to the downtown commercial district. Kearny Street and the Beers Street Basin Neighborhood act as the western boundary while the northern boundaries include West Front Street, the Division Street Basin Neighborhood, and First Street Neighborhood. The eastern boundary is formed by Fulton Street while the Henry Hudson Trail runs along the southern boundary of vulnerable area two.

Vulnerable area three is situated to the eastern portion of Keyport bordering Hazlet Township and the Chingarora Creek. This area is almost entirely residential with numerous large apartment or condo complexes, open space areas including a park and cemetery and some commercial properties positioned along Route 36. The western boundary is shared with a number of streets including Broad Street, Main Street, and Atlantic Street. The southern and eastern borders are formed by the Chingarora Creek. The northern boundary is delineated by the Henry Hudson Trail and 2nd Street.

The fourth and final vulnerable area is located in the most northeastern section of the Borough. This area is an open space area known as the Aeromarine Redevelopment Area. There are no uses currently in existence in this location, but the area consists of open space, a landfill, benches, and vegetation. The borders include the Chingarora Creek to the south, east, and north, the Raritan Bay to the west, and a small portion of the Aeromarine Redevelopment Area forming the rest of the southern border.

## Goals and Objectives

The Borough's priorities with respect to hazard mitigation revolve around the Borough's main Hazard Mitigation Goal:

*"Protect the Borough of Keyport, its citizens, assets, and operations in the best possible manner from the effects of natural hazards."*

All objectives and strategies included and proposed within this Plan will ultimately be aimed at accomplishing the Borough's main Hazard Mitigation Goal. The following objectives were decided to be accomplished as benchmarks to achieve the Borough's main Hazard Mitigation Goal:

- Reduce exposure of all properties within the flood hazard area of the Borough including residential homes proximate to the Raritan Bay and creeks/waterways leading to the Bay;
- Protect the Borough's Commercial district by reducing exposure of commercial properties from damages from all hazards;
- Mitigate risk to all potential natural hazards and reduce the vulnerability of critical facilities that the Borough and its citizens rely upon;
- Implement multiple hazard mitigation techniques including buying at-risk properties, increasing open space, reducing impervious coverage, improving stormwater drainage through green and grey infrastructure, raising at-risk structures, and constructing hazard mitigation structures where needed;
- Effectively implement floodplain ordinances, regulations, and building codes designed to protect structures from flood hazard damage;
- Continue to pursue CRS certification to improve flood insurance rates and also improve public education regarding potential flood hazard damages to Borough residents and businesses; and
- Work with federal, state, and county agencies to leverage mitigation funds to reduce exposure and increase resiliency to all hazards that threaten the Borough.

In addition, the objectives of the Hazard Mitigation Plan are pursued through the following initiatives:

- Protect vulnerable areas from coastal and pluvial flooding.
- Develop gray and green infrastructure solutions to mitigate the impact of flooding events.
- Identify points of necessary infrastructure coordination with neighboring municipalities.
- Plan for operational continuity of critical infrastructure networks (energy, water, sewage, mobility, medical, communications, etc.) in the case of an emergency event.
- Facilitate mobility and connectivity for ease of emergency evacuation.

## Stakeholder Engagement

A local planning team including the Resiliency Sub-committee was formed to assist with the Post Sandy Planning Assistance Grant projects and to provide valuable citizen knowledge to these projects. This sub-committee consisted of key stakeholders and several participating residents of Keyport. Borough officials participated in the stakeholder engagement process as part of the overall local planning team. In coordination with the local planning team, a Community Resiliency Meeting was held on June 30th, 2016 at the consolidated Firehouse located at 34 First Street in the Borough of Keyport. At this meeting, many residents came to provide input regarding the community's needs and issues with respect to hazard mitigation. The input and recommendations from residents have been included not only within this Plan, but throughout Keyport's Post Sandy Planning documents such as the Master Plan and Neighborhood Plans.

## Hazard Identification and Analysis

The hazard identification section will overview and evaluate all natural hazards that have the potential to impact the Borough of Keyport including previous hazards the Borough has experienced, the type and location of natural hazards that can affect the Borough, and the magnitude of damage of said natural hazards on the Borough. Please note that when the term "planning area" is used, it is referring to the boundary limits of the

Borough of Keyport. It is important to note that only natural hazards are included within this assessment so this precludes terrorism or man-made disasters. The hazards identified herein that threaten the Borough of Keyport were mainly found through research of existing sources such as the Monmouth County Multi-Jurisdictional Hazard Mitigation Plan (MCMJHMP) or the New Jersey State Hazard Mitigation Plan. This section begins with previous hazards the Borough of Keyport has experienced over the last several decades.

## Significant Previous Hazards

Keyport Borough is susceptible to several hazard events due to its geographic location such as extreme temperatures, extreme wind, hurricane and tropical storms, lighting, nor'easters, tornados, winter storms coastal erosion, drought, flooding, storm surge, wave action, earthquakes, and wildfires. Each one of these hazards plays a significant role in the impact it can have on a community. Shown below is a list from the Multi-Jurisdictional Natural Hazard Mitigation Plan of Monmouth County, New Jersey that has effected the Borough over the past several decades.

**Table 1.2**

**Summary of Identified Hazard Events in Keyport**

| | Atmospheric | | | | | | | Hydrologic | | | | | | Geologic | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jurisdiction | Extreme Temperatures | Extreme Wind | Hurricanes and Tropical Storms | Lightning | Nor'easter | Tornado | Winter Storm | Coastal Erosion | Dam Failure | Drought | Flood | Storm Surge | Wave Action | Earthquake | Landslide | Wildfire |
| Keyport Borough | • | • | • | • | • | • | • | • | | • | • | • | • | • | | • |

Some of these hazards occur more often within the Borough then others. Keyport is mainly affected by tidal flooding, storm surge, erosion, and wind damage from coastal storms, nor'easters, and hurricanes. An example is on February 24th, 1998, a powerful nor'easter brought very strong winds and coastal flooding to the Jersey Shore. The worst conditions affected Monmouth County with tidal departures averaging around three feet above the normal height. This storm caused a breach in a sea wall in Borough of Allenhurst causing immense flooding, which closed several roads such as New Jersey State Route 35 and 36 in the Township of Sandy Hook and the Boroughs of Sea Bright and Keyport.

Between March 12 and April 15, 2010 there was an incident period in which a severe storm producing a large amount of rain in a very short period of time had sustaining winds of over 70 miles per hour (MPH) that passed throughout the Borough. The strong winds and wave actions caused damage to four seafront locations including the Fireman's Park Boardwalk, Benjamin Terry Park Bulkhead, the William Ralph Fishing Pier, and the Keyport Waterfront Park.

During an incident period lasting from December 26 through December 27, 2010 a severe snow storm disrupted transportation and public safety systems. Several roads were closed or severely compromised creating threats to public health and safety as well as limiting access to medical facilities, schools, food, fuel, utilities, and access for Police, Fire and Rescue units. A major disaster was declared on February 2011. A Major Disaster Declaration is declared by the President of the United States in the occurrence of any natural event that has caused damage of such severity that it's beyond the combined capabilities of State and local governments to respond. This declaration provides a vast array of Federal assistance programs for individuals and public infrastructure, including funds for emergency and permanent work.

High winds, heavy rain, and localized flooding from Hurricane Irene occurred during an incident period between August 27, 2011 and September 5, 2011. The Hurricane caused the evacuation of residents and created a public health threat due to reduced access to medical facilities, school, food, fuel, and utilities. The storm also caused a public safety threat due to reduced access to services to Police and Fire and Rescue units. On August 31, 2011, a major disaster was declared.

One of the more recent past hazards that hit the Borough was Superstorm Sandy. This incident period occurred between October 26 and November 8, 2012 with a major disaster being declared for the State of New Jersey

on October 29, 2012. Sandy caused widespread damage throughout New Jersey including power outages, severe coastal erosion, flooding, and damage or destruction to infrastructure, public properties, and caused very large volumes of storm related debris. More specifically, heavy rains, high sea levels and winds caused the inundation of two of the Borough's sanitary pump stations known as the Maple Place Pump Station and Cedar Street Pump Station. During this incident period, severe storm surge, flooding, and high winds also caused damages to Waterfront Park located on American Legion Drive situated along the Raritan Bay.

## Assessment of Type and Location of Natural Hazards

As illustrated in Table 1.2, the Borough has experienced and continues to be susceptible to the following Natural Hazards:

- Extreme Temperatures
- Extreme Wind
- Hurricanes and Tropical Storms
- Lightning
- Nor'easter
- Tornado
- Winter Storm
- Coastal Erosion
- Drought
- Flood
- Storm Surge
- Wave Action
- Earthquake
- Wildfire

This section will discuss each identified hazard in terms of the threat it poses to the Borough and potential magnitude of damage for each.

**Extreme Temperatures**

Keyport is located in a region within Monmouth County that is susceptible to both extreme heat and extreme cold. During periods of extreme temperature conditions, the effects are felt over a widespread geographic area and it is generally assumed that the entire planning area is uniformly exposed to extreme heat and extreme cold. Areas along the immediate coast might experience minor differences in apparent temperatures due to the combined effects of air temperature, relative humidity, and wind speed.

The onset speed of extreme temperature events typically offers 24 hours of warning time. The duration of historic events in Monmouth County is commonly less than on week. The extent of extremely cold temperatures is typically measured through the Wind Chill Temperature (WCT) Index. The WCT Index provides a formula for calculating the dangers from winter winds and freezing temperatures. It is essentially, a calculation of the temperature that is felt when the effects of wind speed are added to the base air temperature. Figure 1.3 displays the NOAA NWS Wind Chill Chart.

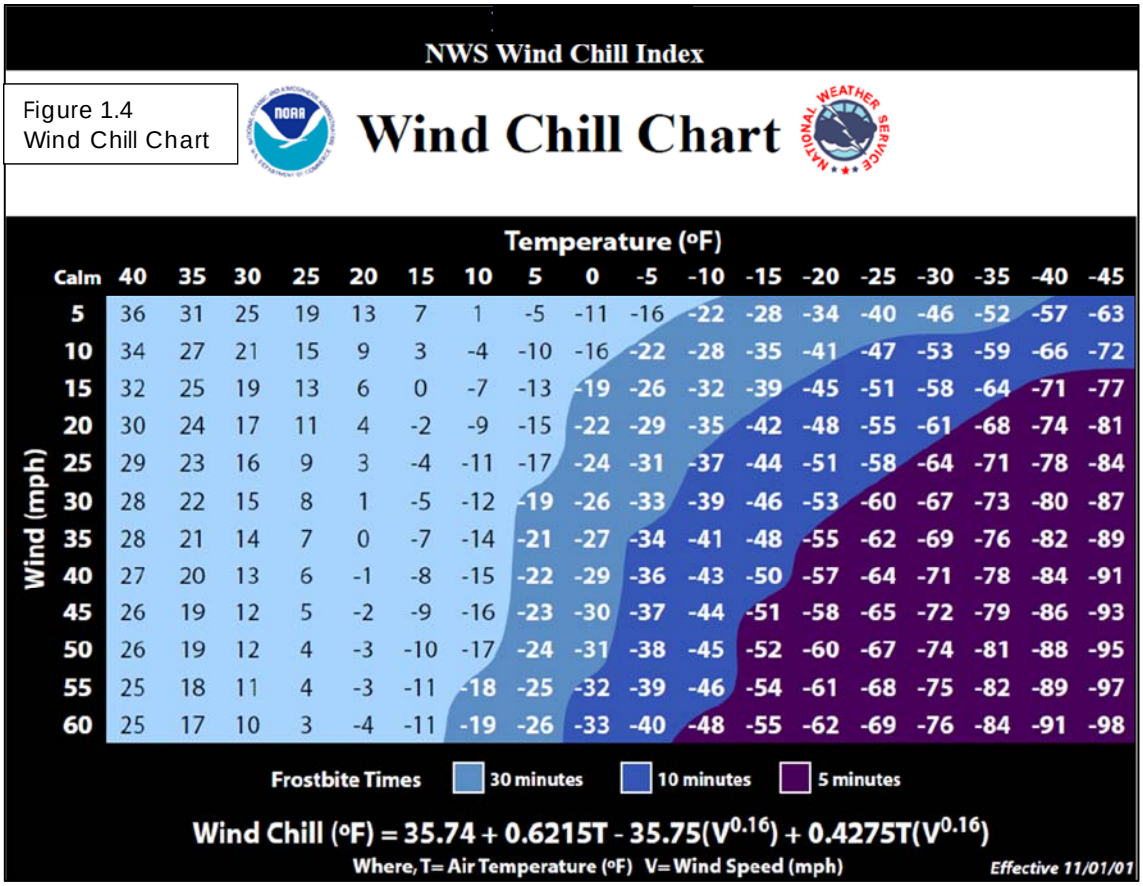



Figure 1.4
Wind Chill Chart

The extent of the extremely hot temperatures is typically measured through the Heat Index shown below in Figure 1.4, which calculated the dangers from high relative humidity and extremely hot temperatures. It is basically, a calculation of temperature that is felt when the effects of relative humidity are added to the base air temperature.

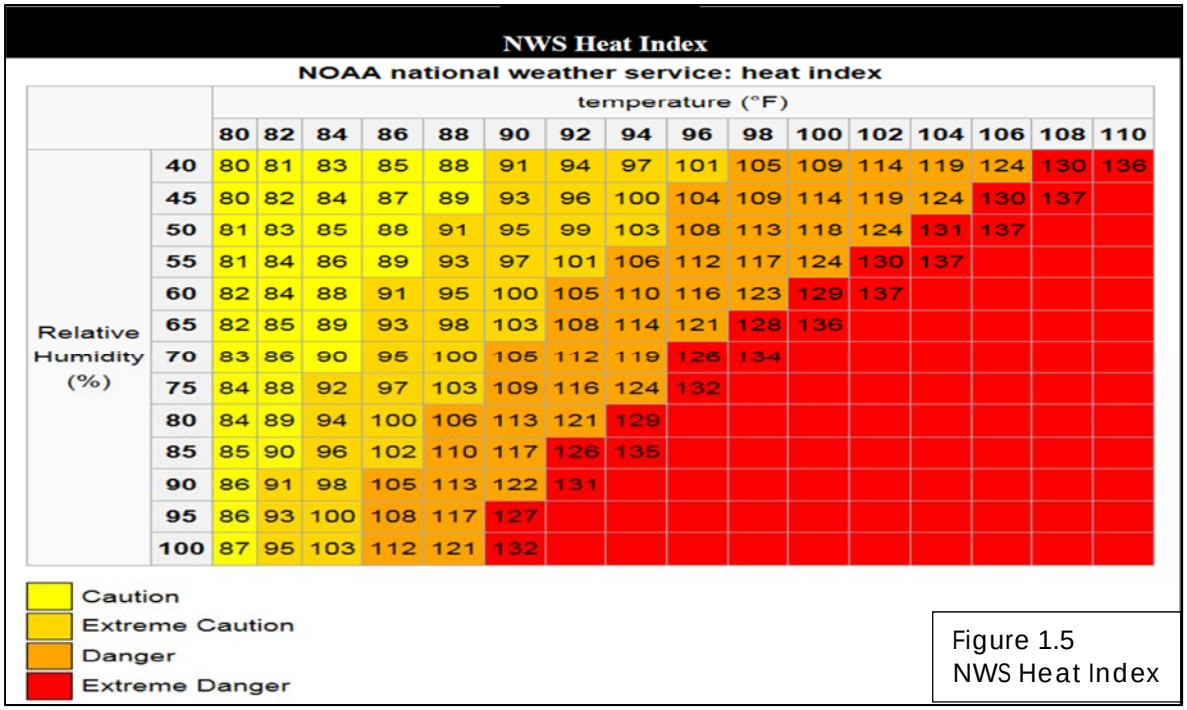



Figure 1.5
NWS Heat Index

Extreme temperature events will continue to have a high probability of occurrence within the Borough and the probability of future occurrences within the Borough is likely (higher for extreme heat than extreme cold). Additionally, climate change may play a role in the probability of increasing or decreasing extreme temperatures for either extreme heat or cold. While the impact of such occurrences on people and property is usually minimal, it is anticipated that the threat to human lives and safety for Keyport's elderly population is increased. The U.S. Global Change Research Program was cited on the EPA's website that by 2100, the average U.S. temperature is projected to increase by about 3 degrees Fahrenheit or more depending on emission scenarios and climate models. This would likely affect Keyport especially in the summer months.

**Extreme Wind**

The entire planning area is subject to extreme wind from Nor'easters, Hurricanes, Tropical Depressions or storms, and Thunderstorms. The Borough is susceptible to extreme wind usually during one of the previously listed events, but can occur on its own. The Planning area is vulnerable to extreme wind most of the year with the highest potential occurring in the summer and fall months. Winter Storms are excluded for this extreme wind category as winter storms has its own category where extreme winds will be addressed. The severity of a wind hazard is usually measured by velocity and the hazard can be exacerbated if wind speeds are high enough to blow debris. The following table was produced from the Monmouth County Multi-Jurisdictional Hazard Mitigation Plan on page 3a-9. The table outlines severity and typical effects of sustained wind speeds at different levels.

**Table 1.3: Severity and Typical Effects of Various Sustained Wind Speeds**

| Sustained Wind Speed (MPH) | Equivalent Saffir-Simpson Scale | Severity of Damage | Typical Effects |
|---|---|---|---|
| 0-73 | N/A | Isolated | Isolated damages below 50 mph. Above 50 mph causes minor damage to buildings of light material, along with small branches blown from trees. |
| 74-95 | 1 | Minor | Very dangerous winds produce damage to frame homes, roofs, shingles, siding, gutters, and trees. Damage to power lines and poles resulting in power outages for several days. |
| 96-110 | 2 | Extensive | Extremely dangerous winds causes extensive damage to homes with major roof and siding damage. Downed trees block roads and power loss is expected for several days to weeks. |
| 111-129 | 3 | Devastating | Devastating damage to homes including roofs, decks, and siding. Many trees uprooted blocking many roads. Electricity and water unavailable for several days to weeks after storm passes. |
| 130-156 | 4 | Catastrophic | Catastrophic damage to homes. Severe damage to roofs and walls. Power outages from fallen trees will last weeks to months. Uninhabitable areas. |
| 157 or higher | 5 | Catastrophic | Catastrophic damage. High percentage of framed homes will be destroyed. Fallen trees and power poles will isolate residential areas. Power outages ranging from weeks to months. Most areas uninhabitable. |

Past occurrences of Extreme Wind events have been collected by the National Oceanic and Atmospheric Administration. The results were filtered and analyzed to include events involving speeds of 50 knots or more, from 1990 to present, and in and around the Planning Area. Based on the following table and historical precedence, the Borough can expect extreme wind vents between 5 and 10 times per year.

| Table 1.4: Past Occurrences of Extreme Wind Events Post 1990 | | | | | |
|---|---|---|---|---|---|
| **Date** | **Velocity** | **Death** | **Injury** | **Property Damage** | **Description*** |
| 9/9/1998 | 75 MPH Gusts | 1 | 30 | $500,000 | A squall line of severe thunderstorms downed trees and power lines in the County. Many boats were rescued in Sandy Hook Bay. |
| 2/23/1998 | 53 Knots | 0 | 0 | $0 | A strong Nor'easter brought very strong winds and coastal flooding to Keyport including flooding on Routes 35 and 36 which were closed. Tidal departures averaged 3 feet above normal throughout the County. |
| 12/12/2000 | 55 Knots | 0 | 0 | $50,000 | A low pressure storm system produced high winds across New Jersey including near Keyport. Impacts near the Borough include winds at 54 miles per hour and lower than normal tides from blow out winds. |
| 8/2/2002 | 83 MPH | 0 | 0 | $10.2 Million | Severe thunderstorms caused hurricane force wind gusts downing thousands of trees and powerlines. Most county municipalities reported damaged and a state of emergency was declared for Monmouth County. |
| 11/13/2003 | 58 Knots | 0 | 0 | $50,000 | A low pressure system produced high winds near the Borough including winds at 67 mph near Sandy Hook. 9,000 homes and businesses lost power in Ocean & Monmouth Counties. |
| 1/14/2006 | 50 Knots | 0 | 0 | $25,000 | An intense low pressure system brought wind gusts in Keansburg near Keyport at 61 miles per hour. Power loss to homes occurred in the County but none reported in the Borough. |
| 2/12/2009 | 50 Knots | 0 | 0 | $100,000 | Strong to High Winds affected New Jersey including Monmouth County. Power lines and trees were brought down and wind gusts in Keansburg were measured at 59 miles per hour. |
| 3/13/2010 | 58 Knots | 0 | 0 | $500,000 | Strong to high winds downed thousands of trees and limbs and telephone poles which caused record breaking outages including 180,000 customers losing power in Monmouth & Ocean Counties. 65 to 70 mile per hour gusts were recorded in Keansburg and Sandy Hook. |
| 8/28/2011 | 63 MPH | 0 | 0 | $100,000 | Hurricane Irene created gusts of 63 mph at Sandy Hook and caused downed trees and power lines leaving some Keyport residents without power. |
| 10/29/2012 | 76 Knots | 0 | 0 | $1.5 Billion | Post Tropical Storm Sandy caused terrible damage to the Borough including wind damage. Large property damage was done to homes and boats from the high winds but difficult to ascertain exactly how much just from wind. |
| 12/26/2012 | 50 Knots | 0 | 0 | $25,000 | An intense low pressure system brought high northeast winds to eastern central Jersey including Keyport and Monmouth County. 7,000 customers lost power and moderate tidal flooding occurred from the winds including Route 35 in sporadic areas around Keyport. The highest tide in Sandy Hook reached 7.83 feet above average and gusts reached 61 MPH in Sandy Hook. |
| 1/31/2013 | 55 Knots | 0 | 0 | $10,000 | High winds caused power outage to 1,700 customers in Monmouth County and reported wind damage. Sandy Hook saw peak wind gusts at 63 mph. |
| 3/6/2013 | 53 Knots | 0 | 0 | $10,000 | An intense Nor'easter brought strong to high winds along the Raritan Bay including minor tidal flooding. Keyport experienced some effects of this Nor'easter including Route 35 closures. |

*Velocity, Death, Injuries, and Property Damage are County wide and not particular to Keyport. Descriptions were summarized based on relativity to the Borough.

### Hurricanes and Tropical Storms

Keyport has a long history of enduring the damaging effects of Hurricanes and Tropical Storms along with the entire Atlantic and Gulf seaboard of the United States. Keyport is vulnerable to all effects and hazards associated with hurricanes and tropical storms including wind damage, flooding from extreme precipitation, storm surge, wind-driven waves, and tidal flooding. Table 1.5 discusses the levels of Hurricane intensity according to the Saffir-Simpson Scale which rates intensity on a scale of 1 to 5 with 5 being the most intense. Categories 3, 4, and 5 are considered "major" hurricanes although the chance of a major hurricane is much lower (20% annually) than a lesser strength tropical storm hitting Keyport.

| Table 1.5: Saffir-Simpson Scale for Hurricanes | | | |
|---|---|---|---|
| **Category** | **Maximum Sustained Wind Speed (mph)** | **Minimum Surface Pressure (Millibars)** | **Storm Surge (Feet)** |
| 1 | 74-95 | Greater than 980 | 3-5 |
| 2 | 96-110 | 979-965 | 6-8 |
| 3 | 111-129 | 964-945 | 9-12 |
| 4 | 130-156 | 944-920 | 13-18 |
| 5 | 157+ | Less than 920 | 19+ |

According to NOAA records, Monmouth County has had 36 hurricane or tropical storms pass within 75 miles since 1850. Almost all of these hurricane events have affected Keyport on some level whether it be major damage caused by multiple hazards from a hurricane, or minor inconveniences such as local roadway flooding that caused minimal to zero damage. Below is a list of Hurricanes or Tropical Storms that have affected Keyport Borough since 1985.

| Table 1.6: Hurricanes/Tropical Storms affecting Keyport Borough since 1985 | | | |
|---|---|---|---|
| **Date** | **Storm Name** | **Maximum Wind Speed (mph)** | **Category** |
| 9/24/1985 | Henri | 40 | Tropical Storm |
| 9/27/1985 | Gloria | 100 | Category 2 |
| 7/13/1996 | Bertha | 70 | Tropical Storm |
| 9/16/1999 | Floyd | 70 | Tropical Storm |
| 9/6/2008 | Hanna | 45 | Tropical Storm |
| 8/28/2011 | Irene | 65 | Tropical Storm |
| 10/29/12 | Sandy | 80 | Post-Tropical Storm |

Of these Hurricanes and Storms, the most impactful to the Borough includes Hurricane Gloria, Tropical Storm Floyd, Tropical Storm Irene, and Superstorm Sandy. All of these events caused tidal flooding, storm surge, and wind damage to Keyport Borough. Hurricane Gloria downed thousands of trees, caused power outages, and averaged storm surge tides of 2 meters above predicted levels. Tropical Storm Floyd was one of the most devastating to Keyport Borough besides Superstorm Sandy due to the very high levels of precipitation that coincided with high tide. This caused damage along coastal areas such as Raritan Bay and waterways, and Routes 35 and 36 were closed from flooding. Keyport received about 6 inches of rain and experienced wind damage.

Tropical Storm Irene brought extreme precipitation and torrential rains which caused major flooding along with a 3 to 5 foot storm surge. Tidal flooding also occurred along the Raritan Bay which caused damage to homes along First Street and other areas proximate to the Raritan Bay. Routes 35 and 36 were closed, many homes lost power, and flood damage was reported throughout the Borough due to the 6 inches of rain that fell coupled with the wind, surge, and tidal flooding.

Superstorm Sandy is still firmly in the minds of all Keyport residents as it caused a record amount of damage to the Borough. The effects of Superstorm Sandy are well documented within the Borough's Strategic Recovery Planning Report and recently adopted Community Resiliency Element of the Master Plan. The Community Resiliency Element notes that "26 percent of the Borough's land area was inundated by flooding." Landmarks within the Borough were destroyed including the Ye Cottage Inn restaurant and the Keyport Steamboat Dock Museum. Overall, 61 residential properties were impacted with a majority being damage from water intrusion, 38 businesses reported impacts especially in the Division Street Neighborhood, and extensive damage was caused to private marinas, public property, and other areas of the Borough from flooding and erosion. Financially, the Borough received $10.5 million in obligated disaster funding but lost almost $6 million in tax ratables. Recovery from Superstorm Sandy is still ongoing today and power outages took weeks to restore. The entire storm was by far the most severe to the Borough in terms of overall impact to public and private property, utilities, operating businesses, and Borough operations.

The probability of future hurricanes and tropical storms affecting the Borough of Keyport is high. Additionally, the frequency and strength of future hurricanes and tropical storms is predicted to increase due to climate change. The following was is an excerpt from the Monmouth County Multi-Jurisdictional Hazard Mitigation Plan,

"*According to the NOAA data on historical storm tracks, the annual probability of a hurricane or tropical storm coming within 75 miles of Monmouth County is 22 percent. Also, a recent study headed by Colorado State University's Dr. William Gray concluded that the probability of a named storm making landfall in the vicinity of Monmouth County is 13.2 percent.*"

There are no statistics available for the probability solely for the Borough of Keyport. However, it is generally accepted that the probability will only go up along with ever increasing intensity, frequency, and negative effects from future Hurricanes or Tropical Storms. As outlined in the Risk Assessment and Action sections of this Plan, it is recommended the Borough of Keyport be as prepared as possible for the next Hurricane or Tropical Storm that comes near or makes actual landfall over the Borough.

**Lightning**

Lightning strikes can occur anywhere and at any time in the World and United States. The Borough of Keyport is no exception. As is commonly known, the area's most common for lighting strikes are open areas with no trees or tall structures such as golf courses, open space, parks, beaches, and similar recreational areas. Of the 18 lightning strike occurrences in Monmouth County over the last 20 years, none have caused death, injury, or damage in the Borough of Keyport. The probability of future lightning strikes is certain. The Borough is in an area of the country that can expect three lightning flashes per square kilometer per year, however, when and where are entirely unknown.

**Nor'easter**

A Nor'easter is a cold-core extratropical cyclone forming along the U.S. Mid-Atlantic coast and moves northeastward as it strengthens according to the Dolan and Davis study from 1992. Nor'easters are quite common for the Borough of Keyport as they are for much of the Atlantic seaboard of the United States. The effects of Nor'easters can be quite significant and the hazards that come with Nor'easters are similar to those hazards from Hurricanes or Tropical Storms albeit on a lesser scale and intensity. Nor'easters are weaker pressure systems with wind speeds typically less than that of a Category 1 hurricane but they occur more frequently, can be much larger in size, and continue for several days. Typical hazardous effects from Nor'easters are extreme wind, flooding, heavy snowfall, storm surge, wave action, coastal erosion, and tidal flooding. Waves can overcome dunes and retaining walls, erosion of beaches can be significant from wave attacks, and tidal flooding can cause serious damage. The last four hazards especially pertain to coastal areas of the Borough. Nor'easters that affect the Borough typically cause damage from flooding and surge in low lying areas such as Beers Street, the Waterfront Promenade near Fireman's Park, and homes along the Raritan Bay on 1st Street. In 1992 Dolan and Davis conducted a 42 year study on the effects of northeast storms from 1942 to 1984 at Cape Hatteras, North Carolina. This study produced an intensity scale based on costal storm erosion, property damage, and overall negative effects. Table 1.7 below outlines the Dolan-Davis scale.

**Table 1.7: Dolan-Davis Nor'easter Intensity Scale**

| Storm Class | Beach Erosion | Dune Erosion | Overwash | Property Damage |
|---|---|---|---|---|
| 1<br>Weak | Minor changes | None | No | No |
| 2<br>Moderate | Modest; mostly to lower beach | Minor | No | Modest |
| 3<br>Significant | Erosion extends across beach | Significant | No | Loss of local level structures |
| 4<br>Severe | Sever beach erosion/recession | Severe dune erosion/destruction | On low beaches | Loss of community scale structures |
| 5<br>Extreme | Extreme beach erosion | Dunes destroyed | Massive in channels | Extensive at regional scale |

Source: FEMA

The Borough has a long record of Nor'easter impacts over the entire Borough's existence. The following table notes significant Nor'easter events since 1962 taken from the State Hazard Mitigation Plan, County Hazard Mitigation Plan, and NOAA records that appeared to have affected the Planning Area in a significant manner Significant in this context means flooding from tidal or surge that caused damage, winds downing trees and power lines causing many homes to lose power, or high winds that caused damage.

| Table 1.8: Significant Nor'easter Events in Keyport Post 1962 | |
|---|---|
| **Date** | **Description** |
| 3/6/1962 | One of the State's worst Nor'easters fueled storm surges for three straight days over five successive high tides with a maximum tidal elevation of 7.8 feet at Sandy Hook. Waves reached heights of 20 to 30 feet doing tremendous damage to Keyport's coastline. |
| 10/28/1991 | The Halloween Nor'easter known as the Perfect Storm caused strong waves 30 feet high, severe tidal flooding in the Bay, and extreme flooding in the Borough. Persistent intense winds caused extreme beach erosion along the bayfront. |
| 12/2/1992 | This storm caused extreme coastal flooding and extensive beach erosion for all of Monmouth County including Keyport. The tide in the Bay was 9 to 10 feet above normal and caused destruction of public and private properties. |
| 3/12/1993 | This was dubbed the "Storm of the Century" as it was one of the most powerful storms on record to hit New Jersey. High winds, high waves, tidal flooding, and 14 inches of precipitation near Keyport greatly impacted the Borough. |
| 2/23/1998 | A strong Nor'easter brought very strong winds and coastal flooding to Keyport including flooding on Routes 35 and 36 which were closed. Tidal departures averaged 3 feet above normal throughout the County. |
| 3/3/1998 | A severe Nor'easter in February impacted Monmouth County and produced some tidal flooding in the Borough. |
| 10/25/2005 | A developing nor'easter caused moderate tidal flooding along the Raritan Bay and Keyport's waterways. Wind gusts of 50 to 60 mph along with high waves caused tidal flooding and damage to the Borough. The Borough's storm drains and creeks overflowed, the waterfront promenade bulkheading was flooded and crashed with waves, and flooding from the Chingarora Creek surrounded 4 local roads in Keyport. |
| 3/16/2007 | High winds and minor tidal flooding caused some damage to the Borough. Hazards included sleet, snow accumulation, high winds, tidal flooding with 6.9 feet above mean lower low water at Sandy Hook. |
| 4/15/2007 | Tidal flooding occurred for three high tide cycles which caused flooding on Routes 35 & 36 and on Borough's local roads. High precipitation levels with tidal flooding caused beach erosion. Peak wind gusts were at 40 to 60 MPH. |
| 11/12/2009 | A major Nor'easter caused large amounts of damage in Monmouth County including Keyport. Governor Jon Corzine declared a state of emergency for the county because the Dolan Davis power ranking ranked it 4$^{th}$ strongest nor'easter to affect New Jersey since 1990. Rains, tidal flooding, and winds caused many Borough residents to lose power and experience flood damage. |
| 11/7/2012 | A strong nor'easter caused high winds and heavy snow along the coast including the Borough with 10 foot waves and minor tidal flooding. Caused setbacks for Superstorm Sandy restoration efforts and forced evacuations again. |
| 12/26/2012 | An intense low pressure system brought high northeast winds to Monmouth County including Keyport. 7,000 customers lost power and moderate tidal flooding occurred from the winds including Route 35 in sporadic areas around Keyport. The high tide in Sandy Hook reached 7.83 feet above the mean and gusts reached 61 MPH. |
| 3/6/2013 | An intense Nor'easter brought strong to high winds along the Raritan Bay including minor tidal flooding. Keyport experienced some effects including Route 35 closures. |

There is a high probability that the Planning Area will experience Nor'easters in the future and Nor'easters are expected to increase in frequency and intensity because of climate change just like Hurricanes and Tropical Storms. Many hazards the Borough faces will be impacted by climate change including higher coastal erosion rates, rising sea levels, and stronger storm effects. This will affect all facets of the Borough including private homes, businesses, public properties, utilities, transportation infrastructure, stormwater infrastructure, wastewater infrastructure, and government buildings.

**Tornado**

The Borough of Keyport has never experienced a tornado, however, nearby municipalities in Monmouth County have experienced tornados over the last 20 years which keeps the possibility of a tornado in the Planning Area within the realm of possibility. Compared to the rest of the nation, the Planning Area and surrounding municipalities experience a very low frequency of tornados and they usually are not very strong. Typically they are of low magnitude such as an F0 to F2. Tornados can occur anywhere and Keyport is no less susceptible than any other place in the County. Tornados are most likely to occur in September and October which is also the highest frequency for tropical storm systems. The most recent tornado that was even remotely close to Keyport was in August 1997 in Middletown Township and Highlands Borough. It was a light tornado that touched down in Middletown briefly, travelled into Highlands Borough, and went into the Sandy Hook Bay where it disappeared. Wind speeds reached 70 miles per hour and caused about $50,000 in damage. The probability of a tornado occurring in Keyport is quite low as less than 1tornado event occurs per year. The annual probability is estimated at less than 15%.

**Winter Storm**

Different kinds of precipitation come into play when dealing with winter storms such as sleet, snow, freezing rain, wintry mix, and the possibility of icy storms or conditions on roadways and sidewalks. The Planning Area has experienced many winter storms and is a common occurrence for the Borough every winter. The Borough of Keyport is not any more or less likely to experience a winter storm or blizzard than surrounding municipalities. The National Climatic Data Center (NCDC) has assigned values to over 500 storms to create ranking categories for regional snowfall. The rankings are in the table below.

| Table 1.9: Regional Snowfall Index Ranking Categories | | |
|---|---|---|
| **Category** | **Description** | **RSI Value** |
| 1 | Notable | 1-3 |
| 2 | Significant | 3-6 |
| 3 | Major | 6-10 |
| 4 | Crippling | 10-18 |
| 5 | Extreme | 18+ |

NOAA's National Centers for Environmental Information keeps a database and ongoing records of storm events across the nation. These records were accessed for Monmouth County winter storms since 1996. Any records that appeared to affect the Borough were included in the following table.

| Table 2.0: NOAA National Center for Environmental Information Records of Significant Winter Storms Post 1996 | |
|---|---|
| **Date** | **Description** |
| 1/6/1996 | Known as the Blizzard of 1996, this storm was technically a nor'easter as well as a winter storm/blizzard. This storm paralyzed the State of New Jersey with up to 4 feet of wind driven snow. This impacted the Borough with school closings, transportation routes shut down, and freezing conditions for multiple days. |
| 12/30/2000 | This storm was the heaviest snow fall since the Blizzard of 1996. Keyport received close to 14 inches of snow accumulation. This caused roads to be impassible until plows were able to clear and the heavy snow caused power outages to Borough residents. |
| 2/16/2003 | Known as the President's Day Storm, this storm caused the Governor to declare a state of emergency. Snow drifts reached six feet in height for Monmouth County. Strong winds caused homes and businesses to lose power in the Borough. Snow accumulations in the Borough came close to 20 inches. |
| 1/22/2005 | A very strong Alberta low pressure system dropped significant amounts of snow in the Borough of Keyport where accumulation reached close to two feet. Power outages occurred to some in the Borough of Keyport, NJ Transit experienced delays or closings, and local roadways were impassable until plowed. Also a state of emergency was declared so vehicles had to stay off public roads and thoroughfares. |
| 2/14/2007 | This Valentine's Day Storm was a severe winter storm that caused icing in Monmouth County including 0.5 inches of ice accumulation, peak winds of 48 mph, and 3 inches of total precipitation. Overall affects to the Borough were sporadic compared to the rest of the County. |
| 12/19/2009 | A major winter storm dropped heavy snow in Monmouth County including the Borough. Accumulations in Keyport reached between 14-20 inches of snow. Transportation options and roads were delayed or closed and schools were closed. The Borough did not report any damage from this storm. |
| 12/26/2010 | A record breaking winter storm and Blizzard affected Monmouth County to the point where the President approved federal disaster reimbursement for damages related to the storm. This storm paralyzed the Borough for several days with snow drifts closing roadways, closing of offices and schools, and some power outages. Snow accumulation reached 3 feet and at Sandy Hook the high tide reached 7.13 feet above mean which caused minor tidal flooding for the low areas of the Borough. |
| 1/21/2014 | A winter storm dropped heavy snow onto the Borough and entire state where the Governor declared a State of Emergency. Local roads were inundated with snowfall accumulation reaching 10 to 14 inches. Schools closed and some regional offices. |
| 1/26/2015 | A complex winter storm poured snow onto the Borough with accumulations around 10 inches. Sandy Hook Bay high tides reached 7.17 feet above mean which caused minor tidal flooding in the Borough. |
| 3/5/2015 | A cold front and low pressure system brought heavy snow to the Borough that reached close to 9 inches of snow. This caused transportation disruptions and early school closings. No tidal flooding associated with this winter storm. |

Winter storms will always have a high probability of occurring in the Planning Area. The same impacts can be expected for all winter storms with 6 or more inches of snow such as transportation issues, closing of schools and public offices, power outages, and some property damage or threats to human life due to ice, heart attacks from shoveling snow, and trees or structures collapsing from the weight of the snow. Winter Storms in Keyport occur usually from late November until the start of April. Peak months are December & March.

**Coastal Erosion**

The Borough of Keyport is susceptible to coastal erosion just like every coastal municipality in New Jersey. The Borough has experienced significant changes to its shorelines due to erosion. The most notable is the constant shoaling near the municipal boat ramp and the loss of beach area from erosion. The Borough's small beaches lose sand and depth but also accumulate debris from other coastal municipalities because of the tides pushing the debris to the Borough's beaches.

Keyport has several beaches, manmade bulkheads, timber breaks, and marshes along its Bayfront all of which are erodible except for bulkheads. The bulkheads and timber breaks help to prevent erosion but beaches and marshes are susceptible to erosion. According to NJDEP Shoreline Classifications in the Monmouth County HMP, Keyport is erodible where its western marinas are located and also where the Chingarora Creek meets the Raritan Bay.

Coastal erosion is caused over time by constant pressures from water, wind, and other forces of nature such as strong storms, flooding, wave action, and sea level rise. It can be intensified by human activities such as development that removes natural features that combat erosion and climate change which intensifies periodic natural events as previously discussed. The severity of coastal erosion is measured each year by comparison of the shoreline changes between each year. Unfortunately there is no erosion rate database for the County or even the Borough of Keyport that keeps track of how and where erosion affects the Borough. The best that can be done is comparing aerials of the Borough over long periods of time, however, this method, is far from perfect. It is recommended that the Borough keep track of major coastal erosions as best as possible such as shoaling, loss of beach area, and changing shorelines in a database. Having this information as current as possible would give the Borough the ability to make a case for grant funding to combat coastal erosion to its beloved Bayfront in crucial areas. The hazard assessments for Nor'easters, Hurricanes/Tropical Storms, and others have mentioned coastal erosion to some degree but never specific to the Borough itself. What is known is that the Borough has been affected by many nor'easters and several Hurricanes or Tropical Storms which have surely caused coastal erosion. A list of major Nor'easters and major storms that likely caused coastal erosion in the Borough are listed below.

- March 6, 1962 Nor'easter
- 1991 Halloween Nor'easter
- 1992 Nor'easter
- January 7, 1996 Blizzard
- August 27, 2011 Hurricane Irene
- October 29, 2012 Superstorm Sandy

Coastal erosion will certainly continue to affect the Borough in the future. Since it is a natural and continuing process due to unending geological forces, coastal erosion will always be a significant hazard that over time can have serious consequences. As iterated previously, coastal erosion will increase in frequency and intensity with sea level rise and overall climate change. Mitigation projects will be needed to combat coastal erosion and sea level rise. It is recommended to incorporate green and grey infrastructure practices when combating coastal erosion.

**Drought**

Droughts are regional hazards because lack of precipitation over time affects larger areas that encompass the Borough. Therefore, when the Borough experiences the drought, more than likely all of Monmouth County and possibly multiple New Jersey counties are experiencing drought at the same time. Monmouth County and the Borough of Keyport usually experience short term, less severe droughts. Drought conditions are possible for the Borough at any time of the year. The intensity of the drought depends on several factors including regional water supply demands for farming and household needs, duration, and temperature. The Palmer Drought Severity Index (PDSI) is an available drought indicator uses to assess a drought event. The PSDI classifications range from -0.5, incipient dry spell, to -4.0, extreme drought. NJDEP uses its own system of indication based on characteristics of the entire State. It supplements the PDSI with additional

measurements such as stream-flow, regional precipitation, reservoir levels, and groundwater levels. NJDEP uses the status of near or above normal, moderately dry, severely dry, and extremely dry. The following historical occurrences since 1997 have affected the County and therefore the Borough. This is an excerpt from the Monmouth County Hazard Mitigation Plan.

*"October 1997. Unseasonably dry weather with below normal rainfall, which became worse during the summer months, forced the Delaware River Basin Commission to declare a drought warning on October 27th. The commission urged the seven million residents within the basin's 13,539 square mile area to voluntarily conserve water. Water levels in the New York City Reservoirs, which are in the headwaters of the Delaware River, fell below 40 percent of capacity in late October. Precipitation deficits through October 31st averaged around five inches.*

*1998-1999. What began as unseasonably dry weather became a drought, which heavily impacted agriculture and water supplies. As reservoir levels continued to fall, the Delaware River Basin Commission declared a drought warning in December 1998. Also in December, NJDEP declared a drought warning for the entire state. In late December, the Delaware River Basin Commission declared Stage Two of its drought warning. In July 1999, Governor Christie Whitman declared a water shortage alert and called for residents to voluntarily conserve water by not watering lawns or washing cars. In Monmouth County, a drought emergency was declared and odd/even non/essential watering restrictions were implemented. The drought finally ended as Tropical Storm Floyd dumped significant rainfall amounts across the state.*

*October 2001 - October 2002. Unseasonably dry weather again turned to drought as precipitation levels fell short of normal levels. Continued dry weather, the drop in stream flow and groundwater levels and the reduced levels in the New York State reservoirs prompted NJDEP to upgrade the drought watch to a drought warning for counties in the Delaware River Basin and southern New Jersey in November 2001, including Monmouth County. By October 2002, a drought disaster was declared by the U.S. Department of Agriculture for several states including New Jersey. Several rain events in October 2002 helped quench the drought.*

*August to September 2008. Excessive heat in June followed by an unseasonably dry August resulted in drought conditions in August 2008. Rainfall returned to above normal levels in September, but was too late to be helpful for farmers. Crops had already been damaged by the combination of excessive June heat and an August hail storm and drought. The United States Secretary of Agriculture issued a drought disaster declaration for ten central and southern New Jersey Counties on September 22nd. Mercer, Monmouth, Burlington, Ocean, Camden, Gloucester, Atlantic, Salem, Cumberland and Cape May Counties were included in the declaration. This made farmers who suffered thirty percent or more direct losses to be eligible for low interest emergency loans from the Farm Services Agency.*

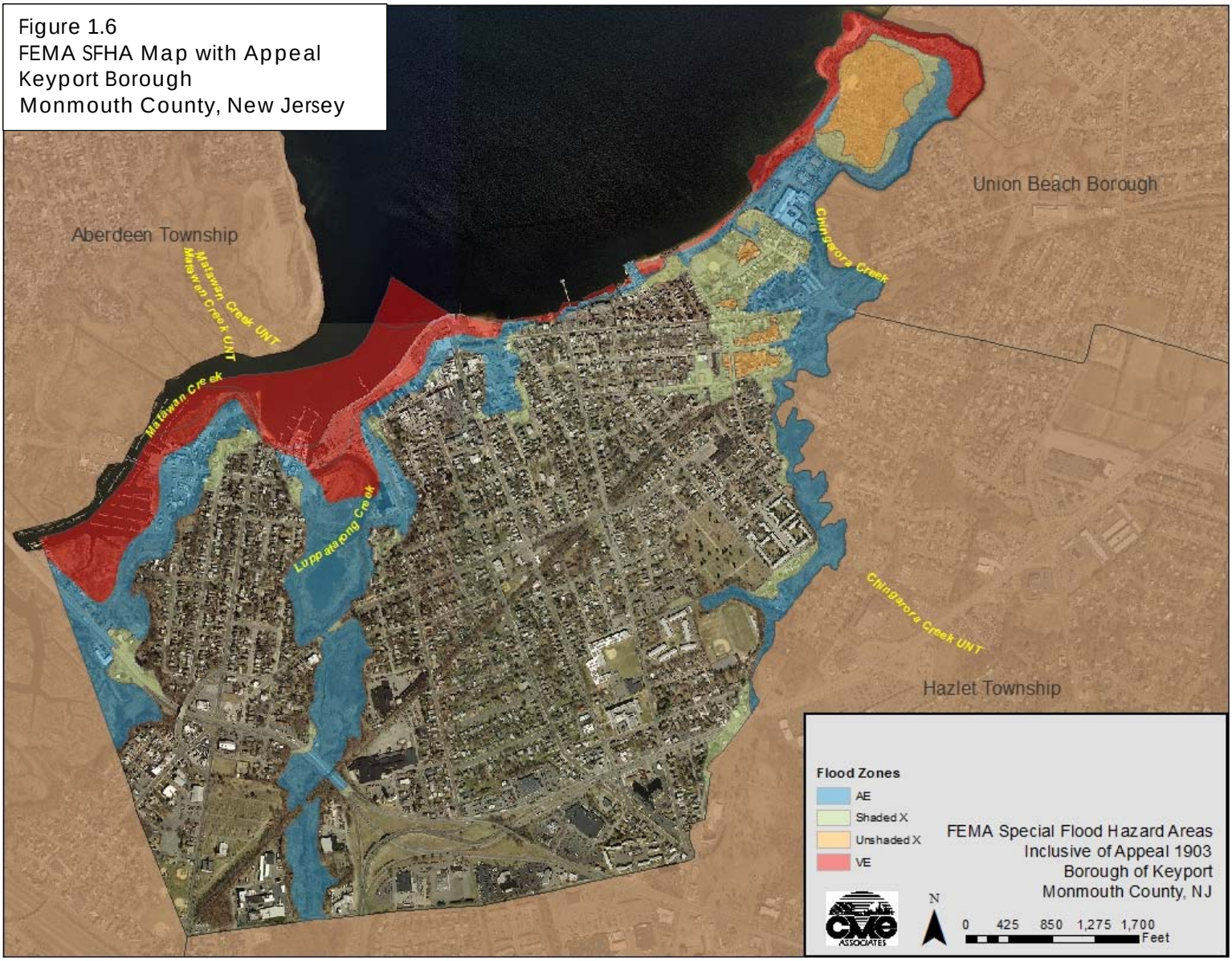
*August to October 2010. On August 5, the NJDEP issued a drought watch for northeast New Jersey including Morris County. On a statewide average, August 2010 was the 15th driest August on record (dating back to 1895) with 2.37 inches of rain. The meteorological summer was the 10th driest (8.65 inches) on record dating back to 1895 in New Jersey and was also the driest summer since 1966. At the Atlantic City International Airport, it was the fourth driest August (1.09 inches) and fifth driest meteorological summer (5.92 inches) on record. In Trenton, it was the third driest August (0.80 inches) and fifth driest meteorological summer (5.90 inches) on record.*

The Borough of Keyport along with the entire County has a low to moderate probability of severe drought conditions that usually will only be in the short term. The entire State of New Jersey has a less than 5% chance of experiencing a severe drought on a yearly basis.

**Flood**

Keyport is vulnerable to both coastal flooding and what is known as riverine flooding along its inland channels or streams including the Luppatatong and Chingarora Creeks. Natural hazards including hurricanes, tropical storms, severe storms, nor'easters, and other extreme precipitation events cause coastal and riverine flooding in the Planning Area. Additionally, the Borough is vulnerable to tidal flooding during full moon phases in its lower areas including Beers Street or even low-lying areas like Division Street during normal precipitation events. Not surprisingly most of Keyport's flooding issues derive from the Raritan Bay and the waterways that connect to the Bay rising above normal levels from average, above average, and extreme rainfall amounts. Keyport has several areas that are within FEMA's Special Flood Hazard Areas including its low areas, coastal areas, and riverine areas. The following map delineates all of Keyport's Special Flood Hazard Areas (SFHA). It should be noted that this map does reflect the Borough's appeal, number 1903 dated May 2015, to FEMA. However, the official appeal maps that were accepted by FEMA should be used to define SFHA in Keyport.

Figure 1.6
FEMA SFHA Map with Appeal
Keyport Borough
Monmouth County, New Jersey




As expected the Borough's floodplain is along the coast and along its creeks and waterways. The red shaded, or VE area, delineates the 100 year coastal flood zones associated with wave action. This zone has a 1% annual chance of flooding. Portions of the Borough that are shaded in blue are in the AE zone which is the 100 year floodplain not associated with coastal areas or wave action, which leaves areas of the Borough near the major waterways. These areas also have a 1% chance of flooding each year. The areas in the light green are known as the Shaded X zone is the moderate flood hazard area. These areas of the Borough are between the 100 year and 500 year floodplains. Finally the Unshaded X areas shown in light orange delineate the 500 year floodplain which has an annual chance of 0.2% of flooding. Very few areas of the Borough are within the 500 year floodplain, which is considered the minimal flood hazard area.

The historical occurrences of flooding in Keyport is almost too many to count given the number of monthly tidal flooding that occurs in the Borough's low-lying areas such as Beers Street during full moon cycles or Division Street during normal rain events that back up existing stormwater systems. Floods have been and continue to be the most frequent, destructive, and costly natural hazards for the Planning Area. The most flood-affected areas of the Borough include the Walnut-Oak Street Neighborhood along the Chingarora Creek, the First Street Neighborhood along the Bayfront, the Division Street Neighborhood, the Beers Street Neighborhood, and the low lying area on West Front Street near Fireman's Park. Since flooding is the most common natural hazard for Keyport, it comes as no surprise that the same applies to Monmouth County. NCDC records indicate 129 recorded flood events including coastal flood, flash flood, and flood occurred in Monmouth County since 1996. Total estimated property damage from these events totals $10.038 billion with

$10 billion attributable to Superstorm Sandy. A similar narrative exists for the Borough where almost all of its total property damage from floods over the last 20 years was because of Superstorm Sandy. Table 2.1 displays notable flooding events for the Borough of Keyport since 1996.

| Table 2.1: Significant Flooding Events in Keyport | |
|---|---|
| **Date** | **Hazard Event** |
| 7/13/1996 | Tropical Storm Bertha |
| 2/23/1998 | Nor'easter |
| 9/16/1999 | Hurricane Floyd |
| 10/25/2005 | Nor'easter |
| 9/6/2008 | Tropical Storm Hanna |
| 11/12/2009 | Nor'easter |
| 8/27/2011 | Hurricane Irene |
| 10/29/2012 | Superstorm Sandy |
| 11/7/2012 | Nor'easter |
| 12/26/2012 | Severe Thunderstorm |
| 3/6/2013 | Nor'easter |

Flooding will continue to be the most common natural hazard to Keyport and the probability of future occurrences is a certainty. The probability of future flooding events is determined by FEMA's SFHA map on the previous page. The 100 year floodplain has a 1 percent annual chance and the 500 year floodplain has a 0.2 percent annual chance. Climate change is anticipated to exacerbate or enlarge Keyport's floodplain areas over the coming decades. This prediction of the SFHA increasing in size is based on the probability of future sea level rise occurring that will increase coastal flooding events. According to the Monmouth County Hazard Mitigation Plan,

"*Rising sea level over time will shorten the return period (increasing the frequency) of significant flood events. For example; sea level rise of 1 foot over a typical project analysis period (50 years) may cause a flood event currently of annual probability 2 percent (50 year flood) to become an event of 10 percent annual probability (10 year flood). This increased probability obviously has an effect on the estimation of annualized loss/damage, but one that is typically only analyzed during detailed feasibility studies for projects proposed by the US Army Corps of Engineers.*"

These effects will make flooding from Hurricanes, Tropical Storms, Nor'easters, or even severe thunderstorms to be worse than they currently are especially in late summer or early autumn.

**Storm Surge**

Storm surge is a topic that was extensively covered in the Borough's Coastal Vulnerability Assessment. This section of the Hazard Mitigation Plan will pull from that assessment to discuss storm surge. The following maps, Figures 1.6 and 1.7, are from the CVA from two separate sources, Rutgers and The Nature Conservancy, delineate storm surge for Category 3 Hurricanes in the Borough.

Figure 1.7
Nature Conservancy Storm Surge Map
Keyport Coastal Vulnerability Assessment

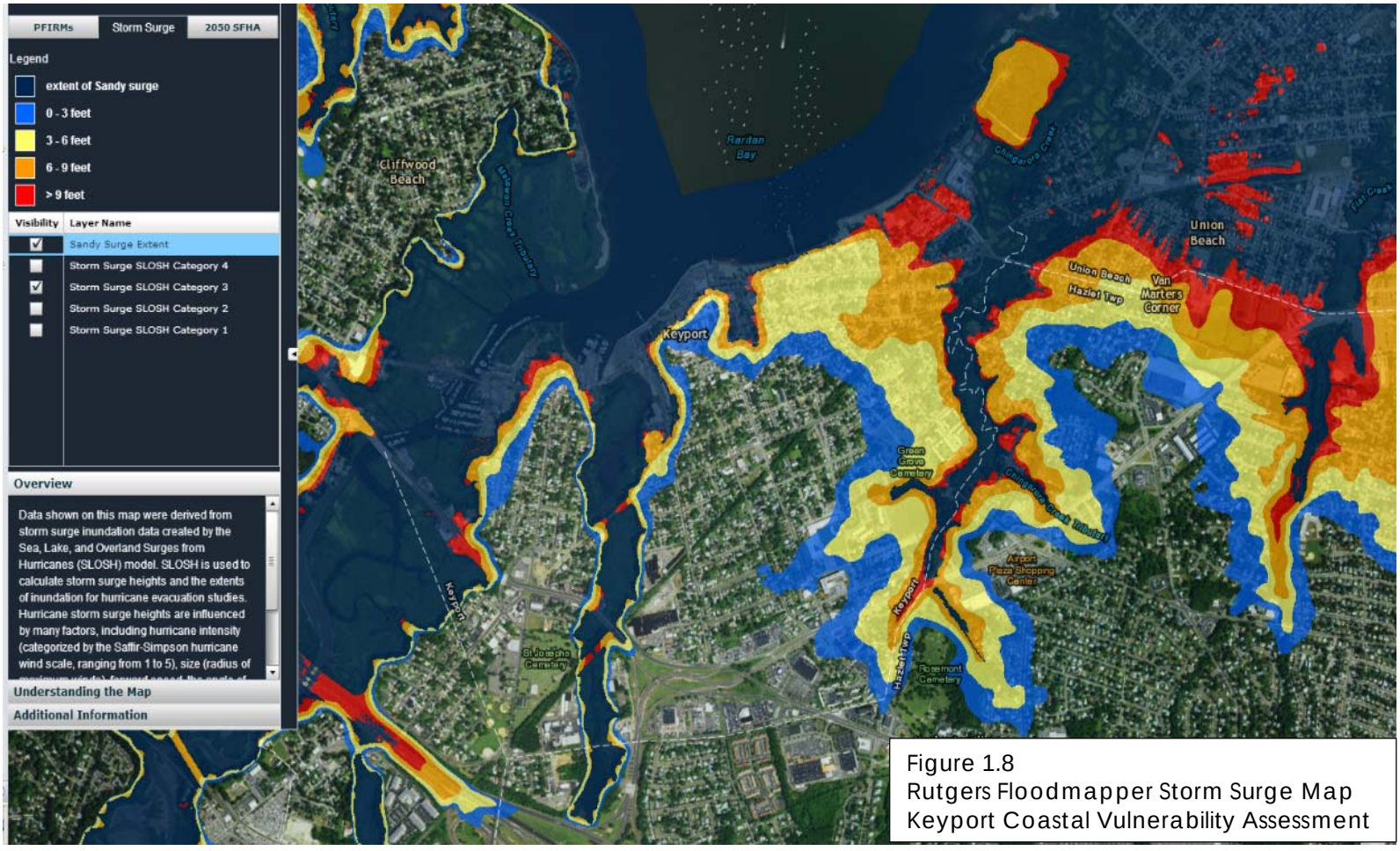




Figure 1.8
Rutgers Floodmapper Storm Surge Map
Keyport Coastal Vulnerability Assessment

It should be noted that The Nature Conservancy's estimates for storm surge extent appear to be much larger because they take into account different factors or analyses (in terms of statistics) that the Rutgers analysis may not. This is most likely a difference in reports used that determine estimates or predictions of the effect of sea level rise and climate change scenarios.

Regardless of which scenario is correct, the take away should be that storm surge from a Category 3 Hurricane would be devastating to Keyport's existing residential neighborhoods, downtown commercial areas, and all land areas near waterways and the Bay. All of these areas are at high risk to storm surge for weaker storms as well, as indicated by the dark blue in the second figure which shows Superstorm Sandy Surge extent. Additionally, areas or neighborhoods such as Vulnerable Areas 1-4, may not be directly impacted by storm surge but could have flooding from storm surge coupled with extremely high tides. This could affect drainage areas of the vulnerable areas to overflow and cause property flood damage.

Before Superstorm Sandy, the NCDC records have limited data of storm surges especially related to nor'easters which is an issue since usually nor'easters produce significant storm surge and therefore coastal & riverine flood damage and coastal erosion. Previously listed storms/extreme precipitation events have produced storm surge to the Borough including the 1991 and 1992 nor'easters, Hurricane Irene, Superstorm Sandy, and several other hazard events. The probability of major storm surge which would include a Category 3 or stronger hurricane is low. According to the MCHMP, the probability of a named storm making land fall near Monmouth County which would most likely include Keyport is 13 percent. This percentage is higher however for less severe to moderate storm surge events such as nor'easters, severe thunderstorms, or similar coastal storms. Storm surge is estimated to get worse because of sea level rise and climate change for the previously discussed reasons. Keyport is recommended to prepare as best as possible for storm surge events.

**Wave Action**

It is not a surprise that the Borough's coastal areas which is the entire Bayfront boundary is the most susceptible to wave action. The areas of the Borough that correlate to wave action vulnerability is shown in the SFHA map, specifically the VE zone. The VE zone takes wave action into account which is why base flood elevation in the VE zone is higher than the AE zone for the Borough. The 1% annual probability associated with the VE zone is the same probability for wave action affecting the Borough's Bayfront. According to NCDC's records, there were 28 records of wave action events in Monmouth County from 1996 to 2014. None of these events seemed to have affected the Borough. However, previously listed major storm events including those listed under the flood section likely produced wave action to the Borough's coastal area. The photo below shows wave action prior to Sandy's arrival in 2012.

*Figure 1.9: Day prior to Superstorm Sandy's Landfall on October 29, 2012.*

The probability of wave action occurring in the Borough is a certainty just as other hazards associated with nor'easters, tropical storms, hurricanes, and severe storms are a certainty.

**Earthquake**

The hazard risk associated with an earthquake in the East Coast, and therefore the Borough, is moderate. Earthquakes occurring in the Borough are less frequent and less intense earthquake events than compared to the western coast of the nation. Very low magnitude earthquakes do occur in New Jersey on a somewhat regular basis. The intensity is so low that most are not felt by people and therefore not capable of causing property damage. There have been 150 earthquakes recorded in New Jersey since 1783 with 7 epicenters located in Monmouth County which could affect the Borough of Keyport. It should be noted that the state's vulnerability to earthquakes extends beyond state borders and more damaging earthquakes may affect the Borough even though they originate somewhere else along the East Coast. The largest earthquake in recent history that was felt in the Borough occurred in Central Virginia on August 23, 2011. The earthquake actually registered as a 5.8 on the Richter Magnitude scale. Reports indicated the earthquake was felt from Georgia to southern Canada and from Indiana to Coastal Maine. This earthquake was felt by Borough residents but no damage was reported by anyone. The probability of a significant earthquake affecting the Borough with damaging consequences is low. The most likely earthquake to occur is a less intense earthquake that people do not feel. More destructive earthquakes will be very rare for the Borough.

**Wildfire**

Since wildfires are typically associated with large areas of undeveloped woodlands or wildlands away from firefighting infrastructure, Keyport is not vulnerable to wildfire and has a very low risk. The Borough has many firefighter stations more than capable of responding quickly to a woodland fire, the lack of remaining woodlands lowers the possibility of wildfire, and the climate for a wildfire to occur is already low in the Borough. There is no history of a wildfire in Keyport and the probability of a wildfire occurring will continue to be extremely low if not outright statistically improbable.

## Vulnerability Risk Assessment

This section will conduct a risk assessment of land uses, emergency and critical facilities or infrastructure, and vulnerable populations for all natural hazards identified in the Hazard Assessment section. The goal of the risk assessment is to identify the negative impacts each hazard poses and attempt to quantify the potential amount of damages. Additionally, areas of the Borough with Repetitive Losses will be identified, existing land uses at risk to hazards, and populations at risk.

### Critical Facilities

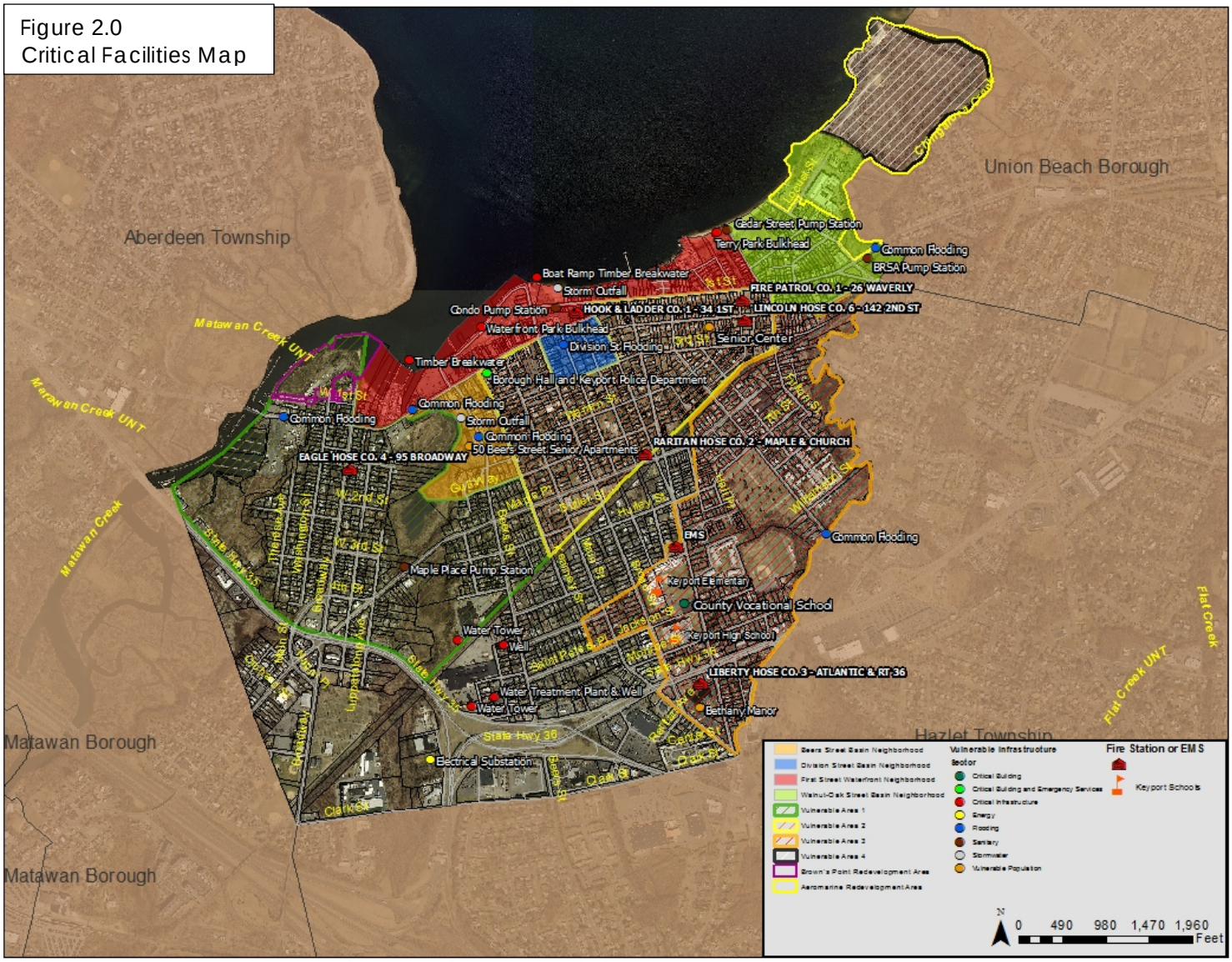
According to the Federal Emergency Management Agency (FEMA), a critical facility provides services and functions essential to a community, especially during and after a disaster. Some of these facilities include police stations and fire stations, critical vehicle and equipment storage facilities, and emergency operations centers which are needed for flood response activities. Places such as medical facilities, including hospitals, nursing homes, blood banks, and health care facilities (including ones storing important medical records) are likely to have occupants who may not be sufficiently mobile to avoid injury or death during a flood. Schools and day care centers are considered critical facilities since they can be designated as shelters or evacuation centers. Power generating stations and other public and private utility facilities are vital in maintaining or restoring normal services to flooded areas before, during, and after a flood. Other critical facilities include drinking water and wastewater treatment plants and structures or facilities that produce, use, or store highly volatile, flammable, explosive, toxic, and/or water-reactive materials. Table 2.2 shows the number of critical facility types located in the Borough according to the 2015 Multi-Jurisdictional Hazard Mitigation Plan for Monmouth County.

| Table 2.2 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Critical Facilities in Keyport Borough from MCHMP | | | | | | | | | | | | |
| Municipality | Critical Facilities Type | | | | | | | | | | | |
| | EOC's | Fire Stations | Police Stations | Hospitals | Potable Water Treatment Facilities | Wastewater Treatment Facilities | Public Works | Airports | Ferry Ports | Schools/Child Care Facilities | Senior Care Facilities | Total |
| **Keyport Borough** | 2 | 7 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | 3 | 18 |

According to the Multi-Jurisdictional Natural Hazard Mitigation Plan of Monmouth County, New Jersey there are a total of eighteen (18) Critical Facilities located within the Borough of Keyport. These facilities include two emergency operation centers, seven fire stations including the first aid station, one police station, one public works lot, four schools/child care facilities, and three senior care facilities. It should be noted that the County seems to count St. Joseph's School which has since been closed. In addition to the Critical Facilities depicted above, the Borough identifies additional Critical Facilities including Hazard Mitigation infrastructure, water sources, pump stations, stormwater/flood areas, and electrical facilities. The following is a complete table of all Keyport's Critical Facilities along with a corresponding map. For reference, Critical Facility Sectors identifies the overarching category or type for each individual critical facility.

| Table 2.3: Keyport Critical Facilities | | |
|---|---|---|
| **Critical Facility Sector** | **Critical Facility Component** | **Address/Location** |
| Critical Building & Emergency Services | Borough Hall, Emergency Operations Center, & Police Station | 70 West Front Street |
| Critical Building | Central Elementary School | 335 Broad Street |
| Critical Building | Keyport High School | 351 Broad Street |
| Emergency Services | Eagle Hose Fire Company | 95 Broadway |
| Emergency Services | Liberty Hose Fire Company | Route 36 |
| Emergency Services | First Aid Squad (Also Emergency Operations Center) | 1927 Atlantic Street |
| Critical Infrastructure | Condo Pump Station | 22 1st Street |
| Emergency Services | Raritan Hose Fire Company | Maple and Church |
| Emergency Services | Hook and Ladder Fire Company | 45 1st Street |
| Emergency Services | Fire Patrol Company | 26 Waverly |
| Emergency Services | Lincoln Hose Fire Company | 142 2nd Street |
| Critical Building | Monmouth County Vocational School | 280 Atlantic Street |
| Critical Infrastructure | Waterfront Park Bulkhead | Bayfront |
| Critical Infrastructure | Timber Breakwater/ Boat Ramp Timber Break Water | American Legion Drive/Bay |
| Critical Infrastructure | Terry Park Bulkhead | Walnut Street |
| Energy | JCP&L Clark Street Substation | 90 Madison Street |
| Vulnerable Population | Keyport Leisure (Senior Apartments) | 50 Beers Street |
| Vulnerable Population | Bethany Manor (Senior Living) | 500 Broad Street |
| Vulnerable Population | Senior Center | 110 2nd Street |
| Critical Infrastructure | Keyport Water Tower | Perry Street |
| Critical Infrastructure | Water Treatment Plant & Well | 102 Perry Street |
| Critical Infrastructure | Well | Perry Street |
| Critical Infrastructure | Maple Place Pump Station | 183 Maple Place |
| Critical Areas | Evacuation Route and Common Flooding | Intersection of Green Grove Avenue & Chingarora Creek |
| Critical Areas | Common Flooding on County Road (Repetitive Loss Area) | Low-lying area on West Front Street near Fireman's Park and Keyport Fishery |
| Critical Areas | Senior Citizen/residential access (Common Flooding) | Beers Street |
| Critical Areas | County Road linking Keyport & Aberdeen (Common Flooding) | West Front Street prior to CR6 Bridge |
| Critical Areas | Emergency Vehicle Access Route (Common Flooding) | Division Street |
| Critical Areas | County Road linking Keyport & Union Beach (Common Flooding) | 393 1st Street at Union Beach Border |
| Critical Infrastructure | Stormwater Outfall | Along Beers Street in the Beers Street Basin Neighborhood |
| Critical Infrastructure | Stormwater Outfall | Beach Park |
| Critical Infrastructure | Cedar Street Pump Station | North end of Cedar Street |
| Critical Infrastructure | BRSA Pump Station | 370 1st Street |

Figure 2.0
Critical Facilities Map




Based upon the updated Critical Facilities list and map, there are thirty five (35) critical facilities spread throughout the Borough. All of these critical facilities are vulnerable to at least one natural hazard but most are vulnerable to several natural hazards. Several natural hazards threaten all areas of the Borough and therefore threaten all of the Borough's critical facilities. These natural hazards include lightning, extreme temperatures, drought, earthquake, tornado, and wildfire. They will not be discussed further as it is accepted all critical facilities are vulnerable to said hazards and the impacts of those natural hazards will mirror those discussed in the Natural Hazard Impacts section. The following sections describe the various hazards that threaten the Borough's critical facilities.

**Emergency Operation Centers**

There are two designated emergency operation centers which are Borough Hall on West Front Street and the First Aid Squad/Emergency Medical Services building on Atlantic Street. Borough Hall is also the location of the Borough Police Department. According to the Borough's CVA, Borough Hall is vulnerable to a Category 3 hurricane's storm surge. In addition Borough Hall is vulnerable to extreme wind and all storm types including Hurricanes, tropical storms, nor'easter, and winter storms. Borough Hall is slightly raised above grade which gives it some protection to storm surge but it is recommended to prepare by moving all sensitive equipment, computers, servers, or other information storage upstairs to protect continuity of government/Borough services. Borough Hall was constructed to withstand extreme wind and extreme storm events so it should not receive negative impacts from those natural hazards. It is recommended to guard against extreme wind damage by anchoring any object capable of becoming flying debris prior to a major

storm event. The First Aid Squad is vulnerable to the same natural hazards as Borough Hall. Therefore, Borough Hall's recommendations apply to the First Aid Squad.

**Fire Stations**

The Borough's fire stations are located throughout the Borough and are vulnerable to a variety of natural hazards. Eagle Hose Fire Company located on Broadway is vulnerable to storm surge but only in very specific circumstances such as an extremely strong hurricane coupled with high tide and other natural hazards. It is outside the flood zone so is not vulnerable to flooding, but it is vulnerable to extreme wind and all storm types. Extreme wind may damage the structure. The Raritan Hose Company on the corner of Maple and Church shares similar vulnerabilities with Eagle Hose Fire Company. It would take exceptional circumstances for storm surge to reach it and is outside the flood zone, but is also vulnerable to extreme wind and all storm types. It is recommended for both stations that any equipment not being used in an emergency situation be moved prior to any storm event.

Liberty Hose Company Station on Route 36 is vulnerable to all storm types and storm surge. It is outside the flood hazard area and is quite a distance away from the coast thereby reducing or completely eliminating any vulnerability to extreme wind or coastal erosion. It is recommended that any equipment not being used in an emergency situation be moved prior to any storm event in case storm surge does reach the station.

Hook and Ladder Fire Company at 45 1st Street is vulnerable to storm surge, flooding, extreme wind, and all extreme storm types including nor'easters, winter storms, hurricanes, and others. Being the closest fire station to the Bayfront makes it the most vulnerable of all the Borough's emergency services. The station is split between the AE flood zone and the Shaded X flood zone which is the transition flood zone between the 100 year and 500 year flood zone. This puts the probability of the station being flooded at 0.1 percent annually or slightly lower for the portion of the station in the Shaded X zone. Storm surge from a Category 2 hurricane or similar strength storm would reach the station. This creates a situation where the Hook and Ladder Company is the most vulnerable to all natural hazards and should prepare the most for an imminent extreme storm. This would include re positioning its equipment to an upland area where it can be effectively used in emergency situations, preparing the structure for possible wind or flood damage, and other necessary preparations.

Finally, the Keyport Fire Patrol and Lincoln Hose Company stations are vulnerable to several natural hazards. The Lincoln Hose Company is within the Shaded X flood zone where the Fire Patrol station is actually outside all flood zones. Both are susceptible to storm surge from a Category 2 Hurricane or stronger storm and to extreme wind. Both structures are constructed with brick so extreme wind damage should be minimal but both stations should make similar preparations to the Hook and Ladder Fire Company to prepare for any major storm event and potential flooding or storm surge damage.

**Public Works Lot**

Keyport Borough's Department of Public Works (DPW) stores a majority of its vehicles, equipment, and other infrastructure on a rented lot located on Francis Street. This lot is particularly close to the Luppatatong Creek. Although it is just outside the AE flood zone the lot could experience storm surge and other effects from Hurricanes, Tropical Storms, Nor'easters, or Winter Storms. It is recommended for all key DPW vehicles and equipment to be moved to a safer upland location prior to a major storm event to avoid damage to any equipment and to ensure that vehicles and equipment can be used in emergency situations such as debris clearing. For winter storms, DPW plows and vehicles should be mobilized to assist in snow clearing as is the normal protocol for the Borough.

**Schools**

Large structures are typically identified as potential emergency shelters during a natural hazard or disaster given that they are usually located away from coastlines, are made of sturdy materials to withstand hazards such as extreme wind, and have the capacity to accommodate larger populations or staging centers for supplies. Therefore, this HMP will identify Keyport's schools as potential emergency shelters. Keyport has two schools within its borders known as Keyport Central Elementary School and Keyport High School both located adjacent to each other on Broad and Atlantic Streets. In addition, the Monmouth County Vocational

School is in between the two schools on Jackson Street but is operated by the County and not the Borough. There are also several privately owned day care centers, however, these locations or structures are not appropriate to be used as emergency shelters due to their insufficient size and some are located in flood zones. The Borough's schools and the County Vocational School are much more appropriate as they can potentially house larger populations in the event of an emergency, are outside the flood zone, and are much more resilient structures. Additionally they are outside the storm surge of a Category 2 Hurricane. They are however within the outer edge of storm surge for a Category 3 Hurricane which may make these schools unsuitable for emergency shelters depending on the specific circumstances of a storm and how close it comes to Keyport's borders. Additionally, if a Category 3 Hurricane or similar strength storm is going to hit the Borough, it may require a full scale evacuation and thereby making the schools insufficient as emergency shelters. Though these schools can act as appropriate emergency shelters or supply locations for a range of natural hazards or disasters.

**Vulnerable Populations**

They are three locations within Keyport that house elderly populations or act as a destination for elderly citizens. Bethany Manor off of Route 36, Keyport Leisure Apartments at 50 Beers Street, and the Senior Center on 2nd Street which have the largest concentrations of elderly populations in the Borough. In addition they are low income households throughout the Borough that may be vulnerable during an evacuation due to lack of personal transportation, however, this is addressed in the Borough's CVA. Of the three elderly

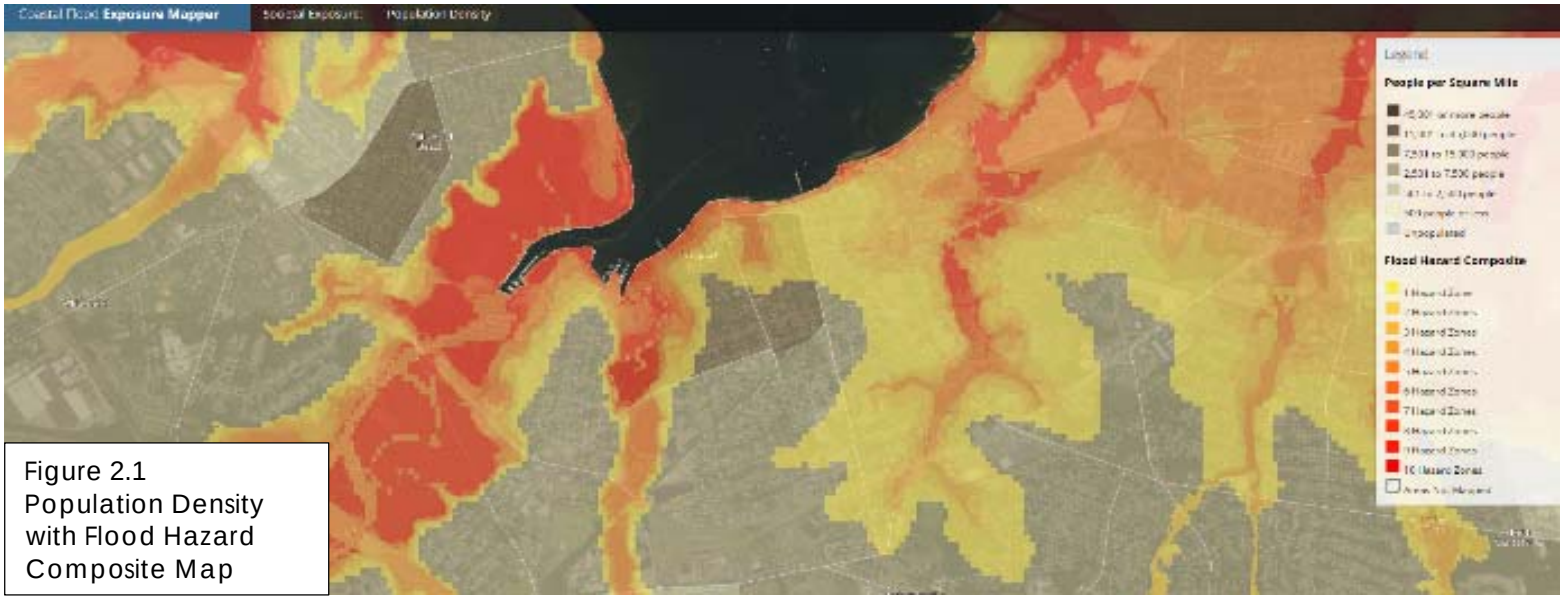



Figure 2.1 Population Density with Flood Hazard Composite Map

population locations, 50 Beers Street is the most vulnerable. It is directly next to the Luppatatong Creek, is in the AE flood zone, is vulnerable to storm surge from all storm strengths, is vulnerable to sea level rise, and is vulnerable to extreme wind and all storm types such as Nor'easters and Winter Storms. This creates a situation where occupants of Keyport Leisure Apartments should be the first to be evacuated prior to a major storm event, especially those occupants with special needs. Bethany Manor is less vulnerable as it is outside the flood zone but is within the storm surge reach of certain strength storms. A similar need for evacuation is needed for these occupants as well. The senior center does not house any elderly citizens, but if there are any present during an emergency they should be evacuated. It is recommended to close the senior center if a major storm is imminent to avoid evacuation complexity and unnecessary issues. It should be noted that elderly populations may be more affected by hazards including extreme temperatures, winter storms, and drought. The operators of Keyport Leisure Apartments, Bethany Manor, and the senior center should be mindful of these vulnerabilities and take appropriate actions to mitigate injury or death from said natural hazards. Other vulnerable populations include areas of the Borough with higher densities. The figure below delineates the Borough's 2010 Census data overlaid onto a map of the Borough. The figure specifically shows which areas of the Borough have higher density and are vulnerable to flood hazards. The flood hazard composite layer includes many natural hazards including flooding, sea level rise, storm surge, wave action, and many others associated with major storm events such as Nor'easters or Hurricanes.

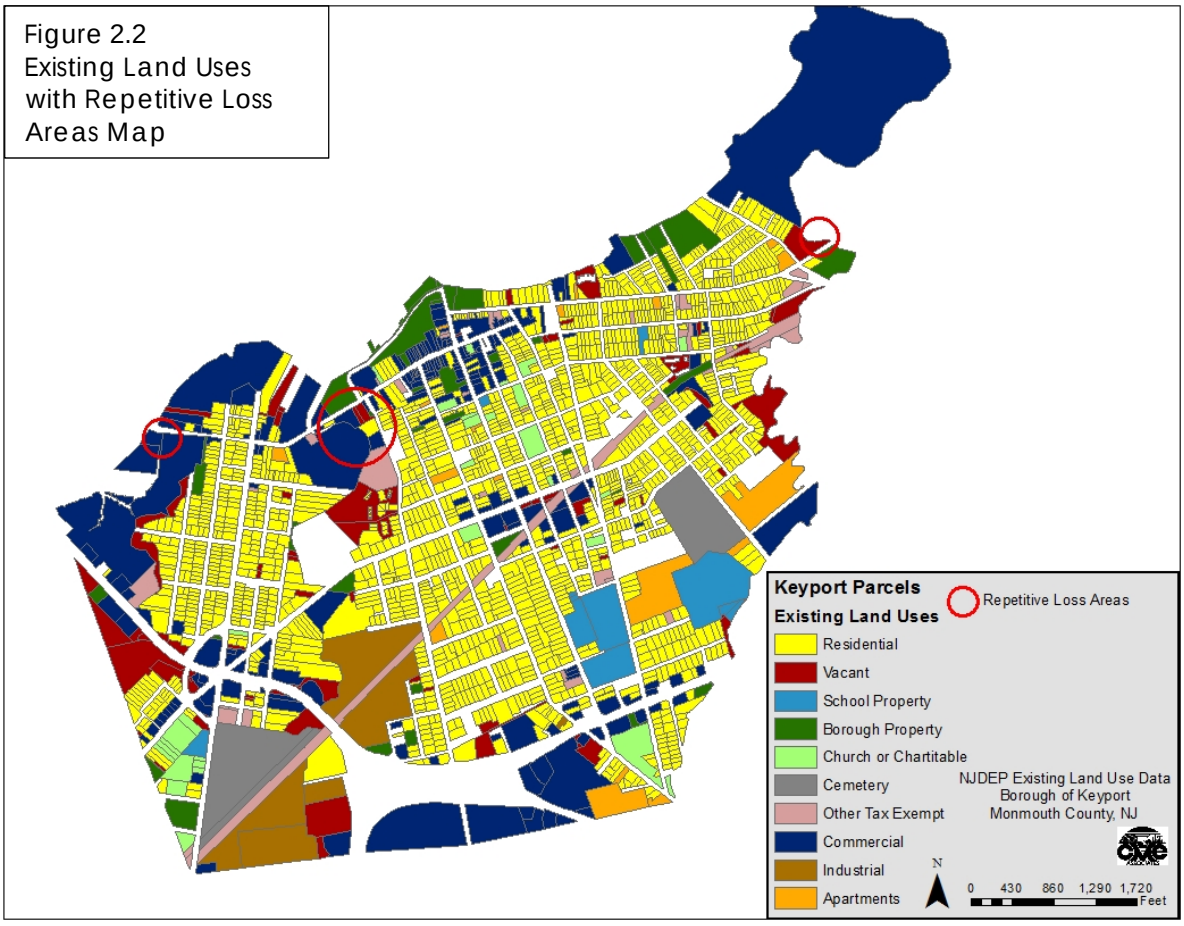
## Critical Infrastructure

Keyport has a range of critical infrastructure including flood mitigation structures such as bulkheads and breakwaters, stormwater infrastructure, sanitary pump stations, potable water infrastructure including treatment plants and wells that can be compromised by natural hazards, and the electrical substation on Clark Street. All of this infrastructure is vulnerable to a wide range of hazards. All are susceptible to damage from Hurricanes, Tropical Storms, Nor'easters, and Winter Storms. Critical infrastructure on the coast such as the bulkheads, breakwaters, and storm outfalls are vulnerable to coastal erosion which over time may compromise the structures. They are also more vulnerable to extreme wind and wave action compared to critical infrastructure located more in land. It is recommended that bulkheads, storm outfalls, breakwaters, and coastal pump stations be inspected after any intense storms to ensure they are not compromised by coastal erosion, wave action, extreme wind, flooding, or any other hazards posed by major storms. Unfortunately a majority of Keyport's critical infrastructure such as its pump stations are located near the coast or along the Borough's waterways. These are recommended to be upgraded for better resiliency. The well located near Beers Street is vulnerable to riverine flooding as it's close to the Luppatatong which may compromise the well. Mitigation strategies are recommended to be implemented to avoid the water supply from being contaminated by flood or stormwater. Overall it is recommended to mitigate damage to the Borough's critical infrastructure with particular emphasis on critical infrastructure most exposed to natural hazards stemming from Hurricanes, Tropical Storms, or Nor'easters.

## Critical Areas

The Borough's CVA identified several critical areas that are susceptible to common flooding and repetitive losses not only for extreme storm events but even normal storm events or moon tides. All of these critical areas are vulnerable to flooding, storm surge, and sea level rise. This can have negative effects on the nearby residential land uses or the commercial uses within the First Street and Division Street Neighborhoods. The Borough's plans for its neighborhoods highlight in detail the vulnerabilities for all land uses, critical facilities, and the impacts of common flooding areas. Also the figure below shows Keyport's existing land uses and areas that experience repetitive losses as defined by FEMA.

Figure 2.2
Existing Land Uses with Repetitive Loss Areas Map



## Land Uses

The Borough of Keyport has a total of 937 acres. Approximately 25% or 234 acres are commercial/mixed use, 46% or 426 acres are residential, another 25% or 234 acres is open space or woodlands, and the remaining acreage is the Bay and Borough waterways. Within the 937 acres of Keyport are 2,401 tax parcels, of which 2,200 are improved which is about 91.63%. Keyport is almost at complete build-out when taking open spaces, environmentally sensitive areas, and other restrictions into account. Land uses along the coast including the First Street Neighborhood and Walnut Street residential Neighborhoods are most vulnerable to Hurricanes, Tropical Storms, Nor'easters, and Winter Storms. Residential structures on the Bayfront should be prepared for extreme wind, storm surge, coastal erosion, sea level rise, and flooding. Commercial areas mainly concentrated in the First Street Neighborhood on Front Street should be prepared for the same hazards except for coastal erosion and sea level rise. Given the built-out nature of the Borough and its location near the bay and waterways, almost every single land use type is vulnerable to some type of natural hazard. Being prepared to face these hazards is the most effective mitigation plan as each tax parcel or land use has a unique location and set of circumstances that dictate the natural hazards that threaten it. The map above shows the Borough's existing land uses. The following section goes into more detail on the impacts of each hazard that can be expected.

## Vulnerability of Transportation

The Borough's evacuation routes are vulnerable to a number of natural hazards including flooding, storm surge, Hurricanes, Tropical Storms, Extreme Wind, and Winter Storms. Additionally, many of the local roads that lead to the evacuation routes are vulnerable to the same hazards. This makes a timely evacuation key before any of the local roads or evacuation routes are affected by these natural hazards which may affect the ability to evacuate the Borough. In terms of public transit the 817 NJ Transit Bus Route is vulnerable to flooding and storm surge as the bus route traverses through the northern section of the Borough including the Beers Street, First Street, and Walnut Street neighborhoods. During a natural hazard or emergency event such as a Nor'easter, Tropical Storm, Hurricane or Winter Storm the bus route will likely not be operational or will be blocked by flooding. Therefore the bus route is vulnerable to natural hazards particularly major storm events and their associated natural hazards. The map in Figure 2.3 below displays Keyport's flood zones impact on roads and transportation infrastructure.

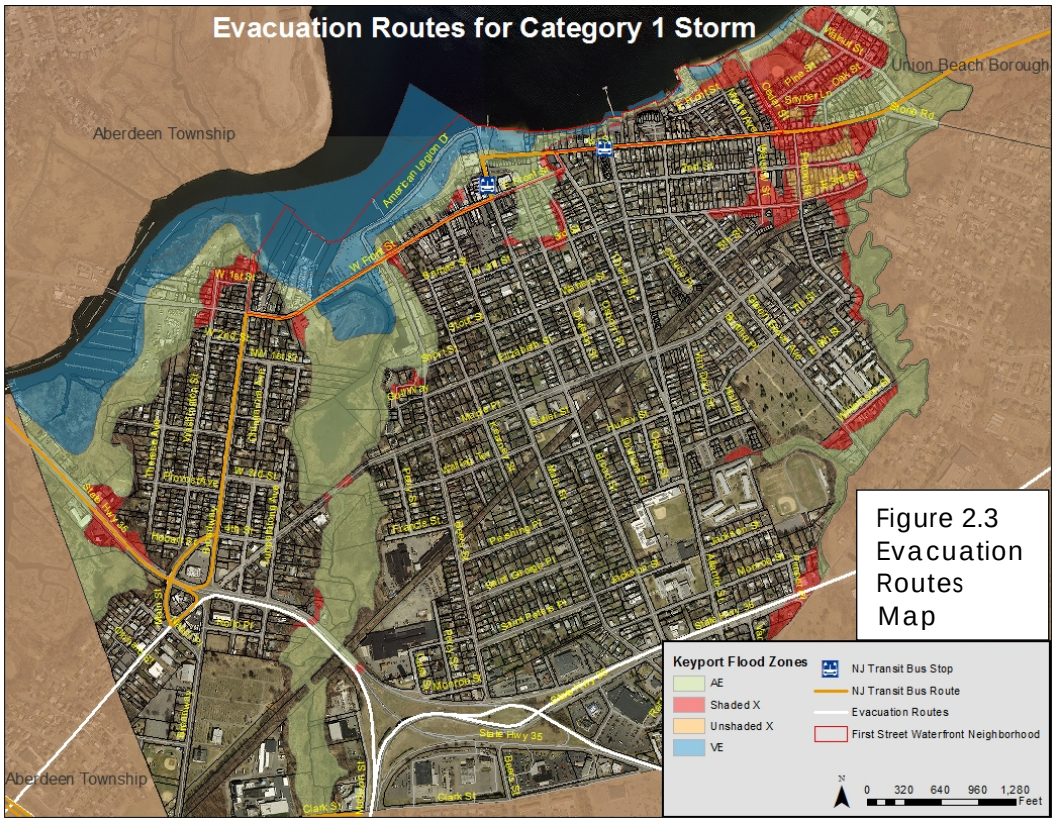



Figure 2.3 Evacuation Routes Map

## Natural Hazard Impacts

The following section will focus upon the impacts that each natural hazard has on the Borough including damage estimates if possible and specific details of natural hazard impacts.

**Extreme Temperatures**

Impacts - Extreme Temperatures

Extreme temperatures are significant threats to human life and health, though they can pose threats to livestock and agricultural crops and in rare cases threaten property and infrastructure. Extreme temperatures tend to exacerbate the impact of other hazards such as severe weather events that cause widespread power outages. In the occurrence of one of these rare events, the Borough is likely to result in relatively minor impacts with very few injuries (if any), minor to erratic property damage, and minimal disruption to quality of life. There could be temporary shutdown of critical facilities to reduce energy usage or lack of staff since they may not be able to get to the facility due to the severe conditions. Extreme temperatures would likely affect the Borough through heat rather than cold. Common impacts associated with extreme heat in Keyport include: injuries associated with swimming in order to avoid the heat, individuals seeking medical treatment for heat related illnesses such as heat stress, exhaustion, heat stroke, etc., and power outages from an associated strain on electrical networks. Primary impacts of concern for extreme cold temperatures include effects of overexposure to hypothermia, which can be life threatening. These natural hazards would mainly affect the elderly and disadvantaged populations as well as livestock and agriculture.

Exposure and Damage Estimates - Extreme Temperatures

While the entire Borough is exposed to extreme temperatures, existing buildings, infrastructure, and critical facilities are not considered vulnerable to significant damage caused by extreme heat or cold events. However, in the event of an extended power outage due to excessive heat, possible shut down of a major critical facility could occur, though this is highly unlikely. Therefore any estimated property losses associated with these hazards are anticipated to be minimal across the Borough.

Heat casualties are usually caused by the lack of adequate air conditioning or from heat exhaustion. As stated above the most vulnerable population to heat causalities are the elderly or infirmed. This is because these populations usually live on low fixed incomes and cannot afford to use air-conditioning on a regular basis. On the opposite end of the spectrum, casualties from extreme cold may result from a lack of adequate heat, carbon monoxide poisoning from unsafe heat sources, and frostbite or hypothermia. Population's within the Borough that are the most vulnerable to cold causalities are also the elderly and disadvantaged as well as low income households. This is due to the fact that these populations may not be able to afford to operate a proper source of heat on a regular basis. The elderly is the most vulnerable to extreme temperatures and they make up a portion of the Borough's population at approximately 16.3 percent according to the U.S. Census Borough's 2015 five-year estimate for ages 65 and up.

Given the lack of historical data and limited likelihood for structural losses resulting from extreme heat or cold occurrences in Keyport Borough, annualizing potential structural losses over a long period of time would most likely yield a negligible annualized loss estimate for the entire Borough.

**Extreme Wind**

Impacts - Extreme Wind

Impacts associated with extreme wind in Keyport Borough can be life-threatening. Multiple deaths/injuries can occur, significant portions of property in the affected area can be damaged or destroyed (depending on the nature of the event), and a complete shutdown of critical facilities for more than a week could all be possible due to the type of wind event and nature of the event. These extreme winds can occur from nor'easters, hurricanes, tropical depressions or storms, and thunderstorms.

Some of these extreme wind events can be forecasted while others are completely unpredictable. In these occurrences emergency responders are called up for evacuations, road closures, and attending to the injured.

Flying debris during these events can cause secondary impacts and injury. Trees can be downed causing damage to buildings and infrastructure. Private property can be directly damaged from high winds as well as roads, schools, and other types of critical facilities. In addition, impaired access to these critical facilities during extreme wind events can cause secondary, indirect damages. The closing or understaffed operations of critical facilities can hinder the Borough of electricity, clean water, and emergency access to those in need of care.

Even though extreme winds may stem from other hazards, only reported extreme wind events not related to those hazards are considered in this analysis. Vulnerability to winds from hurricanes and tropical storms, nor'easters, and tornadoes are addressed individually in the following sections.

**Exposure and Damage Estimates - Extreme Wind**

Since it can cannot be predicted where all extreme winds may occur, all existing and future buildings, facilities, and populations are considered to be exposed to this hazard and could potentially be impacted. It is important to note that the only reported extreme wind occurrences have been factored into this vulnerability assessment[3]. The National Climate Data Center's (NCDC) historical extreme wind loss data is as current as September 2014 and includes a total of 238 days with high wind, thunderstorm wind, and strong wind events between October 1968 and May 2014 (not including Superstorm Sandy). All events recorded prior to the year 2000 include $0 in damages due to database limitations as opposed to decades of non-damaging wind events. Therefore, to estimate the Borough's losses due to extreme wind, expected annualized losses were calculated for the 14.5 year period of record between January 2000 and May 2014. Monmouth County estimates that about 5 to 10 extreme wind events will occur every year of which some will impact Keyport.

Table 2.4 below extracted data from Table 3c.1 of the Monmouth County Hazard Mitigation Plan (page 3c-7). It shows the potential annualized property losses and percent loss ratio resulting from extreme wind for the Borough of Keyport based on historic occurrences as reported by the NCDC. The County HMP used population estimates that were refined using Census 2010 block level data, and annualized expected property losses were based on updated (2012) improvement values.

**Table 2.4**

**Potential Annualized Losses from Extreme Wind**

| Municipality | Estimated Population At Risk | Total Assessed Value of Improvements (Buildings)* | Annualized Expected Property Losses | Annualized Percent Loss |
|---|---|---|---|---|
| Keyport Borough | 7,240 | $422,424,400 | $22,922 | 0.01% |

**Exposure calculated by GIS Analysis using local assessed values*

**Hurricane and Tropical Storm**

Impacts – Hurricanes and Tropical Storms

Hurricanes and tropical storms are capable of producing catastrophic impacts over a small or large area. A substantial number of deaths and/or injuries are possible, more than 50 percent of property within the Borough could be damaged or destroyed due to its proximity to the Raritan Bay and low lying vulnerable areas, and a complete shutdown of critical facilities would be possible for 30 days or more, depending on the nature of the event.

Historical records from NOAA indicate that 11 hurricanes and 25 tropical storms have affected Keyport in some way. Recent events have caused substantial wind, flood, and coastal erosion related damages. Table 1.6 listed in the previous section above on page 15 shows all hurricanes and tropical storms that have affected the Borough since 1985.

[3] *It is possible that additional extreme wind events may have occurred since 1990 that were not reported to the National Oceanic and Atmospheric Administration and are not accounted for in this analysis.*

Since Keyport lies on the waterfront of the Raritan Bay it is a dynamic environment that is susceptible to hazards associated with hurricanes and tropical storms. Effects of sea level rise will only increase these susceptibilities over time. Impacts of hurricanes and tropical storms are associated with damages as a result of riverine, coastal, and back-bay flooding. Other associated hazards include storm surge, high winds, damaging waves, and coastal erosion. It is possible for the entire Borough to be impacted by one of these events, though in different ways. Wind impacts may be widespread throughout the Borough while structures close to the waterfront can suffer catastrophic damage from wind, storm surge, waves, and beach erosion. Flooding along the Luppatatong Creek to the West and the Chingarora Creek on the eastern border of the Borough can flood during these storms as well causing widespread structural damage to homes located inland along these waterbodies. Bridges and Roads like Route 4, 6, 35, 36, and 39 would be susceptible to overtopping and damage from flood waters. Beach erosion can often be severe during hurricanes and tropical storms.

With summer being peak vacation time coinciding with hurricane season, the potential population at risk is at its highest during the summer when the Borough is most likely to be impacted by a hurricane or tropical storms. Impacts to the general public include evacuation and sheltering needs, as well as emergency response for those who shelter in place or are injured during the event. During these hazards all property types are impacted, with residential and commercial impacts being greatest due to their proximity to the coast. Areas such as the Beer Street, Division Street, and the Walnut-Oak Street Basin Neighborhoods as well as the First Street Waterfront Neighborhood will all be heavily affected by hurricane and tropical storm events. Roads, bridges, schools, senior care facilities and all other types of critical facilities like pump stations and electrical substations are susceptible to wind and water damage. Secondary impacts would be associated with flying debris, as well as drifting sand from storm surges. Beach erosion can be extremely severe depending on the particular area and nature of the event, though Keyport has taken preventative measures in the occurrence of future major storm events. Public transportation, communications, and municipal and governmental services may also be considerably impacted due to the Borough's downtown proximity to the waterfront in which these facilities operate. Impacts would increase when high tides, or prolonged events that extend across several tidal cycles.

**Exposure and Damage Estimates – Hurricanes and Tropical Storms**

Hurricanes and tropical storms are complex systems that pose separate hazards occurring simultaneously. Damage can occur during hurricanes and tropical storms resulting from the cumulative impacts from a wide range of hazards that include flooding, storm surge, coastal erosion, wave action, and high tides. No two hurricanes or tropical storms can be identical. Even hurricanes within the same category can bring different impacts depending on whether they occur during a time of high or low tide. As an example, variations in inland wind affects and the amount of precipitation an area receives widely varies. It is difficult to estimate the total potential losses from these cumulative effects in a method that would allow for the calculation of meaningful annual "hurricane and tropical storm" average annual loss estimate. Since the HAZUS-MH hurricane model only analyzes winds and cannot estimate the cumulative losses from all hazards that are associated with hurricanes, only hurricane wind losses are reported in this section. Since this section focuses on vulnerabilities strictly with regard to hurricane winds, vulnerability to the component hazards of hurricane and tropical storm events such as flooding, storm surge, coastal erosion, wave action, and high winds are addressed separately in this section.

The Monmouth County Hazard Mitigation Plan used HAZUS-MH to create a probabilistic scenario to assess the vulnerability of Keyport Borough to hurricane winds. Default HAZUS-MH wind speed data and damage functions, and methodology were used to determine the potential estimated losses for 50-, 100-, 200-, 500-, and 1000-year frequency events and annual expected loss at the census tract level[4]. Table 2.5 below represents the estimated potential losses for 50-, 100-, 200-, 500-, and 1000-year hurricane wind event scenarios within the Borough. Table 2.6 shows the potential annualized property losses and percent loss ratios resulting from hurricane wind within the Borough from the MCHMP.

[4] *Multi-Jurisdictional Natural Hazard Mitigation Plan Monmouth County, New Jersey. URS, 2014. 02/27/17.*

| Table 2.5 | | | | | | |
|---|---|---|---|---|---|---|
| Estimated Potential Losses from 50-,100-,200-,500-, and 1000-year Hurricane Wind Events | | | | | | |
| Municipality | Total Assessed Value of Improvements (Buildings) | Potential Total Building Losses from Hurricane Wind | | | | |
| | | 50-Year Hurricane Wind Event | 100-Year Hurricane Wind Event | 200-Year Hurricane Wind Event | 500-Year Hurricane Wind Event | 1000-Year Hurricane Wind Event |
| Keyport Borough | $422,424,400 | $213,025 | $466,481 | $822,135 | $5,974,295 | $19,496,200 |
| *Source: MCHMP/ HAZUS-MH* | | | | | | |

| Table 2.6 | | | | |
|---|---|---|---|---|
| Potential Annualized Losses from Hurricane Wind | | | | |
| Municipality | Estimated Population At Risk | Total Assessed Value of Improvements (Buildings) | Total Annualized Expected Property Losses - Hurricane Wind | Annualized Percent Loss Ration |
| Keyport Borough | 7,240 | $422,424,400 | $88,648 | 0.02% |
| *Source: MCHMP/ HAZUS-MH* | | | | |

**Lightning**

Impacts – Lightning

In the United States it is reported that on average, 55 people are killed and hundreds are injured each year by lightning strikes. Lightning has the ability to affect a large or small area with one strike. It can strike communications equipment like radio or cell towers, antennae's, satellite dishes, electrical transformers, etc., and hinder communication and emergency responses. Lightning strikes can even ignite fires or wildfires that can cause significant damage to buildings, critical facilities, and infrastructure.

Impacts by lightning are usually characterized as being minor in Keyport and have not caused any significant property damage, injuries, or loss of life over the past 20 years. The shutdown of critical facilities, if at all, is typically temporary in nature depending on the severity and length of any affected power lines or electrical equipment. Building codes require structures to be grounded to decrease damages in the occurrence of a significant lightning strike. Lightning and thunderstorms typically accompany one another and occur within 10 miles of another. Members of the public who are outdoors are particularly vulnerable during an event, especially if they are near parks or open areas in the Borough.

**Exposure and Damage Estimates – Lightning**

Since the areas where lightning can strike are highly unpredictable, all existing and future buildings, facilities, and populations within the Borough are considered to be exposed to this hazard and could potentially be impacted. NCDC historical lightning data as current as September of 2014 includes a total of 60 lightning events between May 1997 and August 2013 within Monmouth County. This is due to database limitations as opposed to data over decades without lightning strikes. Data extracted in the table below from the MCHMP represents the potential annualized property losses and percent loss ratios resulting from the lightning hazard for the Borough of Keyport based on historic occurrences as reported by NCDC. Population estimates were refined using Census 2010 block level data; and annualized expected property losses reflect updated (2012) improvement values.

| Table 2.7 | | | | |
|---|---|---|---|---|
| Potential Annualized Losses from Lightning | | | | |
| Municipality | Estimated Population At Risk | Total Assessed Value of Improvements | Annualized Expected Property Losses | Annualized Percent Loss Ration |
| Keyport Borough | 7,240 | $422,424,400 | $516 | 0.00% |
| *Source: MCHMP/ HAZUS-MH* | | | | |

**Nor'easter**

Impacts – Nor'easter

Nor'easters are known for producing large amounts of rain and snow, creating hurricane-force winds, and generating high surf that causes severe beach erosion and coastal flooding. According to the Monmouth County HMP,

"There are two main components that create a Nor'easter. The first one is a Gulf Stream Low-pressure system (counter-clockwise winds) generated off of the southeastern U.S. coast, which gathers warm air and moisture from the Atlantic, and pulled up the East Coast by strong northeasterly winds at the leading edge of the storm. The second component in creating a nor'easter is an Arctic high-pressure system (clockwise winds) which meets the low-pressure system with cold, artic air blowing down from Canada. When both of these systems collide, the moisture and cold air produce a mixture of precipitation that has the potential to create dangerously high winds and heavy seas. As the low-pressure system deepens, the intensity of the winds and waves will increase and cause severe damage to coastal areas as the storm moves northeast. Nor'easters can be exceptionally large (up to 1,000 miles in diameter) and the duration of the storm can last for days and multiple tidal cycles, often causing major coastal flooding, erosion, and damages that can even exceed the impacts of shorter-term hurricane events."

Impacts that occur from a nor'easter are high winds, severe beach erosion, and flood hazards. Impacts can be similar to winter storms with snow accumulations creating hazardous driving conditions, office closures, roof damage or structure collapse from snow accumulations on buildings. Coastal communities tend to see the greatest impacts from this type of natural hazard, but waterfront and inland communities can be affected as well. Keyport Borough's remains highly susceptible to the effects of major coastal storms, including nor'easters. Nor'easters are similar to hurricanes and tropical storms in that they are highly capable of producing catastrophic impacts, depending on a few key factors such as the nature of the storm, its intensity, and its duration. Impacts that can affect the Borough if hit with a nor'easter include high numbers of deaths/injuries, more than 50 percent of property could be damaged or destroyed, and critical facilities could be shut down for 30 days or more. Historical records indicate that the Borough has a long record of nor'easter impacts over the time of its existence. Data taken from the State Hazard Mitigation Plan, the County Hazard Mitigation Plan, and NOAA show that the Borough has gone through at least 13 significant nor'easter events since 1962 that has significantly impacted the area. This meaning flooding from tidal or surge that has caused damage, winds downing trees and power lines causing many homes to lose power, or high winds that can cause structural damage.

Waterfront areas such as Keyport are considered a dynamic environment, and are susceptible to hazards associated with nor'easters. These susceptibilities are expected to increase over time due to the effects of sea level rise. Impacts that can be associated with nor'easters include damages as a result of flooding, high winds, damaging waves, and coastal erosion. It is possible for the entire Borough to be impacted by one of these events, though it can be in different forms. For example, winds that may have a widespread impact would be more severe along the waterfront than in inland areas. Structures close to the waterfront such as the bulkheads, breakwaters, Cedar Street Pump Station, the Terry Park Bulkhead, along with several homes situated between the waterfront and 1st Street could suffer catastrophic damages from wind, surge, waves, and beach erosion while impacts to inland structures would be less substantial due to lower wind speeds and the absence of surge impacts. Flooding along the Luppatatong Creek to the West and the Chingarora Creek on the eastern border of the Borough can flood during these storms as well causing widespread structural damage to homes located inland along these waterbodies. Bridges and Roads would be susceptible to overtopping and damage from flood waters. Beach erosion can often be severe during nor'easters; though beach restoration and maintenance activities have been undertaken since Hurricane Sandy such as the installation of stormwater outfalls and bulkheads to offset storm impacts.

Nor'easters usually occur during the winter time, which has a lower impact than during the summer when it is peak vacation and tourism time. Impacts to the general population include evacuation and sheltering needs, as well as emergency responses for those who shelter in place or are injured during one of these hazard events. All property types throughout the Borough can be impacted with residential and commercial impacts being the greatest due to their location to the Raritan Bay and lying in between the Luppatatong and Chingarora Creeks. Roads, bridges, schools, and other community and critical facilities are susceptible to wind and water

damage. Secondary impacts would be associated with flying debris, as well as drifting sand from storm surges. Beach erosion can be calamitous depending on the specific area and nature of the event. Transportation, communications, and governmental services may be severely impacted. Impacts would be exacerbated when coincident with high tides, or during extended types of events that extend across numerous tidal cycles. Sea level rise will increase these impacts over time.

Exposure and Damage Estimates – Nor'easters

Since nor'easters often affect large areas across several municipalities and usually can't be defined to one area, all existing and future buildings, facilities, and populations are considered to be vulnerable to this hazard and could be impacted. Similar to hurricanes and tropical storms, nor'easters are complex combinations of separate components of other hazards occurring simultaneously. Damages during these events result from the collective impacts of component hazards such as flooding, storm surge, erosion, wave action, and high winds. Just like hurricanes and tropical storms no two nor'easters are identical. Even storms of the same scale and strength can deliver widely different impacts depending on whether they occur during a time of high or low tide; and, since it is not uncommon for nor'easters to stall off of the coast, damages are affected by the number of tidal cycles during which they occur. Variations in inland wind affects and precipitation amounts can greatly vary. This makes it difficult to estimate the potential losses from the cumulative effects in a way that allows for the calculation of a meaningful annual loss estimate for nor'easters. Since nor'easters are low pressure systems, the impacts from winds found in a powerful nor'easter can be modeled using methodology similar to that used for hurricanes.

The following text and data were taken from the MCHMP and modified to describe its affect to the Borough of Keyport. "Since the HAZUS-MH hurricane model only analyzes winds and cannot estimate the cumulative losses from all hazards that are associated with hurricanes, only nor'easter wind losses are reported in this section. The MCHMP used HAZUS-MH to model two representative nor'easters which directly impacted the County and the Borough in December of 1992 and April of 2007, and for which data was readily available. The County chose these two storms for analysis since wind speed data was available for georeferenced buoy points and varied in strength, with the 1992 storm identified by locals as one of the most notable in several decades. Although the modeling does account for increased duration or precipitation levels which could exceed those found in typical hurricanes, it could help quantify a conservative estimate of potential of potential losses if these storms were to impact the Borough today. They County warn that the modeled damage estimates may not closely reflect actual recorded damages in every case. To use the HAZUS-MH hurricane model to analyze data for nor'easters, historical wind speed data for each storm for georeferenced buoys within range of Monmouth County was obtained (where available) from the National Data Buoy Centers[5]. In order to model peak intensity, peak wind gusts measured on December 11, 1992 at 4 p.m. EST was used for the December 1992 storm analysis, and peak wind gusts measured on April 16, 2007 at 2 a.m. EST was used for the April 2007 storm analysis. Using known wind gust data standardized to 10-meter height for at least three (3) georeferenced points (buoy locations), wind gust speeds were interpolated[6] to estimate wind gust speed at the centroid of each census tract, which was imported into HAZUS-MH for analysis and potential loss estimates."

The HAZUS-MH modeling used by Monmouth County from the December 1992 nor'easter estimates resulted of wind gusts ranging from 63 to 79 mph with an estimated $645,507.00 in damages throughout Keyport. These higher wind speeds are comparable to Category 1 wind speeds that occurred throughout Monmouth County. Table 2.8 represents estimated potential wind losses for a nor'easter that is similar in strength to the December 1992 storm if it were to occur in the current built environment in Keyport.

**Table 2.8**

**Potential Losses from Nor'easter Winds (December 11, 1992 Storm Model)**

| Municipality | Total Assessed Value of Improvements (Buildings) | Modeled Nor'easter Wind Losses 12/11/1992 Storm |
|---|---|---|
| Keyport Borough | $422,424,400 | $645,507 |

*Source: MCHMP/ HAZUS-MH*

[5] *www.ndbc.noaa.gov*

[6] *This method assumes that the wind speeds are linear and can be interpolated with reasonable results.*

Nor'easters that contain the strength and magnitude like that of the December 1992 storm are not common and do not occur on a frequent basis. In the absence of a frequency level determination for this specific event, the County estimates the likelihood of such a strong nor'easter causing this amount of damage could be 0.2 percent in any given year (i.e., a 500-year event occurrence). This probability can be multiplied by the modeled losses from the 1992 storm to conservatively estimate potential annualized losses that are shown in Table 2.9 below. It is expected that the frequency and intensity of coastal storms and nor'easters will increase with climate change that can affect the characteristics of future nor'easters such as intensity, frequency, and storm path. Therefore, there is a high probability of occurrence of a nor'easter every year for the Borough.

**Table 2.9**
**Potential Annualized Losses from Nor'easter Winds**

| Municipality | Estimated Population At Risk | Total Assessed Value of Improvements (Buildings) | Annualized Expected Property Losses - Nor'easter Winds | Annualized Percent Loss Ration |
|---|---|---|---|---|
| Keyport Borough | 7,240 | $422,424,400 | $1,291 | 0.00031% |

**Tornado**

Impacts – Tornado

Tornados are considered to be one of nature's most violent storms. While extremely rare for the Borough of Keyport, more intense tornados in other parts of the United States can cause fatalities and catastrophic damage to both trees and the built environment in a matter of seconds. The number of deaths, injuries, and dollar amount of damages can fluctuate severely depending on the severity of the tornado and the type of development in the damage path. Like other storms referenced above, a lot of the damage that would occur to the Borough would be caused by wind since tornadoes can reach wind speeds of up to 300 mph.

Tornados in the northern states usually happen in the summer months around the same time as hurricanes or tropical storms. They are able to form and touch down at any time of the day since they are formed from thunderstorms. Impacts to the general population can include evacuation and sheltering needs, as well as emergency responses for those who shelter in place or are injured during one of these hazard events. All property types throughout the Borough can be impacted with residential and commercial impacts being the greatest due to their location to the Raritan Bay and lying in between the Luppatatong and Chingarora Creeks. Roads, bridges, schools, and other community and critical facilities are susceptible to wind and water damage. Secondary impacts would be associated with flying debris, as well as drifting sand from storm surges. Beach erosion can be calamitous depending on the specific area and nature of the event. Transportation, communications, and municipal and governmental services may be severely impacted. These impacts tend to be contained in rather limited areas, due to the nature of the tornado hazard itself (if tornados with limited widths and path lengths after touchdown). The destruction caused by tornados can range from light to catastrophic depending on the intensity, size and duration of the storm. Usually, tornados cause the greatest damage to structures of light construction, including residential dwellings and particularly manufactured homes. The entire Borough is susceptible to a tornado if one were ever to occur.

Exposure and Damage Estimates – Tornados

Historical evidence shows that the Borough is vulnerable to tornado activity since this particular hazard can result from severe thunderstorm activity or may even occur during a major tropical storm or hurricane. This historical evidence is quite small in scope, there have been instances of tornados in neighboring municipalities. Since it cannot be predicted where a tornado might arise, all existing and future structures, facilities, and populations are considered to be exposed to this hazard and could potentially be impacted.

The following was produced by the MCHMP using NCDC historical tornado data as current as September 2014. A total of 9 tornado events occurred in Monmouth County between August 1952 and September 2014 of which none hit Keyport. Annualized losses for the Borough were calculated using this 62-year period of record. Table 3.0 below shows the potential annualized property losses and percent loss ratios resulting from the tornado hazard based on historic occurrence data.

| Table 3.0 | | | | |
|---|---|---|---|---|
| Potential Annualized Losses from Tornado | | | | |
| Municipality | Estimated Population At Risk | Total Assessed Value of Improvements (Buildings) | Annualized Expected Property Losses | Annualized Percent Loss Ration |
| Keyport Borough | 7,240 | $422,424,400 | $99 | 0.0000% |

**Winter Storm**

Impacts – Winter Storm

Winter storms can have a tremendous impact on the Borough even though they are typically short in duration. Winter storms can result in significant snow accumulations, with significant impacts on local roadways and sidewalks. Impacts can be exacerbated if storms have an ice component, as snow loads are increased and driving conditions worsen. Heavy snow on building roofs can compromise the structural integrity and potentially collapse the structure. This is especially true for older structure's where the roofs may already be vulnerable to collapse. Heavy snow and ice loads can result in downed trees and limbs, particularly during periods of high winds, which can result in outages when limbs fall on power lines and communication lines. This type of weather can affect the elderly or infirmed and may cause casualties from extreme cold that may result from a lack of adequate heat, carbon monoxide poisoning from unsafe heat sources, and frostbite or hypothermia. Population's within the Borough that are the most vulnerable to cold causalities are also the elderly and disadvantaged as well as low income households. This is due to the fact that these populations may not be able to afford to operate a proper source of heat on a regular basis and may not have immediate family or friends to look out for their well-being. Secondary impacts from power outages can include frozen pipes, business losses, downed communication lines, which can hamper the response and recovery efforts of the local first aid squads and fire departments due to lack of communications.

Exposure and Damage Estimates – Winter Storms

Due to the fact that winter storms often impact large areas and cross municipal boundaries, all existing and future buildings, and populations are considered to be exposed to this hazard and could potentially be impacted. For this HMP, NCDC historical winter storm data as current as September 2014 was recorded for events categorized as: blizzards, heavy snow, ice storms, sleet, winter storms, and winter weather. The data included winter weather days between January 1996[7] and September 2014 with no events recorded prior to 1996. For the County to estimate losses due to winter storms, expected annualized losses were analyzed for the 18-year period of record.

It should be noted that the estimation of losses to winter storms was limited to documented structural damages and do not include other types of damages or economic impacts such as power outages, infrastructure repair and restoration, loss of business income and snow removal costs. In the absence of detailed historical data, it is difficult to model and quantify other types of non-structural losses for winter storms at a municipal level. However, it should be known that such losses are indeed significant and their associated costs are most often created by local government and the private sector. Table 3.1 represents potential annualized property losses and percent loss ratios resulting from the winter storm hazard for the Borough of Keyport based on historic occurrences.

| Table 3.1 | | | | |
|---|---|---|---|---|
| Potential Annualized Losses from Winter Storms | | | | |
| Municipality | Estimated Population At Risk | Total Assessed Value of Improvements (Buildings) | Annualized Expected Property Losses | Annualized Percent Loss Ration |
| Keyport Borough | 7,240 | $422,424,400 | $5,241 | 0.00% |

[7] *Events between 1950 and 1995 were not included in the NCDC database and, therefore are not accounted for in this analysis.*

**Coastal Erosion**

Impacts – Coastal Erosion

Coastal erosion's impacts are generally associated with damage to beaches, dunes, shoreline infrastructure, harming the stability of infrastructure, and other types of damage to buildings near shorelines. Therefore, coastal erosion represents a major threat to the Borough's economy. The areas that would be affected the most within the Borough would be its existing beach areas which are mainly the Aeromarine area, public spaces along the Raritan Bay including Beach Park or Veterans Park, the many bulkhead areas of the Borough may be affected over time, and the coastal areas near the western marinas and along the Matawan Creek.

Exposure and Damage Estimates – Coastal Erosion

Coastal erosion is described as a relatively slow natural process occurring over a long period of time, with occasional major impacts from natural hazards such as hurricanes and nor'easters. Monitoring specific coastal erosion hazard areas is difficult because of constant shoreline reinforcement or nourishment projects completed by federal, state, and local government agencies. Another difficulty is the washing up of debris from other coastal towns due to the way the tides flow from the Raritan Bay to Keyport. Typically, areas of high concern with regard to long term coastal erosion are addressed through shoreline hardening or stabilization projects, which can include seawalls, breakwaters, and beach nourishment. However, Keyport does not have extensive shorelines and addresses coastal erosion in only the very specific areas that require hardening or stabilization. The ability to continue successfully mitigating the effects of coastal erosion hazards within the Borough will therefore depend on regular shoreline monitoring and the design and implementation of site-specific solutions. The New Jersey Coastal Zone Management Rules (N.J.A.C. 7:7E) defines erosion hazard areas as extending inland from the edge of a stabilized upland area to the limit of the area likely to be eroded in 30 years for one to four unit dwellings structures, and 60 years for all other structures, including developed and undeveloped areas[8]. The extent of an erosion hazard area is calculated by multiplying the projected annual erosion rate at a site by 30 for the development of one to four unit dwelling structures and by 60 for all other developments. According to the study by the Heinz Center[9], much of the coastline of New Jersey experiences an average of three (3) feet of erosion per year.

The Borough has an active history of researching and implementing shoreline protection strategies in areas in which property is threatened by erosion. Over the years, the Borough has implemented bulkheads, both public and private, to combat coastal erosion and now has many protected areas that are included in the critical facilities map on page 28. Also marshes in certain areas of the Borough protect those areas from coastal erosion. Sea level rise will only increase the risk of damages/losses due to future coastal erosion and flood events. Rising sea levels over time will inevitably shorten the return period (increasing the frequency) of episodic coastal erosion. The increased probability of sea level rise will have an effect on lose and damage to the Borough, but one that is usually only analyzed during detailed feasibility studies for projects proposed by the US Army Corps of Engineers. Table 3.2 represents exposure to the coastal erosion hazard within the Borough. The data within this table was extracted from the MCHMP on page 3c-26.

**Table 3.2**

**Exposure in Coastal Erosion Areas**

| Municipality | Estimated Population At Risk | Total Assessed Value of Improvements (Buildings) | Total Assessed Value of Buildings Located Within 200 Feet of Beach/Erodible Shoreline Types | Percent of Total Building Value Located Within 200 Feet of Beach/Erodible Shoreline Types | Average Annual Building Damages Directly Attributable to Coastal Erosion Assuming Continued Beach Nourishment and Shoreline Stabilization Practices |
|---|---|---|---|---|---|
| Keyport Borough | 80 | $422,424,400 | $2,883,941 | 0.68% | Negligible |

[8] *This distance is measured from the crest of a bluff for coastal bluff areas, the most seaward established dune crest for un-vegetated dune area, the first vegetation line from the water for established vegetated dun areas, and the landward edge of a beach or the eight foot North American Datum (NAD) 1983, contour line, whichever is farther inland, for non-dune areas.*

[9] *"Evaluation of Erosion Hazards"* prepared by the H. John Heinz III Center for Science, Economics and Environment, April 2000. www.heinzctr.org/NEWWEB/PDF/erosnrpt.pdf#/pagemode=bookmarks&view= FIT

**Drought**

Impacts – Drought

Droughts are slow hazards, but, over a long period of time, they can affect agriculture, municipal water supplies, recreational resources, and increase the likeliness of wildfires. When drought conditions continue over a number of years, the economic impacts can be significant. High temperatures, extreme winds, and low humidity can exacerbate drought conditions. In addition, human actions and demands for water can accelerate drought-related impacts. Drought has occurred in the Borough of Keyport and will likely happen again at some time in the future.

Exposure and Damage Estimates – Drought

Since impacts caused by droughts affect large areas that cross municipal boundaries, all existing and future buildings, facilities, and populations are considered to be exposed to this type of hazard and could potentially be impacted. Drought impacts commonly occur during water shortages and crop losses on agricultural lands and have no impacts on buildings. Damage estimates to the Borough from drought are almost impossible to calculate as the intensity of a coming drought is unknown as well as the impacts to local food and water resources. Additionally there is no agricultural land in the Borough of Keyport that can be affected by drought.

**Flood**

Impacts – Flood

Along the Raritan Bay, serious flooding problems are the result of high tidal surge and associated wave activity caused primarily by tropical storms, especially hurricanes. Other low-lying areas are susceptible to extreme flooding and normal flood-related damages due to the periodic flooding caused by the overflow of creeks from moon tides or normal precipitation events. Due to high tidal stages along the Raritan Bay, the Borough is vulnerable to flooding, especially within the Borough's Neighborhood and along the Borough's creeks and waterways. Keyport is susceptible to both riverine and coastal flooding.

An estimate from the Keyport SRPR assessed the value of property in Keyport that is still at risk for flooding which is between $19,286,400 and $109,451,100. These numbers are higher than the actual damage caused by Superstorm Sandy. A large portion of Keyport's land area and overall property valuation is still vulnerable and at risk to flooding and storm surge events. Other areas such as the Beers, Division, and Walnut-Oak Street Basin Neighborhoods experience flooding in certain sections of the Neighborhoods. In severe weather events where flooding does occur, this would highly affect the elderly and infirmed populations of the Borough making it difficult for emergency responders to reach them.

The Borough of Keyport is mainly located within the AE and VE flood zones with small pockets of the X flood zone found off of these other zones. The AE flood zone is situated along the Luppatatong and Chingarora Creeks which runs north to south in the western and eastern portions of the Borough. Neighborhoods most affected by this flood zone are the Walnut-Oak Street Basin, the Division Street Basin, and the Beers Street Basin Neighborhoods. These neighborhoods experience common flooding during times of extreme storms and there are critical infrastructures situated along both creeks such as the Maple Place Pump Station and an electrical substation (Luppatatong Creek) and the BRSA Pump Station (Chingarora Creek). There are also small pockets of the X flood zone located off of the AE flood zone within the Division Street Basin Neighborhood while there are larger areas of the X flood zone found more inland off of the AE flood zones within portions of the Walnut-Oak Street Basin and First Street Waterfront Neighborhoods. These areas are at the highest risk for flooding since they are within the 1% annual chance or 100-year flood-plain. The VE flood zone can be specifically found along the waterfront of the Raritan Bay First Street Waterfront Neighborhood area. This section of the Borough is also at high risk of flooding since it has a 0.1% annual chance or 100-year floodplain. The First Street Waterfront Neighborhood also contains several critical infrastructures such as the Cedar Street and Condo Pump Stations, the Terry Park and Waterfront Park Bulkheads, and the Timber Breakwater and the Timber Breakwater Boat Ramp.

Exposure and Damage Estimates – Flood

In order to assess flood risk within the Borough, a GIS based analysis of FEMA's latest PFIRMS, including the Borough's appeal, in conjunction with local tax assessor records was applied. The findings are in Table 3.3 below which shows the GIS analysis findings using improvement values from NJDEP tax records.

**Table 3.3**
**Exposure in Flood Zones**

| Municipality | Total Assessed Value of Improvements (Buildings) | Buildings Located in A/AE Zones | | Buildings Located in Shaded and Unshaded X Zones | | Buildings Located in VE Zones | | Buildings Located in All Flood Zones | |
|---|---|---|---|---|---|---|---|---|---|
| | | Value At-Risk | % | Value At-Risk | % | Value At-Risk | % | Value At-Risk | % |
| Keyport Borough | $422,424,400 | $79,489,400 | 18.8% | 78,206,400 | 18.5% | $20,247,800 | 4.8% | $177,943,600 | 42.1% |

*Notes: Exposure calculated by GIS Analysis using local assessed values from NJDEP*

The map on page 22 illustrates the special flood hazard areas for Keyport based on FEMA's 2015 Preliminary Digital Flood Insurance Rate Maps (DFIRMs). Keyport Borough in 2015 appealed the FEMA DFIRMs for an area of the Raritan Bay shoreline from Broad Street to Cedar Street. Keyport successfully showed that the V-zone designations should be removed in certain areas or replaced with the AE zone. The map on page 22 incorporates this appeal. The MCHMP also estimated riverine flooding losses using HAZUS-MH. It utilized HAZUS-MH to estimate floodplain boundaries, potential exposure for each event frequency, and loss estimates based on probabilistic scenarios for 10-, 50-, 100-, 200-, 500-year and annualized flood events using a Level 2 analysis 13. Table 3.4 shows estimated potential losses for 10-, 50-, 100-, 200-, and 500-year riverine flood; and Table 3.5 shows estimated annualized riverine flood event losses through annualized property losses calculated by HAZUS-MH as well as percent loss ratios resulting from riverine flooding within the Borough.

**Table 3.4**
**Estimated Potential Losses from 50-,100-,200-, and 500-year Riverine Flood Events**

| Municipality | Potential Total Building Losses | | | | |
|---|---|---|---|---|---|
| | 10-Year Riverine Flood Event | 50-Year Riverine Flood Event | 100-Year Riverine Flood Event | 200-Year Riverine Flood Event | 500-Year Riverine Flood Event |
| Keyport Borough | $123,279 | $149,218 | $173,584 | $203,368 | $896,666 |

*Source: MCHMP/ HAZUS-MH*

**Table 3.5**
**Potential Annualized Losses from Riverine Flooding**

| Municipality | Estimated Population At Risk | Total Assessed Value of Improvements (Buildings) | Annualized Expected Property Losses | Annualized Percent Loss Ration |
|---|---|---|---|---|
| Keyport Borough | 1,027 | $422,424,400 | $16,614 | 0.00% |

*Source: MCHMP/ HAZUS-MH*

As stated above, this analysis only estimates damages from riverine sources such as the Luppatatong and Chingarora Creeks, therefore the risks and damages in this section for coastal communities may appear underestimated when read in isolation from the accompanying sections estimating damages from storm surge, wave action, and erosion.

For the potential annualized losses from riverine flooding, the data suggests there is an annualized loss of approximately $16,614 for 1,027 citizens within the Borough. Without efforts to mitigate these and other individual properties at risk from frequent flooding, annual repetitive loss can be expected to remain at this scale, and even to increase, as structures that have up until now have only been flooded once become flooded repeatedly and therefore may meet the definition of a "Repetitive Loss Property".

**Storm Surge**

Impacts – Storm Surge

Storm surge is a flood hazard which is related to hurricanes, which differs from coastal flood events. Storm surge can be catastrophic to coastal regions, causing flooding, severe beach erosion, and property damage along the immediate coast. Keyport is no stranger to this natural hazard as storm surge has overcome land areas within the Borough time and again during extreme weather events. Experts and climatologists anticipate that sea level rise will reach 1.3 feet by 2050 and is predicted to rise as high as 3 feet by 2100 using the intermediate to high risk factor. This will substantially increase the effects of storm surge in future storm events. Even if this is not accurate, sea level rise is still expected to increase as it has over the centuries that will cause problems when only viewed by itself and increase storm surge damage potential. Sea level rise and the resulting increased storm surges have the potential to have a very significant effect on the Borough, particularly in low lying neighborhoods near streams and waterways that are vulnerable to flooding. Keyport's waterfront is the most vulnerable to sea level rise and storm surge. The increase in sea level rise directly correlates to the increase in the amount of land affected by flooding and storm surge by a significant amount. Sea level rise can be very slow and gradual but its negative effects can be exponential. Therefore, storm surge in combination with sea level rise, will affect the Borough's neighborhoods and vulnerable areas and impact all infrastructure and buildings within those areas. The Borough's CVA and Neighborhood Plans go into detail as to specific low-lying areas and critical facilities that are vulnerable to storm surge on its own and exacerbated by sea level rise. Examples of what will be impacted from storm surge incorporating sea level rise include the Waterfront Promenade, Cedar Street Park, marinas such as the Hans Pedersen Marina, and homes along the Raritan Bay or the waterways that lead to the Raritan Bay such as the Luppatatong and Chingarora Creeks.

Exposure and Damage Estimates – Storm Surge

In order to assess storm surge risk, the MCHMP took two vulnerability assessment approaches and applied them assess exposure and potential losses to storm surge hazard events. This includes GIS-based analysis to estimate exposure and HAZUS-MH to estimate potential losses for storm surge events. The following information was gathered from the MCHMP on page 3c-43 and displays exposure to storm surge, the determination of value and population at-risk, and percent total at risk to storm surge. Approximately 38.56% of the Borough's building value is exposed to storm surge according to the table reproduced from the MCHMP below.

**Table 3.6**

**Exposure in Storm Surge Areas**

| Municipality | Estimated Population At Risk | Total Assessed Value of Improvements (Buildings) | Total Assessed Value of Buildings Located in Category 1-4 Storm Surge Areas* | Percent of Total Building Value Exposed to Surge |
|---|---|---|---|---|
| Keyport Borough | 3,548 | $422,424,400 | $162,876,900 | 38.56% |

The MCHMP also produced data for the County that includes information on the Borough using HAZUS-MH to estimate potential losses within the Borough resulting from different strength storm surge events. Table 3.7 estimated potential losses for Categories 1, 2, 3, and 4 storm surge event scenarios for Keyport. Table 3.8 from the MCHMP represents potential annualized losses from storm surge.

| Table 3.7 | | | | |
|---|---|---|---|---|
| Estimated Potential Losses from Category 1, 2, 3, and 4 Storm Surge Events | | | | |
| Municipality | Potential Total Building Losses | | | |
| | Category 1 Event | Category 2 Event | Category 3 Event | Category 4 Event |
| Keyport Borough | $15,754,700 | $37,693,800 | $80,824,100 | $162,876,900 |
| *Source: MCHMP/ HAZUS-MH* | | | | |

| Table 3.8 | | | | |
|---|---|---|---|---|
| Potential Annualized Losses from Storm Surge | | | | |
| Municipality | Estimated Population At Risk | Total Assessed Value of Buildings Exposed to Surge* | Total Annualized Expected Property Losses** | Annualized Percent Loss Ratio |
| Keyport Borough | 3,548 | $162,876,900 | $879,535 | 0.54% |
| *Source: MCHMP/ HAZUS-MH* | | | | |
| **Exposure calculated by GIS Analysis using local assessed values of buildings In Category 1 through 4 SLOSH zones.* | | | | |
| ***Annualized expected losses for the 2014 plan update were calculated by applying the annualized percent loss ratios to the 2012 assessed value of buildings exposed.* | | | | |

**Sea Level Rise**

The Monmouth County Hazard Mitigation Plan also looked at sea level rise as a stand-alone natural hazard. While the other analyses here within have evaluated the impact of long-term sea level rise on 100-year flood damages based on readily-available GIS mapping prepared by NOAA, sea level rise can also have negative effects on its own. The following table was extracted from the MCHMP to show data relating to the Borough of Keyport for sea level rise. The County's estimated potential losses are based on the "Highest" 2050 scenario which is 2 feet of sea level rise above current special flood hazard areas. Table 3.9 below illustrates the County findings relating to Keyport Borough.

| Table 3.9 | | |
|---|---|---|
| Estimated Potential Losses from 2050 SLR (highest risk factor of 2 feet above SFHA) | | |
| Municipality | Total Assessed Value of Improvements (Buildings) | Estimated Potential Losses (2050 highest risk factor) |
| Keyport Borough | $422,424,400 | $16,438,040 |
| *Source: MCHMP/ HAZUS-MH* | | |

**Wave Action**

Impacts – Wave Action

Wave action is a significant hazard to buildings and infrastructure located in coastal areas. Large, fast moving waves from extreme weather events can cause extreme erosion and impact buildings. Storm surge and wind increase the destructiveness of waves and allow waves to reach higher elevations and penetrate further inland. Areas within the Borough are all coastal areas along the Raritan Bay including Aeromarine, Walnut-Oak Street Neighborhood, First Street Neighborhood, and western marinas.

Exposure and Damage Estimates – Wave Action

In order to estimate exposure to wave action, it is assumed that the most vulnerable areas are located within the VE flood zone, which experiences coastal flooding with velocity hazard (wave action). The Table 4.0 displays exposure to wave action within the Borough according to the MCHMP.

| Table 4.0 | | | | |
|---|---|---|---|---|
| **Exposure to Wave Action** | | | | |
| **Municipality** | **Estimated Population At Risk** | **Total Assessed Value of Improvements (Buildings)** | **Total Assessed Value of Buildings Located in VE Flood Zone*** | **Percent of Total Building Value Exposed to Wave Action** |
| Keyport Borough | 185 | $422,424,400 | $20,247,800 | 4.8% |
| **Exposure calculated by GIS analysis using local assessed values of buildings located in VE Zones* | | | | |

Given the lack of readily available historical loss data on significant wave action occurrences within the Borough, it is assumed that while one major event (i.e., hurricane or nor'easter) could result in significant losses due to wave action, annualizing structural losses over a long period of time would most likely yield a negligible annualized loss estimate within Borough when exposed to this hazard. However, it should also be noted that over the long term, anticipated sea level rise will increase the risk of damages/losses to future wave action events.

**Earthquakes**

Impacts – Earthquakes

Most earthquake-related property damage and deaths are caused by the failure and collapse of structures due to ground shaking. The level of damage depends upon the extent and duration of the shaking. Other damaging earthquake effects include landslides, the down-slope movement of soil and rock (in mountain regions and along hillsides), and liquefaction. The entire Borough would be at risk in the occurrence of an earthquake, but this sort of hazard is very unlikely to occur or cause significant damage to the Borough. The total annualized expected property loss in the occurrence of an earthquake is approximately $917.00 while there is a 0% annualized percent loss ratio.

Exposure and Damage Estimates – Earthquakes

Since earthquakes often impact large areas and cross municipal boundaries, all existing and future buildings, facilities, and populations are considered to be exposed to this hazard and could potentially be impacted. Monmouth County produced the following tables in its Hazard Mitigation Plan to determine the potential estimated losses for 100-, 500-, 1000-, and 2500-year frequency events and annual expected loss at the census tract level. Table 4.1 lists the expected peak found acceleration (PGA) for 100- and 500-year earthquake events for the Borough.

| Table 4.1 | | |
|---|---|---|
| **Peak Ground Acceleration for 100- and 500-Year Earthquake Events** | | |
| **Municipality** | **100-year PGA** | **500-year PGA** |
| Keyport Borough | 0.0084 | 0.0447 |
| *Source: HAZUS-MH* | | |

Earthquakes with higher levels of PGA cause more damage, but have a lower probability of occurrence. Conversely, earthquakes with low PGA levels such as those which could potentially impact the Borough, have a higher probability of occurrence but would only cause negligible to minor damage due to light shaking. In comparison to PGA levels above 0.25g which can cause strong to violent shaking and major damage, expected PGA levels for the Borough of Keyport will likely only cause negligible to light shaking and negligible to minor damage. Estimated losses for a 100-year earthquake event within the Borough is considered to be negligible. Table 4.2 displays estimated potential losses for 500-, 1000-, and 2500-year events as estimated using HAZUS-MH.

| Table 4.2 | | | | |
|---|---|---|---|---|
| Estimated Potential Losses from 500-,1000-, and 2500-year Earth Events | | | | |
| Municipality | Total Assessed Value of Improvements | Potential Total Building Losses | | |
| | | 500-Year Hurricane Wind Event | 1000-Year Hurricane Wind Event | 2500-Year Hurricane Wind Event |
| Keyport Borough | $422,424,400 | $58,227 | $215,113 | $869,069 |
| *Source: HAZUS-MH* | | | | |

**Wildfires**

Impacts – Wildfires

Wildfires have the potential to destroy large portions of a community. Firefighters are at risk during the time that they are trying to contain and control a wildfire. Loss of life and injuries are possible for people living, working, or traveling through an impacted area. Beyond the loss of vegetation that wildfires leave in their wake, structures in the wildland/urban interface can be severely damaged or destroyed. As discussed previously, a wildfire occurring in Keyport is almost nonexistent, but if one were to occur, the population at risk within the Borough is an estimated 764 citizens with a total building value exposed to this hazard being approximately 3.98%.

Exposure and Damage Estimates – Wildfires

The following data was extracted from the Monmouth County Hazard Mitigation Plan that relates to the Borough of Keyport. Table 4.3 below shows exposure to wildfire within the Borough.

| Table 4.3 | | | | | | |
|---|---|---|---|---|---|---|
| Exposure to Wildfire | | | | | | |
| Municipality | Estimated Population At Risk | Total Assessed Value of Improvements (Buildings) | Total Assessed Value of Buildings Located in Low/Moderate Susceptibility Areas | Total Assessed Value of Buildings Located in High/Extreme Susceptibility Areas | Total Assessed Value of Buildings Located in All Wildfire Susceptibility Areas | Percent of Total Building Value Exposed to Wildfire |
| Keyport Borough | 764 | $422,424,400 | $10,843,036 | $5,974,671 | $16,817,707 | 3.98% |
| *Note: Exposure calculated by GIS Analysis using local assessed values* | | | | | | |

## Mitigation Action Strategies and Alternatives from MCMJHMP

This section outlines ten different action strategies submitted to the MCMJHMP including financial, engineering, environmental, and political while also looking into potential regulatory complications and coordination with federal and state agencies. The ten (10) Action worksheets were created for the Borough of Keyport through the MCMJHMP and are listed below explaining various projects that could help in protecting the Borough against future storm events. Comments will be provided regarding each action strategy including current status, prioritization, and feasibility.

The first action worksheet assesses risks pertaining to flooding, storm surge, wave action, hurricanes, tropical storms, and nor'easters. About half of the Borough is susceptible to storm surge, mainly due to tidal surges up local streams. During Superstorm Sandy, 95 homes encountered flood damage from storm tides and surges. Sea level rise and climate change will exacerbate severe flooding and surge events over a larger area. Climate change will contribute to more frequent and severe weather events. Structural projects such as elevating these homes is a way to relieve future damage and protect this existing development. By elevating the residential

properties to move them out of dangerous flood levels and avoid the loss of homes. The losses avoided is estimated to be $8,850,000 with a cost of approximately $2,850,000. The Borough has the authority to implement this action on a voluntary basis with outside contractor assistance. The project would only have environmental and social benefits that outweigh the cost of the action and it is feasible for many homes in the Borough to be raised. The project is considered a medium priority and would comply with environmental regulations with no negative impacts expected. Currently the Borough is working on raising homes along Beers Street that were damaged in Superstorm Sandy.

The second action worksheet addresses the same hazards as the first one listed above. As stated earlier, about half of the Borough is susceptible to these hazards, so the action that is proposed by this worksheet is have the Borough acquire two (2) flood prone properties and prohibit future building in flood prone areas. Losses avoided by acquiring these two properties are estimated to be a total of $12,324,200 with the project costing $3,566,800. The Borough has the authority to implement this action as well as the administrative authority to maintain it. The project would only have environmental and social benefits that outweigh the cost of the action. The project is considered a medium priority and would comply with environmental regulations with no negative impacts expected and is feasible. Negotiations are ongoing with respect to the acquisitions.

The next action worksheet pertains to flooding hazards within the Borough's existing bulkhead system being comprised of both public and private bulkheads with certain areas having no bulkheads. While the bulkhead system, in conjunction with some roads that have been raised, have worked to protect certain areas and locations where there are breaks in the line of protection that are more vulnerable than other areas. The properties affected by this are contained within residential and commercial zones. The action would implement increased elevation to bulkheads as well as replacing existing bulkheads. With the vulnerable properties in this area being commercial and residential and the roadway affected in this area being a major artery leading to the New Jersey Evacuation Route, the losses avoided for this project would be substantial and are estimated to be approximately $10,670,800 with a total cost of $951,800. The Borough has the authority to implement this action on a voluntary basis with outside contractor assistance. The project would only have environmental and social benefits that outweigh the cost of the action. The elevation of certain bulkheads is considered a high priority, is ongoing, and is feasible.

The next action worksheet addresses hazards such as flooding, storm surge, hurricanes, tropical storms, and nor'easters. The risks found in this evaluation are from flooding and damage to the sewer system pump stations (i.e., Maple Place) that can result in the overflow of untreated sewage into natural waterways. The action to be taken for this project would involve making improvements to the Maple Place Pump Station, which includes elevating electrical panels, modifications for water tightness, and the addition of generators to mitigate power loss and surging. These improvements will prevent untreated sewage leakage, and protect the natural waterways as well as public health. Elevating electrical panels and making modifications for water tightness will eliminate damage repair costs for various system components. There are secondary benefits to this action plan that include reduced environmental impacts to the adjacent waterway due to untreated wastewater overflows and the fact that the pump station is located in a flood prone area, which presents a health and safety concern to Borough personnel that need to maintain and keep the station operational during severe storm events. The action worksheet states that the benefits of this project are unquantifiable but are expected to be at least equal to the cost of the project which would be approximately $718,900. The community has the capacity to implement and maintain the project with outside contractor assistance. The improvements are considered a high priority and will be beneficial to the population as a whole, and will not disrupt any residents, neighborhoods, or districts. The Borough believes that the proposed mitigation is cost effective when considering the environmental impacts it would have to the adjacent waterway and that it will comply with environmental regulations with no negative impacts expected. The project has had funding set aside and is ongoing.

Action Worksheet five consists of the same addressed hazards and risks found in action worksheet four. This worksheet focuses more on the installment of a generator to ensure that there is a proper performance of the pump station facility in the event of a loss of power. Installing a generator would efficiently power the pump station in the event of power loss to prevent untreated sewage leakage, and protect the natural waterways as well as public health. The losses avoided are estimated to be approximately $55,543 with the project cost totaling $44,301. The improvements are considered a high priority and will be beneficial to the population as a whole, and will not disrupt any residents, neighborhoods, or districts. The generator has been purchased and this action is complete.

The sixth action worksheet also addressed hazards caused by flooding, hurricanes, tropical storms, and nor'easters. The risks found in combination with these hazards were insufficient roadway drainage (curbing, culverts, etc.), which leads to street flooding and flooding of multi-family, residential, and commercial properties. Lack of drainage and subsequent flooding can hinder access to the Borough's evacuation route, and the emergency vehicles access to the roadway. The action taken for this project would be to make improvements to the stormwater drainage system by increasing drainage and curbing along Green Grove Avenue. Losses avoided are estimated to be an approximate $966,600 in property damage as well as avoiding the potential loss of life with an estimated cost of $308,427. The Borough has the capacity to implement and maintain the project with outside contractor assistance. The improvements are considered a high priority and will be beneficial to the population as a whole, and will not disrupt any residents, neighborhoods, or districts. The project would only have environmental and social benefits that outweigh the cost of the action when considering that the project could not only reduce property damage, but potentially save lives. Funding has been set aside for this project and will continue to move forward until completed as the project is still feasible.

The seventh action worksheet addressed the hazards of flooding and how it affects the environment. The project would alleviate insufficient capacity of the stormwater system that results in frequent flooding in residential and commercial areas. With the reduced frequency and severity of flooding in commercial and residential areas the losses avoided from this action would be an approximate $2,412,600 with a cost of 1,102,556. The Borough has the capacity to implement and maintain the project with outside contractor assistance. The improvements are considered a high priority and will be beneficial to the population as a whole, and will not disrupt any residents, neighborhoods, or districts. The project is still feasible and is currently ongoing. Funding is set aside for this project.

Action worksheet eight has identified hazards such as flooding, storm surge, hurricanes, tropical storms, and nor'easters and has acknowledged the risks of the current Fireman's Park bulkhead height that is not sufficient to mitigate against high tide and storm related flooding. This has been a repetitive loss area affecting public property and the safe enjoyment of recreational areas as well as safe passage through roadways and access to commercial properties. This action would call for construction flood control measures by making improvements to the Fireman's Park bulkhead by elevating the structure to prevent future flooding of public properties and roadways. The land behind the bulkhead must also be raised to be effective. The losses avoided by completing the project are estimated to be $6,500,000 with a total cost of approximately $569,370. The Borough has the capacity to implement and maintain the project with outside contractor assistance. The improvements are considered a high priority and will be beneficial to the population as a whole, and will not disrupt any residents, neighborhoods, or districts. Elevation of the height of the bulkhead will comply with environmental regulations. Funds have been set aside to complete this project and is projected to be completed by 2018.

Action worksheet nine identifies hazards related to flooding, storm surge, hurricanes, tropical storms, and nor'easters and found that blockages and backflow of tidal and stormwaters in drainage systems contributes to flooding of roadways, the Borough, and commercial and residential properties. The action taken would make improvements to the stormwater drainage system by installing tideflex valves to alleviate blockages and prohibit foreign objectives in the outflow pipes. The losses avoided by this project are estimated to be roughly $3,560,000 with a cost of approximately $46,188. The Borough has the capacity to implement and maintain the project with outside contractor assistance. The improvements are considered a high priority and will be beneficial to the population as a whole, and will not disrupt any residents, neighborhoods, or districts. The addition of the valves will comply with environmental regulations. The project is ongoing and still is feasible for the Borough.

The final action worksheet created for the Borough addresses hazards such as flooding, hurricanes, tropical storms, nor'easters, coastal erosion, and storm surge. Silting continually blocks the discharge of stormwater from Division Street into the bay via the outfall pipe located at Beach Park. This inhibits the Borough's ability to complete beach restoration projects and future maintenance projects on the beach without risk of obstructing the pipe. Preventing the backup of stormwater discharge in several areas of the Borough and allowing future maintenance projects onto the beach without risk of obstructing the pipe would provide secondary erosion and surge protection from having adequate and maintained beaches. The losses that would be avoided from this action would be an approximate $8,000,000 with a total cost of $700,000. The Borough has the capacity to implement and maintain the project with outside contractor assistance. The improvements are considered a high priority and will be beneficial to the population as a whole, and will not disrupt any residents,

neighborhoods, or districts. The project will comply with environmental regulations with no negative impacts are expected. Funds have been earmarked for this project. Work on this project is expected to begin in 2017 and be completed by end of 2018.

In addition to the above projects, there are additional recommendations within the Borough's Neighborhood Plans and within the Borough's Coastal Vulnerability Assessment. All of these projects are included in the Borough's Capital Improvement Plan in terms of priority and funding. The table below outlines all ten worksheets.

**Table 4.4**
**Monmouth County Hazard Mitigation Plan Action Worksheets for Keyport**

| Action Category | Action Description | Priority | Projected Costs |
|---|---|---|---|
| Structural | Elevate 95 Homes | Medium | $2,850,000 |
| Acquisition | Acquire 2 Flood Prone Properties | Medium | $3,566,800 |
| Infrastructure | Increase elevation/replacement of bulkhead | High | $951,800 |
| Protect Critical Facilities | Maple Place Pump Station Improvements | High | $718,900 |
| Protect Critical Facilities | Install/Purchase Generator (completed) | High | $44,301 |
| Infrastructure | Green Grove culvert & Drainage Improvements | High | $308,427 |
| Infrastructure | Stormwater Drainage Improvements | High | $1,102,556 |
| Infrastructure | Fireman's Park Bulkhead Improvements | High | $569,370 |
| Infrastructure | Install Tideflex Valves | High | $46,188 |
| Infrastructure | Beach Park Pipe Improvements | High | $700,000 |

## Hazard Mitigation Recommendations

Superstorm Sandy hit the coastal areas of Ocean and Monmouth Counties the hardest. Every municipality in Monmouth County that bordered the Raritan Bay and the Atlantic Ocean suffered extensive damage while every inland municipality within the County experienced some sporadic damage. The Borough of Keyport was no exception to the devastation which caused over 26 percent of the Borough's land area to be inundated by flooding. Most of the downtown commercial district and residences were located on higher grand avoiding some of the damage caused by the storm. However, several landmarks and historic structures were adversely impacted such as the Keyport Steamboat Dock Museum and the Ye Cottage Inn restaurant. Detailed information about the impacts the Borough suffered during the superstorm are set forth within the 2014 Strategic Recovery Planning Report (SRPR) that was prepared by Maser Consulting.

The term "mitigation", defined by FEMA, refers to efforts to reduce loss of life and property by lessening the impacts of disasters. The following guidelines will be followed by the Borough in achieving hazard mitigation:

- Promote disaster-resistant development.
- Build and support local capacity to enable the public to prepare for, respond to, and recover from disasters.
- Update Borough ordinances to reflect the recommendations of this Hazard Mitigation Plan.
- Reduce the possibility of damage and losses due to flooding caused by floods, hurricanes, and nor'easters. Specifically, some of the actions include:
    - Limit uses in floodways to those tolerant of occasional flooding, including but not limited to agriculture, outdoor recreation, and natural resource areas.
    - Identify and document repetitively flooded properties. Explore mitigation opportunities for repetitively flooded properties, and if necessary, carry out acquisition, relocation, elevation, and flood-proofing measures to protect these properties.
    - Conduct a routine stream maintenance program and seek financial assistance to clean-out stream segments with heavy sediment deposits (i.e., this could be through participating in the Monmouth County/Bridge Commission routine stream maintenance program).

    - Develop specific mitigation solutions for flood-prone roadways and intersections in conjunction with State DOT. Develop a work plan for when sites will be surveyed and what role can the local government play in selection and implementation of mitigation activities (e.g. any monetary or contextual support through the local capital improvement plan).
- Reduce the possibility of damages and losses due to coastal erosion and wave action, specifically the actions below:
    - Establish an erosion setback line which is located landward of the first stable natural vegetation at a specified distance based on the long term rate of erosion.
    - Implement V Zone construction requirements for new development located in Coastal A Zones.
- Reduce the possibility of damage and losses due to tornadoes and high winds caused by windstorms, hurricanes, and nor'easters, specifically the following:
    - Adopt an ordinance to require hurricane clips on new construction.
    - Install hurricane clips and wind shutters on existing development especially emergency facilities and shelters built before existing codes were adopted to offer a degree of wind protection in compliance with the applicable codes and standards.
- Reduce the possibility of damages to emergency facilities from flooding, wind damage, and wildfire damage.
    - Conduct a study to determine the year built and level of protections for each emergency facility for each hazard.
    - Seek funding for mitigation projects for emergency facilities not currently designed for flood and high wind protection.

## FEMA MITIGATION TECHNIQUES

In support of the above guidelines, FEMA offers mitigation ideas that this 2017 Hazard Mitigation Plan recommends as being relevant to the Borough of Keyport:

**Extreme Temperatures**

- Reduce the heat island effect by installing green roofs, having more shade trees in parking lots, and reducing overall impervious surfaces;
- Increase awareness of extreme temperature risk and safety particularly for at risk populations such as citizens over the age of 65 or low-income residents;
- Encouraging utility companies to offer special payment options for paying heating bills for low income and elderly populations;
- Creating a database of individuals at high risk; and
- Educate homeowners about freezing pipes.

**Drought**

- Identify all available water supplies that can alleviate drought in an emergency;
- Monitor drought conditions as they can last for weeks to months;
- Monitor the water supply during a drought to determine the need for water conservation;
- Work with emergency managers to identify key criteria that triggers certain responses to drought such as conservation of water and regular information updates;
- Implement irrigation time or a scheduling program for water use; and
- Educate residents on water saving techniques.

**Coastal Erosion**

- Identify and monitor erosion areas;
- Inspect bulkheads, breakwaters, and other flood mitigation infrastructure after storm events;
- Locating utilities and critical facilities outside areas of erosion to decrease risk of service disruption or overflow of sanitary pump stations;
- Constructing deep foundations in erosion hazard areas;
- Stabilize erosion hazard areas through bank stabilization, planning vegetation on slopes, installing

riprap boulders, living shoreline techniques, or bioengineered bank stabilization techniques; and
- Increase awareness of erosion hazards.

**Flood**
- Mitigating hazards during infrastructure planning;
- Establishing a green infrastructure program;
- Participate in the CRS program to decrease flood insurance rates and increase resiliency to flooding;
- Adopting Flood Resistant Design and Construction ASCE 24;
- Improve stormwater management planning especially in vulnerable neighborhoods;
- Adopt policies to reduce stormwater runoff;
- Elevate or retrofit structures and utilities;
- Implementing floodproof techniques in residential and non-residential structures
- Protect infrastructure and critical facilities to the extent possible;
- Increase awareness of flood risk and safety

**Sea Level Rise**
- Manage development in High-Risk Areas;
- Protect existing buildings and infrastructure by retrofitting elevation or with more hazard resistant materials; and
- Protect and restore natural buffers to combat sea level rise where it is predicted to manifest.

**Extreme Wind**
- Adopt and enforce building codes that prevent wind damage such as anchoring, improving nail patterns, and other techniques;
- Incorporating passive ventilation in building and site design through architectural design standards or wind-resistant roof shapes;
- Protect powerlines with wind resistant utility poles, burying power lines if feasible and not too close to coastal/riverine flooding, and installing redundancies or loop feeds; and
- Retrofit residential homes, public buildings, and critical facilities to be resilient to high winds.

**Winter Storms**
- Ensuring enforcement of building codes for roof snow loads;
- Retrofit critical structures to withstand snow loads if needed;
- Protect power lines by pruning around power lines and installing redundancies;
- Work with the State and County to install roadway heating technology;
- Increase information to the public about severe winter weather impacts;
- Educating citizens that all fuel burning equipment should be vented to the outside; and
- Assist vulnerable populations to access heating centers in the community especially if they are at-risk to long-term power outages.

**Storm Surge**
- Improve building codes by incorporating V flood zone construction requirements for A flood zones or adopting building requirements for higher elevation in surge inundation zones;
- Planning for future storm surge heights due to sea level rise;
- Locating future critical facilities outside of areas susceptible to storm surge;
- Maintain a database of affected properties from storm surge after significant storm events to track community vulnerability and plan for increased resiliency; and
- Protect and restore natural buffers to help reduce storm surge damage.

**Earthquake**
As the occurrence of a major damaging earthquake in Keyport is minor only the following are recommended for the Borough:
- Develop an inventory on particularly vulnerable structures to earthquake damage to determine any that can be improved;

- Conduct inspections on building safety; and
- Protect critical facilities and infrastructure by installing shut off valves or retrofitting to reduce the impacts of an earthquake.

**Lightning**

- Protect critical facilities and equipment from lightning such as installing lightning rods, grounding, or surge protection; and
- Conduct lightning awareness programs for school children and the general population.

**Tornado**

The occurrence of a tornado in the Borough is very low, however, the following mitigation strategies can be useful to the Borough for tornados and other wind related storms.

- Require wind-resistant building techniques such as structural bracing, anchor bolts, or waterproof adhesive sealing strips; and
- Educate citizens on what to do if a tornado or high wind event is imminent to the Borough.

**Wildfire**

Once again the occurrence of a wildfire in the Borough is very low, but the following strategies may be useful to the Borough.

- Identify and catalog all remaining areas within the Borough that are vulnerable to wildfire including the wooded areas near and along creeks or along the Henry Hudson Trail;
- Reduce the risk by requiring land use buffers from areas vulnerable to wildfire; and
- Have a plan set in place for the fire department to implement if the risk of wildfire is high during the summer months or during a drought.

**Other Recommendations**

- Continually update community risk mapping based on new hazard data to properly prepare for multiple hazards that Hurricanes, Tropical Storms, and Nor'easters typically bring to the Borough. Being as prepared as possible for these extreme weather events can reduce the amount of damage to private and public property;
- Continue to implement the Borough's Capital Improvement Plan which identifies the most at risk areas and critical facilities in the Borough and provides a time frame to implement the proposed mitigation techniques;
- Integrate hazard mitigation into local planning and the Borough's zoning ordinance;
- Adopt and enforce building codes that increase resiliency of new and existing structures;
- Incentivize hazard mitigation through the CRS program and other types of incentives; and
- Increase hazard education and risk awareness.

FEMA is an excellent resource for providing information and tips on how to best prepare for all types of hazards. Visiting their website for updates and using this publication, https://www.fema.gov/media-library/assets/documents/30627, will assist the Borough in being as prepared as possible for the next extreme weather event.

## 2014 STRATEGIC RECOVERY PLANNING REPORT

In support of the Hazard Mitigation Guidelines, the Borough's SRPR recommendations related to hazard mitigation that have not been completed or that are still relevant are as follows:

1.) Fireman's Park Bulkhead – extension of the bulkhead (Elevation of 8.1 feet) from Fireman's Park, along West Front Street, to Monmouth County Bridge.

2.) Raising of Green Grove Avenue – raise Green Grove Avenue at Chingarora Creek culvert crossing to alleviate storm flooding.

3.) Division Street Stormwater Management Improvements.

a.) Replace damaged outfall pipe in Beach Park.
b.) Expand capacity of stormwater system along Division Street between Third & Front Streets.

4.) Beers Street Stormwater Management Improvements include elevating low lying sections of Beers Street near Front Street and rehabilitating stormwater management systems to prevent backflow from Luppatatong Creek during moon high tide and heavy rainfall events.

5.) Elevate Maple Place over Luppatatong Creek to increase capacity of culvert or convert culvert to a bridge (Environmental Impact Statement is likely to be required).

6.) Elevate First Street over Chingarora Creek to improve stormwater drainage and prevent blockage during storm events.

7.) Raise Bulkheads Along First Street & Raise Abutting Land.

a.) History of rising surges with past storms leading up to Sandy and expectation of continued need for higher bulkheads from sea level rise.
b.) May need to be combined with elevation of occupied structures.
c.) Land behind elevated bulk heads must be filled so that bulkheads can be capped in accordance with NJDEP requirements.

8.) Elevate Occupied Structures: Necessary for occupied properties in special flood hazard areas where bulkheading is not an option or is not practical to achieve resiliency.

a.) Occupied structures along Walnut Street, Cedar Street, Locust Street, Walnut Terrace, First Street, and Oak Street may be prioritized to be elevated. Very few structures in the Neighborhood abut a body of water; however, some of the flood hazard areas that are also the lowest and most vulnerable are located slightly inland and should be elevated.

9.) Replace or combine rip-rap with bulkheading in areas of extreme coastal erosion. Conventional rip-rap was insufficient to withstand erosion and scouring from Sandy's surge. Concrete bulkheads of insufficient height and/or design were also broken up by the surge.

10.) Army Corps of Engineers Study Recommendations: Alternative #7 of Study prop of Study proposes the combination of elevated bulkheading and flood prone properties such as the parking lot of the First Street Firehouse to create the effect of a levee with an elevation of 12.5 feet.

a.) The Borough should continue to monitor and comment on recommendations provided by the Army Corps of Engineers to ensure that any projects meet the needs of the Borough and Harbor neighborhoods and any negative impact is minimized.

11.) Acquire key properties for open space expansion.

a.) Coastal and riverine properties may be acquired through NJDEP's Blue Acres Program, which allows willing landowners to offer their properties for sale that have been damaged by, or prone to damage caused by storms or storm-related flooding, or that may buffer or protect lands from such damage. The NJDEP Green Acres Program "provides low interest (2%) loans and grants to municipal and county governments to acquire open space and develop outdoor recreation facilities." There are matching grants to acquire land, as well. Green Acres spaces are to remain in the public domain. Ralph Pier in Keyport was replaced using Green Acres funding.

12.) Restoration of Walnut Street bulkhead and beach access

a.) The Borough should consider removing the end of Walnut Street and rebuilding the bulkhead further upland using corrugated interlocking steel with an ecologically enhanced revetment (See above reference) around the base on the beach to protect from erosion and to absorb the impact of waves and land-based runoff.
b.) Additionally, the Borough should construct an ADA-accessible ramp from the sidewalk to the beach to provide public access.

13.) Ordinance requiring securing of floating docks, gangways, etc.

a.) Supplement Flood Prevention Ordinance or add regulations to Borough Code requiring removal

or securing of boats, floating docks, gangways, etc. from Keyport Harbor within a specified period from the issuance of an order from Emergency Management personnel. Establish penalties for owners of floating objects removed by the Borough due to compliance issues in order to prevent property damage during storm events.

b.) Amend Flood Prevention Ordinance or add regulations to Borough Code prohibiting the construction of occupied structures seaward of the mean high water line or on piers or platforms except for essential structures for "functionally dependent uses" such as marinas.

14.) Design Standards (integrating elevated structures into community design character) are being prepared under the PSPAG grant this has funded the preparation of this Community Resiliency Plan. It is recommended that these design standards address the visual impact of mitigation measures such as elevating bulkheads, elevating buildings on foundations or pilings, etc. Such design standards might include requirements for skirting exposed pilings, parking under the lowest habitable floor, or using exterior decking to stagger stairways to *elevated* first floor levels.

15.) Hardening of Infrastructure – The Borough's water and sewer capacity was impacted by either flooding or loss of power. Operating equipment at pump stations needs to be either raised above flood levels or hardened for protection against future events.

a.) As previously stated, critical infrastructure, such as pump stations, need to be raised or hardened; however, this recommendation should be revisited for shorelines, roads, and other infrastructure that may benefit from other methods of protection.

The following sections will discuss the various hazard mitigation recommendations for the four unique Neighborhoods in the Borough. The PSPAG Neighborhood Plan reports document unique risks associated to each neighborhood that deserve special attention herein. Building on these four documents which include numerous projects to project each neighborhood from future natural hazard events, this Plan recommends implementing the FEMA mitigation techniques and the SRPR mitigation recommendations to each specific neighborhood discussed below.

## BEERS STREET NEIGHBORHOOD PLAN

Below is an overview of high priority recommendations for the Beers Street Neighborhood.

- GREEN INFRASTRUCTURE TECHNIQUES
    - Identify the watershed/drainage basin area that is feeding Luppatatong Creek and the major contributors to the stormwater runoff into this creek. Develop a plan to mitigate excessive stormwater runoff and communicate this plan to parties contributing to the excessive stormwater runoff. This plan will likely involve generation of retention facilities for major areas of impervious surface and some Green Infrastructure Techniques for the entire watershed drainage area.
- ELEVATION OF LOW LYING AREAS
    - Either elevate the land to close to BFE +1 for new subdivisions and multi-family developments per the N.J.A.C. 7:13 Flood Hazard Control Act Rule or convert the low lying property which cannot meet this criteria to open space.

## FIRST STREET NEIGHBORHOOD PLANS

The First Street Neighborhood is the area of the Borough that borders the Raritan Bay waterfront and, as such, it has to deal with sea level rise, wave action, and storm surges. This Plan proposes to develop a hybrid strategy to mitigate sea level rise and storm surge.

### Develop a Hybrid Strategy to Mitigate Sea Level Rise and Storm Surge

As detailed in the Coastal Vulnerability Assessment, multiple areas in the First Street Neighborhood are at risk for loss of infrastructure and land from Sea Level Rise and significant amounts of damage from storm surge and/or extreme precipitation events. In order to mitigate these risks it is recommended to adopt a hybrid strategy that combines natural and built defense structures to resist Sea Level Rise and Storm Surge. This

would manifest itself in elevated bulkheads, levees, wave breaks, living shorelines, improved dunes, increased open space along the Bay, stormwater infrastructure, and other similar options. All of these would coexist and work together to reduce and mitigate the effects of Sea Level Rise and Storm Surge for the First Street Neighborhood. Some examples of living shorelines, wave breaks, and other techniques are shown in the images below. These are purely examples. Finding the best options will require cost/benefit analyses and research of which projects to pursue including appropriate locations.

This hybrid strategy recommendation includes the following potential actions:

- Implement Living Shorelines at Beach Park, the end of Broadway, and Terry Park to reduce the effects of storm surge and slow Sea Level Rise;
- Improve existing dunes at Terry Park and at the end of Broadway;
- Overall drainage improvements to the Neighborhood to assist in mitigating floods including Green Stormwater Infrastructure in the entire watershed of the creeks;
- Construct a wave break in the Raritan Bay harbor to decrease wave action and reduce the strength of any storm surge making its way to the First Street Neighborhood and beyond;
- Elevate existing bulkheads and add bulkheads with the land elevated behind the bulkhead wherever possible, especially at Fireman's Park to combat Sea Level Rise;
- Implement the SRPR recommendations for the First Street Firehouse parking lot in conjunction with Division Street stormwater improvements; and
- Acquire at-risk properties along the Raritan Bay for open space if the opportunity presents itself.

## DIVISION STREET NEIGHBORHOOD PLAN

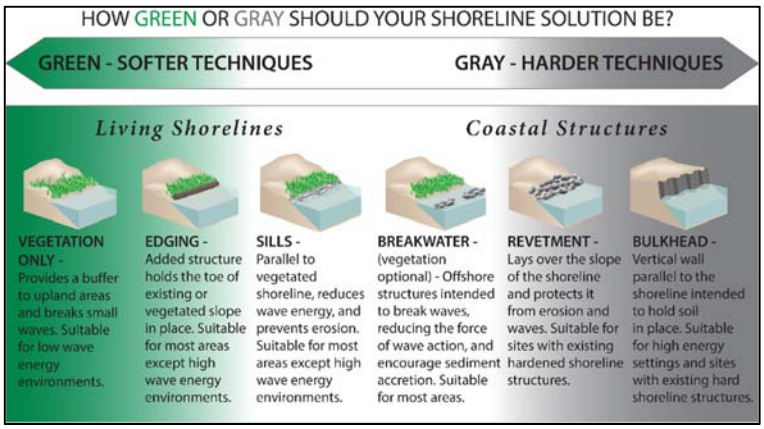
The key to mitigating the Division Street flooding is to implement a new outflow pipe at Beach Park with the capability to block tidal water flow into the Division Street area. The watershed/drainage area impacting Division Street needs to be mapped out in order to properly mitigate the flooding issue. The recommendation to increase the height of the Hook and Ladder Firehouse Parking area to act as a levee for protecting the Division Street Neighborhood from storm surge should be implemented.

## WALNUT-OAK STREET NEIGHBORHOOD PLAN

Considering the significant structural repair needed at the end of Walnut Street on the road, sidewalks, drainage, and bulkhead, and the use of the location almost exclusively for passive recreation, the Borough should consider removing part of the bulkhead and road back to the existing vegetated buffer, after assessing the potential effect, if any, on adjacent private property. The paved area at the existing street-end could be replaced with a bio-swale and newly constructed bulkhead with both natural drainage and improved pipe systems and a flood tolerant garden or estuarine vegetation and dunes below, to which filtered runoff would drain from the bio-swale. The end of Walnut Street should be considered public access under the New Jersey Department of Environmental Protection (NJDEP) Green Acres or Blue Acres programs. A horseshoe-shaped road at an elevation of BFE +1 from Walnut Street around the Aeromarine site along the Chingarora Creek could act as a levee for the interior neighborhood, while also providing necessary access to the site. Periodic dredging of the Chingarora Creek is recommended to address silting, and elevating the bridge structures over the Creek may allow for a better flow of water and sediment downstream.

The following are recommendations within the Walnut-Oak Street Neighborhood Plan that pertain to hazard mitigation.

- Shoreline Treatments are recommended to be implemented in the Walnut-Oak Street Neighborhood and elsewhere in the Borough where feasible;




*Source: Keyport Walnut-Oak Neighborhood Plan, Image: NOAA*

- Implement tidal marshes (low level wave energy);
- Implement living shoreline techniques including living breakwaters, marsh sills, beach restoration, and several others. Specifically at the end of Walnut Street;
- Make drainage improvements to stormwater conveyance systems in the Neighborhood including green streets and green stormwater infrastructure;
- Recommendation to elevation homes in the Neighborhood where feasible; and
- Improve evacuation routes.

## BOROUGH OF KEYPORT

The following are mitigation projects that are recommended for the entire Borough.

### Hardening Techniques

The most common hardening practice is replacing wooden utility poles with poles made of steel, concrete, or a composite material and upgrading transmission towers from aluminum to galvanized-steel lattice or concrete. Installing guy wires and other structural supports is another common tactic, as is increasing the number of poles. Such measures are intended to allow the pole, tower, or other structure to better withstand wind, including hurricane-force winds, as well as ice storms and snowstorms. These measures do not protect the power lines, transformers or conductors mounted on the poles themselves. Undergrounding of overhead utilities is not realistic for an area subject to flooding by seawater.

### Elevate Pump Stations and Address Critical Facility Vulnerabilities

Based upon the vulnerability assessment's findings that several critical facilities require resiliency improvements, this recommendation encourages the Borough to address these vulnerabilities. It is recommended to raise the pump stations and related critical infrastructure to above base flood elevation plus 3 feet, raise existing bulkheads to combat Sea Level Rise, improve breakwaters to handle increased storm surge, prepare a plan to address the possibility of losing West Front Street to Sea Level Rise, prepare a plan to protect the fire station's critical equipment, and improve the Beach Park outfall pipe.

### Reduce Impervious Surfaces

It is recommended to reduce impervious surfaces throughout the Neighborhood and increase open space to the maximum extent possible. Removing impervious surfaces through either pervious surface enhancements or natural open space will increase the amount of stormwater and flood waters that can be naturally percolated into the soil. Reducing overall impervious surface in the Neighborhood and Borough will also lower the strain put on existing or improved stormwater systems. Potential means of reducing impervious surface in the Neighborhood are Green Streets outlined above, more street trees or planters throughout the Neighborhood, installing green roofs on existing structures, and to look into possibly converting the existing parking lot on the corner of 1st Street and Church Street into permeable pavement or permanent open space. Changing the existing parking lot into Open Space would have the additional advantage of potentially installing further stormwater management improvements.

**Raise Structures and Purchase At-Risk Properties**

Reduced impervious surfaces and improved stormwater systems in the Borough will certainly improve resiliency and mitigate flood hazards but as the Vulnerability Assessment shows, many properties within the Neighborhood basin will still experience flood damage from a major hurricane's Storm Surge. In order to combat this and increase resiliency, it is recommended to raise occupied structures and buy at risk properties to be turned into open space.

**Monitor Ongoing Army Corp of Engineer Projects in Surrounding Municipalities**

The Army Corp of Engineers is implementing a very large capital project known as the Hurricane Sandy Limited Reevaluation Report (HSLRR) for Coastal Storm Risk Management in Union Beach, New Jersey. This HSLRR's recommended plan includes levees, roller gates, floodwalls, and other major flood mitigation projects right on the border of Keyport near Aeromarine and where Route 36 enters Keyport from Union Beach. The impacts of these projects should be monitored to ensure flood waters are not pushed towards Keyport once the HSLRR plan is implemented.

**Zoning Ordinance Recommendations**

It is recommended to revise the Borough's Zoning Ordinance to permit hazard mitigation techniques such as living shorelines, green stormwater improvements, and other techniques noted herein.

**Pre-Flood Plan**

Develop a pre-flood plan that disseminates key information to residents such as evacuation routes, safety procedures, and recovery operations. This should include the location of the Borough's emergency shelters, emergency operations center, and supply areas. Also all loose items should be secured prior to a flood or storm such as unanchored sheds, outside objects, garbage cans, or outside furniture.

**Special Needs Database**

Create a special needs database for the First Street Neighborhood and other areas of the Borough. This database should include elderly citizens with mobility issues that may need special assistance during an evacuation, citizens that do not have access to a car or public transit during a disaster, and anyone else in the Neighborhood that requires special needs during an evacuation.

**Emergency Operations Plan and Evacuation Plan**

The borough should create both plans to implement a hierarchy during emergencies that highlights the jobs/objectives for first responders, any preparations such as anchoring throughout the Borough prior to an imminent storm or natural hazard, and how to efficiently evacuate the Borough including areas that are blocked from flood.

**Relocation of Critical Equipment**

In anticipation of a major disaster, crucial Borough equipment and vehicles that are in flood zones should be moved to higher ground to ensure they can be used in disaster evacuation, response, and overall operations.

## FUNDING SOURCES FOR MITIGATION PROGRAMS

The following are financial options available to the Borough to implement hazard mitigation projects that were outlined in the 2016 Getting to Resiliency Report and Community Resiliency Element.

**Financial Leverage**

*New Jersey Environmental Infrastructure Trust (NJEIT)*

NJEIT is an independent State financing authority that provides low-interest rate loans ("H2lOans") to qualified borrowers in New Jersey for water quality and infrastructure projects. "Clean Water" loans are available for Wastewater Projects associated with sewage collection, treatment or disposal, including

correction of inflow/infiltration problems, sludge management and combined sewer overflows. Loans are also available for Stormwater Projects including construction, expansion or replacement of stormwater management systems, construction or expansion of basins, replacement of storm drains and rehabilitation of tide gates and extension of outfall points. Green projects which Keyport may also wish to implement to reduce the impact of rainwater are also eligible, including replacing existing pavement with porous pavement, utilizing bio-retention, constructing green roofs, creating rain gardens, and other practices that mimic natural hydrology and increase effective perviousness.

*Flood Mitigation Assistance (FMA) Program*

The FMA program seeks to reduce or eliminate claims under the National Flood Insurance Program (NFIP). FMA provides funding to local communities for projects and planning that reduces or eliminates long-term risk of flood damage to structures insured under the NFIP. FMA funding is also available for management costs. Funding for FMA is very limited and applications must come from local governments or other eligible organizations. The federal cost share for an FMA project is 75%. At least 25% of the total eligible costs must be provided by a non-federal source. At minimum, a FEMA-approved local flood mitigation plan is required before a project can be approved.

*Pre-Disaster Mitigation (PDM) Program*

The PDM Program is designed to assist local communities in implementing a sustained pre-disaster natural hazard mitigation program, with the goal of reducing overall risk to the population and structures from future hazard events, while also reducing reliance on Federal funding in future disasters. This program awards planning and project grants and provides opportunities for raising public awareness about reducing future losses before disaster strikes. Mitigation planning is a key process used to break the cycle of disaster damage, reconstruction, and repeated damage. PDM grants are funded annually by Congressional appropriations and are awarded on a nationally competitive basis. FEMA requires the adoption of a hazard mitigation plan as a condition for receiving funding for PDM mitigation projects.

*Emergency Management Performance Grant (EMPG)*

The Emergency Management Performance Grant Program plays an important role in the implementation of the National Preparedness System by supporting the building, sustainment, and delivery of core capabilities essential to achieving the National Preparedness Goal of a secure and resilient Nation. The EMPG supports efforts to build and sustain core capabilities across the five mission areas of Prevention, Protection, Mitigation, Response, and Recovery based on allowable costs.

*Homeland Security Grant Program (HSGP)*

Like the EMPG above, HSGP plays an important role in the implementation of the National Preparedness System by supporting the building, sustainment, and delivery of core capabilities essential to achieving the National Preparedness Goal of a secure and resilient Nation. The HSGP supports efforts to build and sustain core capabilities across the five mission areas of Prevention, Protection, Mitigation, Response, and Recovery based on allowable costs. HSGP is comprised of three interconnected grant programs including the State Homeland Security Program (SHSP), Urban Areas Security Initiative (UASI), and the Operation Stone garden (OPSG). Together, these grant programs fund a range of preparedness activities, including planning, organization, equipment purchase, training, exercises, and management and administration.

*Community Development Block Grants (CDBG)*

Entitlement Community grants through CDBG are federal funds, through the Department of Housing and Urban Development (HUD), intended to provide low and moderate-income households with viable communities, including decent housing, as suitable living environment, and expanded economic opportunities. Eligible activities include community facilities and improvements, roads and infrastructure, housing rehabilitation and preservation, development activities, public services, economic development, planning, and administration. Public improvements may include flood and drainage improvements.

*NJDEP Blue Acres Floodplain Program*

Properties and structures that have been damaged by, or may be prone to incurring damage caused by, storms or storm-related flooding, or that may buffer or protect other lands from such damage, are eligible for acquisition through the NJDEP Blue Acres Program. All Blue Acres acquisitions must be from willing sellers.

*NJDEP Green Acres Program*

Green Acres provides low interest loans and grants to assist local governments in the acquisition and development of open space for recreation and conservation purposes. Should Keyport wish to acquire property for open space in order to increase pervious coverage and mitigate the impact of rainfall, these funds would be applicable.

*Floodplain Management Plan*

FEMA defines Floodplain Management as the operation of a community program of preventive and corrective measures to reduce the risk of current and future flooding, resulting in a more resilient community. High standards for floodplain management will create safer, stronger, and more resilient communities. Approximately 26 percent of the Borough's land area is located in the one-percent annual chance floodplain area. With that in mind, it is recommended that the Borough pursue funding for a Floodplain Management Plan. While the Borough adopted its Stormwater Management Plan in 2009, adopting a Floodplain Management Plan would take that a step further to include sea level rise, major storm events, and the concept of a "living shoreline" or other waterfront solutions.

*Repetitive Loss Area Analysis*

This Plan identifies the low-lying area near Fireman's Park, the marinas at the Borough's western border, and the eastern border of the Borough to Union Beach as a Repetitive Loss Areas as defined by FEMA. These local areas have sustained repetitive losses thereby putting stress on the National Flood Insurance Program. The Neighborhood Plans and Master Plan address these areas and recommend to improve their resiliency. The preparation of a more thorough RLAA can also provide additional points for the Borough's CRS program. An RLAA is highly recommended for the Borough to pursue. The Borough has several properties that are a repetitive loss property, and are the source of over half the paid NFIP claims.