

SECTION 5: RISK ASSESSMENT

According to FEMA Guidance 386-2, “risk assessment is the process of measuring the potential loss of life, personal injury, economic injury and property damage resulting from natural hazards by assessing the vulnerability of people, buildings and infrastructure to natural hazards.” The City of New Rochelle’s risk assessment is organized into four sections. Section 5.1 describes the methodology and tools used to support the risk assessment process. Section 5.2 identifies the natural hazards of concern for further profiling and evaluation. In Section 5.3, the identified hazards of concern are ranked for the City as a whole to describe their probability of occurrence and their impact on population, property (general building stock including critical facilities) and the economy. Lastly, Section 5.4 profiles and assesses vulnerability for each hazard of concern.

5.1 METHODOLOGY AND TOOLS

This section describes the methodology and tools used to support the risk assessment process.

Methodology

The risk assessment process used for this Plan is consistent with the process and steps presented in FEMA 386-2, State and Local Mitigation Planning How-to-Guide, Understanding Your Risks – Identifying Hazards and Estimating Losses (FEMA, 2001). This process identifies and profiles the hazards of concern and assesses the vulnerability of assets (population, structures, critical facilities and the economy) at risk in the community. A risk assessment provides a foundation for the community’s decision makers to evaluate mitigation measures that can help reduce the impacts of a hazard when one occurs (Section 6 of this plan).

Step 1: The first step of the risk assessment process is to identify the hazards of concern. FEMA’s current regulations only require an evaluation of natural hazards. Natural hazards are natural events that threaten lives, property, and many other assets. Often, natural hazards can be predicted, where they tend to occur repeatedly in the same geographical locations because they are related to weather patterns or physical characteristics of an area.

Step 2: The next step of the risk assessment is to prepare a profile for each hazard of concern. These profiles assist communities in evaluating and comparing the hazards that can impact their area. Each type of hazard has unique characteristics that vary from event to event. That is, the impacts associated with a specific hazard can vary depending on the magnitude and location of each event (a hazard event is a specific, uninterrupted occurrence of a particular type of hazard). Further, the probability of occurrence of a hazard in a given location impacts the priority assigned to that hazard. Finally, each hazard will impact different communities in different ways, based on geography, local development, population distribution, age of buildings, and mitigation measures already implemented.

Steps 3 and 4: To understand risk, a community must evaluate what assets it possesses and which assets are exposed or vulnerable to the identified hazards of concern. Hazard profile information combined with data regarding population, demographics, general building stock, and critical facilities at risk, located in Section 4, prepares the community to develop risk scenarios and estimate potential damages and losses for each hazard.

Tools

To address the requirements of DMA 2000 and better understand potential vulnerability and losses associated with hazards of concern, the City of New Rochelle used standardized tools, combined with local, state, and federal data and expertise to conduct the risk assessment. Our standardized tools used to support the risk assessment are described below.

Hazards U.S. – Multi-Hazard (HAZUS-MH)

In 1997, FEMA developed a standardized model for estimating losses caused by earthquakes, known as Hazards U.S. or HAZUS. HAZUS was developed in response to the need for more effective national-, state-, and community-level planning and the need to identify areas that face the highest risk and potential for loss. HAZUS was expanded into a multi-hazard methodology, HAZUS-MH with new models for estimating potential losses from wind (hurricanes) and flood (riverine and coastal) hazards. HAZUS-MH is a Geographic Information System (GIS)-based software tool that applies engineering and scientific risk calculations that have been developed by hazard and information technology experts to provide defensible

damage and loss estimates. These methodologies are accepted by FEMA and provide a consistent framework for assessing risk across a variety of hazards. The GIS framework also supports the evaluation of hazards and assessment of inventory and loss estimates for these hazards.

HAZUS-MH uses GIS technology to produce detailed maps and analytical reports that estimate a community's direct physical damage to building stock, critical facilities, transportation systems and utility systems. To generate this information, HAZUS-MH uses default HAZUS-MH provided data for inventory, vulnerability, and hazards; this default data can be supplemented with local data to provide a more refined analysis. Damage reports can include induced damage (inundation, fire, threats posed by hazardous materials and debris) and direct economic and social losses (casualties, shelter requirements, and economic impact) depending on the hazard and available local data. HAZUS-MH's open data architecture can be used to manage community GIS data in a central location. The use of this software also promotes consistency of data output now and in the future and standardization of data collection and storage. The guidance *Using HAZUS-MH for Risk Assessment: How-to Guide (FEMA 433)* was used to support the application of HAZUS-MH for this risk assessment and plan. More information on HAZUS-MH is available at <http://www.fema.gov/plan/prevent/hazus/index.shtm>.

In general, probabilistic analyses were performed to develop estimates of long-term average losses (annualized losses) as well as an expected/estimated distribution of losses (mean return period losses) for the earthquake, flood and wind hazards. The probabilistic hazard generates estimates of damage and loss for specified return periods (e.g., 100- and 500-year). For annualized losses, HAZUS-MH MR4 calculates the maximum potential annual dollar loss resulting from various return periods averaged on a "per year" basis. It is the summation of all HAZUS-supplied return periods (e.g., 10, 50, 100, 200, 500) multiplied by the return period probability (as a weighted calculation). In summary, the estimated cost of a hazard each year is calculated.

Custom methodologies in HAZUS-MH MR4 were used to assess potential exposure and losses associated with hazards of concern for the City of New Rochelle:

- **Inventory:** The default demographic data in HAZUS-MH MR4, based on the 2000 U.S. Census, was used for analysis. The valuation of general building stock and the loss estimates determined in the City were based on the default general building stock database provided in HAZUS-MH MR4. The general building stock valuations are Replacement Cost Value from RSMeans as of 2006. The critical facility inventory (essential facilities, utilities, transportation features and user-defined facilities) was updated for the earthquake, flood and wind hazard models. This comprehensive inventory was developed by gathering input from numerous sources including HAZUS-MH MR4, Westchester County GIS, City of New Rochelle and input from the Planning Committee.

The 'user-defined facilities' category includes all assets that the City deemed critical to include in the inventory and that do not fit within a pre-defined HAZUS-MH facility category. These facilities include shelters, City hall, and senior facilities. Because user-defined facilities are points in HAZUS-MH, the asset's location was either provided by the County/municipality or is the calculated parcel centroid of the polygon provided.

- **Earthquake:** A Level 2 HAZUS-MH MR4 analysis using a probabilistic scenario was performed to analyze the earthquake hazard losses for the City of New Rochelle (annualized losses and 100-, 500- and 2,500-year mean return period [MRP] losses). A Level 1 analysis is a basic estimate of earthquake losses based on national databases and using the default data in the model. Default demographic and general building stock data in HAZUS-MH MR4 were used for the earthquake analysis. However, as described above, updated critical facility inventories were used. Additionally,

a local soil map provided by NYSEMO was entered into HAZUS-MH MR4 to replace default soil conditions. HAZUS-MH MR4 uses the seismic soil type classes recommended by the National Earthquake Hazard Reduction Program (NEHRP). The NEHRP soils classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage and losses (NYSEMO, 2004; NYCEM, 2003). When a Level 1 HAZUS-MH MR4 earthquake analysis is conducted, the NEHRP soil classification type “D” is used as the soil type across the entire study region. For this HMP, a local soil map with the City of New Rochelle’s NEHRP soil types provided by NYSEMO was entered into HAZUS-MH MR4 and used for all analyses.

- **Flood:** The HAZUS-MH MR4 coastal and riverine models; the FEMA Digital Flood Insurance Rate Maps (DFIRMs), effective September 28, 2007; USGS one-third ArcSecond Digital Elevation Models (DEM) (10 meter resolution), and NOAA’s Environmental Sensitivity Index (ESI) were used to estimate exposure and losses associated with the flood hazard (see Figure 5.1-1).

HAZUS-MH MR4 was used to run the hydrology and hydraulics for the selected river and coastal reaches, using the DFIRMs as a guide, HAZUS-MH MR4 generated the flood-depth grid and flood boundary for the specified return periods (annualized losses and the 100- and 500- MRPs) and calculated the estimated damages to the general building stock and critical facilities based on this depth grid.

- **Hurricane/Wind:** A modified Level 1 HAZUS-MH probabilistic analysis was performed to analyze the wind hazard losses for the City. The probabilistic hurricane hazard activates a database of thousands of potential storms that have tracks and intensities reflecting the full spectrum of Atlantic hurricanes observed since 1886 and identifies those with tracks associated with the County. Annualized losses and the 100- and 500-year MRPs were examined for the wind/severe storm hazard. Default demographic and general building stock data in HAZUS-MH MR4 were used for the analysis. However, as described above, updated critical facility inventories were used.

Currently HAZUS-MH MR4 only analyzes the flood and wind models separately, producing independent results. However, it is recognized that hurricanes cause both wind and storm surge related damage. In addition to analyzing and reporting wind-only loss estimates generated by the HAZUS-MH MR4 wind model, an attempt was made to combine the wind and storm surge hazards to produce wind and storm surge loss estimates for the hurricane hazard.

NYSEMO provided a GIS shapefile of the ‘SLOSH grid and associated surge height “maximum envelope of water – MEOW” for Category 1 to 4 storms with northwest directional track which landfalls at high tide (worst case scenario).’ Please note, these surge heights were calculated using several possible landfall locations; therefore, these values are not from a single worst case storm but are the highest values at any given geographic location for the associated category storm factoring several possible landfalls (O’Brien, 2010).

To perform this probabilistic wind/hurricane analysis for the City of New Rochelle a coastal flood probabilistic scenario was set up using the Category 1 and 2 Sea, Land and Overland Surge from Hurricanes (SLOSH) model surge heights, provided by NYSEMO, as the 100- and 500-year stillwater elevations respectively.

For each Census block, the storm surge and wind damages were compared and the larger damage value for building structure and contents is estimated as the minimum damage sustained for each general occupancy type. The storm surge damage was added to the wind damage and compared to the total inventory value. If the damage total is greater than the inventory total, the inventory total is

the maximum damage sustained. If the damage total is smaller than the inventory total, the damage total is the maximum value. Therefore, the combined wind and storm surge damage results are presented as minimum and maximum value range. In addition, potential losses calculated using the HAZUS-MH MR4 hurricane model (wind only) are integrated and presented for other high wind events such as Nor'Easters and severe storms.

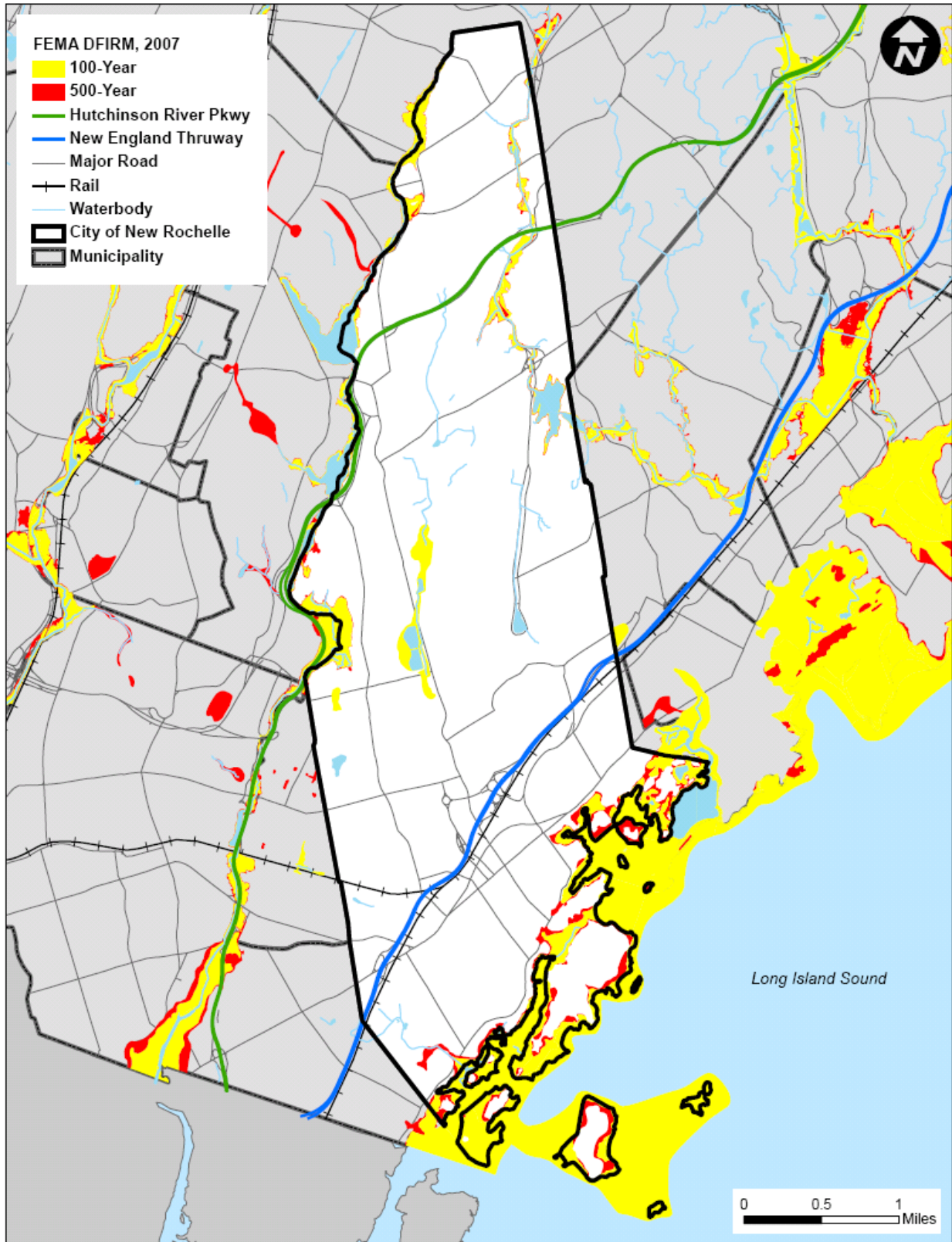
- Other Hazards: HAZUS-MH support was used to evaluate other hazards, as feasible. For many of the hazards evaluated in this risk assessment, historic data are not adequate to model future losses at this time. However, HAZUS-MH can map hazard areas and calculate exposures if geographic information on the locations of the hazards and inventory data are available. For some of the other hazards of concern, areas and inventory susceptible to specific hazards were mapped and exposure was evaluated to help guide mitigation efforts discussed in Section 6. For other hazards, a qualitative analysis was conducted using the best available data and professional judgment.

For this risk assessment, the loss estimates, exposure assessments, and hazard-specific vulnerability evaluations rely on the best available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their affects on the built environment. Uncertainties also result from the following:

- 1) Approximations and simplifications necessary to conduct such a study
- 2) Incomplete or dated inventory, demographic, or economic parameter data
- 3) The unique nature, geographic extent, and severity of each hazard
- 4) Mitigation measures already employed by the City of New Rochelle and the amount of advance notice residents have to prepare for a specific hazard event

These factors can result in a range of uncertainty in loss estimates, possibly by a factor of two or more. Therefore, potential exposure and loss estimates are approximate. These results do not predict precise results and should be used to understand relative risk. Over the long term, the City of New Rochelle will collect additional data to assist in developing refined estimates of vulnerabilities to natural hazards.

Figure 5.1-1. FEMA 100- and 500-Year Regulatory Floodplains within the City of New Rochelle



Source: FEMA DFIRM, 2007

5.2 IDENTIFICATION OF HAZARDS OF CONCERN

To provide a strong foundation for mitigation strategies considered in Section 6, the City of New Rochelle in Westchester County, focused on considering a full range of hazards that could impact the area, and then identified and ranked those hazards that presented the greatest concern. The hazard of concern identification process incorporated input from the County, the City of New Rochelle; review of the 2008 New York State Hazard Mitigation Plan (NYS HMP) and previous hazard identification efforts; research and local, state, and federal information on the frequency, magnitude, and costs associated with the various hazards that have previously, or could feasibly, impact the region; and qualitative or anecdotal information regarding natural hazards and the perceived vulnerability of the study area’s assets to them. Table 5.2-1 documents the process of identifying the natural hazards of concern, and one man-made hazard of concern (transportation), for further profiling and evaluation.

Hazards of Concern is defined as those hazards that are considered most likely to impact a community. These are identified using available data and local knowledge.

For the purposes of this planning effort, the Planning Committee chose to group some natural hazards together, based on the similarity of hazard events, their typical concurrence or their impacts, consideration of how hazards have been grouped in Federal Emergency Management Agency (FEMA) guidance documents (FEMA 386-1, “Understanding Your Risks, Identifying Hazards and Estimating Losses; FEMA’s “Multi-Hazard Identification and Risk Assessment – The Cornerstone of the National Mitigation Strategy”), and consideration of hazard grouping in the NYS HMP.

The “Flooding” hazard includes coastal flooding, flash flooding, ice jam flooding, and riverine flooding (including storm surges). Inclusion of the various forms of flooding under a general “Flood” hazard is consistent with that used in FEMA’s “Multi-Hazard Identification and Risk Assessment” guidance.

The “Coastal Storms” hazard includes tropical (hurricanes, tropical storms and tropical depressions) and extra-tropical cyclones (Nor’Easters and severe winter low-pressure systems). This hazard grouping is consistent with that used in FEMA 386-1. The “Severe Storm” hazard includes windstorms that often entail a variety of other influencing weather conditions including thunderstorms, hail and tornadoes. Many of the severe storm events were due to the effects of a coastal storm; therefore, severe storm events have been grouped with this hazard.

The “Severe Winter Storm” hazard includes heavy snow, blizzards, sleet, freezing rain, ice storms and Nor’Easters. Since extreme cold temperatures are generated during winter weather months and/or accompany winter storms, extreme cold events have also been grouped with this hazard. This grouping is consistent with that used in the NYS HMP, as well as the “Severe Winter Storm” hazard used in FEMA’s “Multi-Hazard Identification and Risk Assessment” guidance.

These groupings do not change the definition of the included specific events/hazards, as defined within FEMA guidance and other risk assessment documents, and does not affect the hazard analysis conducted through the use of HAZUS-MH, either directly or as a risk assessment support tool.

Due to the limited availability of budget resources, this mitigation planning effort has, at least initially, evaluated four natural hazards (earthquake, flood, severe storm, severe winter storm/extreme temperature) and one man-made hazard (transportation hazards). The City may attempt to expand the scope of this HMP to include other less frequent natural hazards and/or additional technological and man-made (for example, terrorism, man-made dam breaches/failures) hazards as resources permit.

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Table 5.2-1. Identification of Hazards of Concern for the City of New Rochelle, New York

Hazard	Step 1	Step 2	Step 3	
	Is this a hazard that may occur in the City of New Rochelle?	If yes, does this hazard pose a significant threat to the City of New Rochelle?	Why was this determination made?	Source(s)
Avalanche	No	No	<ul style="list-style-type: none"> The NYS HMP does not identify avalanche as a hazard of concern for New York State. The topography and climate of the City of New Rochelle does not readily support the occurrence of an avalanche event. New York State in general has a very low occurrence of avalanche events based on statistics provided by National Avalanche Center – American Avalanche Association (NAC-AAA) between 1950 and 2007. Between this time period, New York State experienced four fatalities due to avalanches. 	<ul style="list-style-type: none"> NYSDPC Review of NAC-AAA database between 1950 and 2007
Coastal Erosion	Yes	Yes	<ul style="list-style-type: none"> The NYS HMP identifies the City of New Rochelle as a Coastal Erosion Hazard Areas (CEHA) Community. It is one of the 86 municipalities under the CEHA program. Coastal erosion is a significant concern for these municipalities. The City of New Rochelle is bounded to the southeast by the Long Island Sound, a coastal waterway. The City contains 9.2 miles of waterfront along the Long Island Sound. The waterfront area of the City of New Rochelle is predominately mixed-density residential. There are areas of recreational, commercial, and water-related uses as well. 	<ul style="list-style-type: none"> NYSDPC Downtown New Rochelle Cashin Associates
Coastal Storm (tropical cyclones, hurricanes, tropical depressions, tropical storms, and Nor'Easters)	Yes	Yes	<ul style="list-style-type: none"> The NYS HMP identified hurricane and tropical storms as a hazard of concern for New York State. The City of New Rochelle is located in U.S. Wind Zone II receiving speeds up to 160 miles per hour and is identified in the Hurricane Susceptibility Region which extends along the eastern and southern coastline of the U.S. The City of New Rochelle is bounded to the south and southeast by the Long Island Sound; making the City susceptible to coastal storms, erosion and flooding. The Historical Hurricane Tracks tool, provided by the NOAA CSC indicates that between 1861 and 2008, the City has experienced 20 tropical storm events, 6 hurricane events, and 11 extra-tropical events within 65 nautical mile radius. 	<ul style="list-style-type: none"> NYSDPC FEMA NOAA CSC
Drought	Yes	No	<ul style="list-style-type: none"> The NYS HMP identifies drought and extreme heat events as hazards of concern for New York State. The City of New Rochelle is located within the Hudson Valley Climate Division. Between 1908 and 2002, the Hudson Valley Climate Division experienced 15 drought periods. These periods include: <ul style="list-style-type: none"> November 1908 – January 1909 	<ul style="list-style-type: none"> NYSDPC NOAA-NCDC Drought Reporter SHELDUS U.S. Drought

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Hazard	Step 1	Step 2	Step 3	
	Is this a hazard that may occur in the City of New Rochelle?	If yes, does this hazard pose a significant threat to the City of New Rochelle?	Why was this determination made?	Source(s)
			<ul style="list-style-type: none"> o November – December 1909 o October 1910 – January 1911 o December 1930 – January 1931 o April – July 1911 o December 1930 – January 1931 o October 1941 – February 1942 o October – December 1949 o August – November 1957 o October – December 1963 o May 1964 – September 1966 o January – February 1967 o April – May 1985 o August – September 1995 o December 2001 – February 2002 <ul style="list-style-type: none"> • Various sources indicated that many drought events or periods impacted large regions of the State, including Westchester County. Such events include: <ul style="list-style-type: none"> o July 1999 – Sustained drought conditions caused a government-mandated water use restrictions for 10 states, including all of New York State. o August 1999 – Several counties in New York State, including Westchester County, were declared farm disaster areas. • While there is a historic record of drought events in the City and Westchester County, there is very little evidence of significant impacts (human, structural, economic) resulting from these events. Further, these risks are properly managed through preparedness and response. Mitigation opportunities are limited or are being addressed along with other hazards and their resulting impacts. The cascading effect of drought exacerbating wildfire risk is addressed in the Wildfire hazard profile and risk assessment. • The City of New Rochelle Planning Committee ranked drought as a low relative risk for the City. 	Monitor Archive
Earthquake	Yes	Yes	<ul style="list-style-type: none"> • The NYS HMP identifies earthquake as a hazard of concern for New York State. • According to the NGDC, New York State has only had 9 significant earthquakes between 2150 B.C. and 2009, including one in 1884 that damaged chimneys in the City of Mount Vernon. • NYCEM indicates that no earthquakes have taken place in or immediately 	<ul style="list-style-type: none"> • NYSDPC • NGDC • NYCEM • USGS – Earthquake Hazards



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	Is this a hazard that may occur in the City of New Rochelle?	If yes, does this hazard pose a significant threat to the City of New Rochelle?	Why was this determination made?	Source(s)
			<p>surrounding the City of New Rochelle between 1730 and 2002. However, NY-NJ-CT Metro region, which includes Westchester County, does have a <i>low hazard / high risk</i> earthquake potential with its dense population, vulnerable infrastructure and substantial economic value.</p> <ul style="list-style-type: none"> • According to the USGS online seismic hazard maps, the peak ground acceleration with a 10-percent probability of exceedance over 50 years for Westchester County is between 3 and 4 %g. FEMA guidance recommends earthquakes be evaluated further if an area has a 3 %g peak acceleration or more. • As indicated by other sources, additional earthquake events to the City of New Rochelle include: <ul style="list-style-type: none"> ○ July 11, 1872 – an earthquake struck in Pelham, New York; it was felt in New Rochelle with an MMI of 5 ○ May 12, 1926 – an earthquake struck in Bronx, New York; it was felt in New Rochelle with an MMI of 5 ○ November 1, 1935 – an earthquake struck near Tea Lake, Quebec, Canada; it was felt in New Rochelle with an MMI of 4 ○ November 22, 1967 – an earthquake struck in Rye, New York; it was felt in New Rochelle with an MMI of 4 ○ October 7, 1983 – an earthquake struck near Blue Mountain Lake, New York; it was felt in New Rochelle with an MMI of 3 ○ October 19, 1985 – an earthquake struck in Yonkers, New York; it was felt in New Rochelle with an MMI of 5 ○ October 21, 1985 – an earthquake struck in Yonkers, New York; it was felt in New Rochelle with an MMI of 4 	<p>Program, Review of USGS Seismic Maps</p>
Expansive Soils	No	No	<ul style="list-style-type: none"> • The NYS HMP identifies expansive soils as a hazard of concern for New York State. • USGS indicated that Westchester County has little or no clays with swelling potential with some locations having generally less than 50-percent of clay, having slight to moderate swelling potential that could result in expansive or swelling soils. • Based on all sources reviewed, no known historical occurrences are reported for the City of New Rochelle. 	<ul style="list-style-type: none"> • NYSDPC • Review of USGS 1989 Swelling Clays Map of the Conterminous United States
Extreme Temperature	Yes	Yes (Extreme Cold)	<ul style="list-style-type: none"> • Record extreme heat events during the summer months of May through September in the City of New Rochelle occurred on: 	<ul style="list-style-type: none"> • NOAA-NCDC • The Weather



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	Is this a hazard that may occur in the City of New Rochelle?	If yes, does this hazard pose a significant threat to the City of New Rochelle?	Why was this determination made?	Source(s)
		only)	<ul style="list-style-type: none"> o August 1948 – Record high for the City was 101°F o September 1953 – Record high for the City was 102°F o June 1954 – Record high for the City was 100°F o May 1962 – Record high for the City was 97°F o July 1966 – Record high for the City was 102°F • Other extreme heat events that occurred in the City and the surrounding areas include: <ul style="list-style-type: none"> o July 4, 1993 – extreme heat o July 4, 1999 – extreme heat; 2 fatalities (in County) o July 2-4, 2002 – extreme heat event; temperatures in the 90s throughout the region; City of New Rochelle power outages to 3,300 people o July 29 – August 5, 2002 – heat waves for eight days with temperatures ranging from 90°F to 105°F in region o August 1-3, 2006 – extreme heat • Please see Severe Winter Storms for Extreme Cold Events 	Channel
Flood (Riverine, Flash, Ice Jam and Dam Failure Flooding [overtopping or breaching from natural causes])	Yes	Yes	<ul style="list-style-type: none"> • The NYS HMP identifies flooding as the main hazard of concern for New York State. • The NYS HMP, NYSEMO, FEMA, SHELDUS and USGS indicate that Westchester County has been issued 10 FEMA Disaster Declarations for flood-related events, each event resulting in extensive damages. <ul style="list-style-type: none"> o FEMA DR-311 (September 1971) - Westchester County experienced approximately \$29 K in property and crop damages. o FEMA DR-338 (Tropical Storm Agnes) (June 1972) - Westchester County experienced \$1.7 M in flood damages. o FEMA DR-487 (Hurricane Eloise) (September 1975) - Losses in Westchester County are unknown. o FEMA DR-702 (April 1984) - Losses in Westchester County are unknown. o FEMA DR-974 (December 1992 Nor'Easter) - Westchester County received between 8 and 11 inches of rain, experiencing \$7.1 M in flood damages. Over 20,000 power failures occurred throughout the County. o FEMA DR-1146 (October 1996) – Coastal flooding event that caused over \$16.1 M in property damages throughout Westchester and Suffolk Counties. Rainfall totals in Westchester County ranged from 2.37 inches at Ossining to 4.98 inches at Dobbs Ferry. o FEMA DR-1296 (Tropical Storm Floyd) (September 14-16, 1999) - 	<ul style="list-style-type: none"> • NYSDPC • NYSEMO • FEMA • Hazards & Vulnerability Research Institute (SHELDUS) • NOAA-NCDC • NPDP • NYS DEC • NFIP • Westchester County GIS System



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	Is this a hazard that may occur in the City of New Rochelle?	If yes, does this hazard pose a significant threat to the City of New Rochelle?	Why was this determination made?	Source(s)
			<p>Westchester County experienced between \$6.6 M and \$10 M in flood damages. Losses in New Castle or unknown.</p> <ul style="list-style-type: none"> ○ FEMA DR-1589 (April 2005) - Westchester County experienced \$4.3 M in property damages. ○ FEMA DR-1650 (June-July 2006) – Losses in Westchester County are unknown. ○ FEMA DR-1692 (April 2007 Nor'Easter) - Flooding and coastal erosion, debris, damage to residential and commercial structures, utility lines, roads and other infrastructure throughout New York State. FEMA gave out more than \$61 M in assistance to affected counties within the State. Losses in Westchester County are unknown; however, disaster assistance to the County totaled \$30 M as of July 23, 2007. ○ FEMA DR-1899 (March 2010) - A torrential rainstorm brought heavy rain, strong winds and flooding to much of the Northeast U.S. In New York State, the President declared a major disaster for the counties of Nassau, Orange, Richmond, Rockland, Suffolk, and Westchester after these areas were struck by severe storms and flooding. The storm resulted in six deaths, damages to homes and cars, power outages and closed roadways. Over 167,000 customers were without power in New York City and Westchester County. <ul style="list-style-type: none"> ● NOAA's NCDC storm events database indicates that Westchester County was impacted by approximately 97 flood events between 1950 and 2009. ● The 2008 NYS HMP indicated that Westchester County has been ranked as the 4th most flood vulnerable county in New York State based on potential flood exposure and vulnerability to loss. Over 11-percent of the County is located in a 100-year floodplain. ● The NYS HMP and SHELDUS indicated that other undeclared flood events within County took place in June 1973 (\$38 M in losses), September 1974, July 1975, January 1976, November 1977 (\$833 K in losses), May 1979 (\$1.3 M in losses) May 1984 (\$2.4 M in losses) August 1990 (\$3.5 M in losses). ● NFIP identifies that City of New Rochelle has made 512 flood claims between 1978 and 2010, receiving approximately \$4.1 M in total payments. ● Ice Jams are mentioned separately in this Table but are grouped with the Flood hazard in this plan (see below). 	
Hailstorm	Yes	Yes	Please see Severe Storm	



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Hurricane (and other Tropical Cyclones)	Yes	Yes	Please see Severe Storm	
Ice Jams (categorized as a Flood hazard in this HMP)	No	No	<ul style="list-style-type: none"> The NYS HMP does identify ice jam flooding as a hazard of concern for New York State (grouped as a type of flood). New York State ranks 2nd in the Nation for total number of ice jam events, with over 1,435 incidents documented between February 1, 1867 and March 16, 2007. However, the NYS HMP indicates that no ice jams have occurred throughout Westchester County The USACE CRREL Ice Jam Database and the NYS HMP, indicates that no reported ice jam events have occurred within Westchester County between 1780 and 2010. 	<ul style="list-style-type: none"> NYSDPC Review of USACE CRREL Ice Jam Database
Ice Storm	Yes	Yes	Please see Severe Winter Storm	
Infestation	No	No	<ul style="list-style-type: none"> The NYS HMP does not identify infestation as a hazard of concern for New York State. Based on all sources reviewed, no known significant occurrences are reported for the City of New Rochelle. 	<ul style="list-style-type: none"> NYSDPC
Land Subsidence	No	No	<ul style="list-style-type: none"> The NYS HMP indicates that New York State is vulnerable to land subsidence; however, this hazard is “extremely localized” and poses a “very low risk to population and property.” The NYS HMP does not identify Westchester County as a community that has experienced land subsidence in the past. According to USGS, Westchester County is not made up of unconsolidated aquifer systems, creating the unlikelihood of permanent subsidence and related ground failures. 	<ul style="list-style-type: none"> NYSDPC USGS Fact Sheet 165-00 (Dec. 2000)
Landslide	No	No	<ul style="list-style-type: none"> The NYS HMP does identify landslide as a hazard of concern for New York State, with most of Westchester County located in a low landslide incidence area. The NYS HMP indicates that Westchester County has had 11 landslide occurrences from 1837 to 2007. The NYS HMP listed Westchester County as the 12th County in the State most threatened by and vulnerable to landslides and landslide losses. USGS indicates through the National Atlas Map Maker program City of New Rochelle has a low landslide incidence. 	<ul style="list-style-type: none"> NYSDPC National Atlas.gov (USGS)
Nor'Easters	Yes	Yes	Please see Severe Winter Storm	



SECTION 5.2: RISK ASSESSMENT – IDENTIFICATION OF HAZARDS OF CONCERN

Hazard	Step 1	Step 2	Step 3	
	Is this a hazard that may occur in the City of New Rochelle?	If yes, does this hazard pose a significant threat to the City of New Rochelle?	Why was this determination made?	Source(s)
(and other extra tropical storms)				
Severe Storm (Windstorms, Thunderstorms, Hail, Lightning, Tornadoes and Hurricanes)	Yes	Yes	<ul style="list-style-type: none"> • The NYS HMP does identify all types of severe storms as hazards of concern for New York State. Westchester County is identified as a high risk area for tornadoes and has experienced 8 tornado events. NYS HMP listed Westchester County as the 8th County in the State most threatened by and vulnerable to extreme wind and wind losses. • The NYS HMP, NYSEMO, FEMA indicate that Westchester County has been issued 10 FEMA Disaster Declarations for severe storm events (also identified as flooding events). Losses and details regarding each of these events are identified in 'Flood' above. <ul style="list-style-type: none"> ○ FEMA DR-311 (September 1971) ○ FEMA DR-338 (Tropical Storm Agnes) (June 1972) ○ FEMA DR-487 (Hurricane Eloise) (September 1975) ○ FEMA DR-702 (April 1984) ○ FEMA DR-974 (December 1992 Nor'Easter) ○ FEMA DR-1296 (Tropical Storm Floyd) (September 14-16, 1999) \$6.6M In Damages Countywide ○ FEMA DR-1146 (October 1996) ○ FEMA DR-1589 (April 2005) ○ FEMA DR-1650 (June-July, 2006) ○ FEMA DR-1692 (April 2007 Nor'Easter) Rainfall Total: 6.75 inches. ○ FEMA DR-1899 (March 2010) • Other severe storm events that specifically impacted the City of New Rochelle, include, but are not limited to: <ul style="list-style-type: none"> ○ October 24-25, 2005 (Heavy Rain) – Heavy rain fell over New Rochelle, totaling approximately 2.95 inches. ○ April 15-16, 2007 (Nor'Easter) - Heavy rain fell over New Rochelle, totaling approximately 6.75 inches. ○ July 7, 2009 (TSTM/Hail) – Heavy rain and quarter-sized hail fell in New Rochelle. Wind speeds in New Rochelle reached 65 mph. Maximum wind speeds were approximately 100mph. The storm resulted in one injury. ○ NOAA's NCDC storm events database indicates that Westchester County was impacted by approximately 290 severe storm events between 1950 and 2009. 	<ul style="list-style-type: none"> • NYSDPC • FEMA • Hazards & Vulnerability Research Institute (SHELDUS) • NOAA-NCDC



SECTION 5.2: RISK ASSESSMENT – IDENTIFICATION OF HAZARDS OF CONCERN

Hazard	Step 1	Step 2	Step 3	
	Is this a hazard that may occur in the City of New Rochelle?	If yes, does this hazard pose a significant threat to the City of New Rochelle?	Why was this determination made?	Source(s)
Severe Winter Storm (Heavy Snow, Blizzards, Freezing Rain/Sleet, Ice Storms, Nor'Easters and Extreme Cold)	Yes	Yes	<ul style="list-style-type: none"> The NYS HMP does identify all types of severe winter storms as hazards of concern for New York State. The NYSDPC and NYSEMO listed Westchester County as the 22nd County in the State most threatened by and vulnerable to snow and snow loss, with an annual average snowfall 32.3 inches. Westchester County is also listed as the 31st County in New York State most threatened by and vulnerable to ice storms and ice storm loss. Westchester County was declared a disaster areas for five FEMA Disaster Declarations (DR) or Emergencies (EM) for severe storm events, including: <ul style="list-style-type: none"> FEMA DR-974 (December 1992 Nor'Easter) - Westchester County received between 8 and 11 inches of rain, experiencing \$7.1 M in flood damages. FEMA EM-3107 (March 1993) - Statewide Blizzard resulting in \$8.4 M in eligible losses to the State. Westchester County received between 10 and 20 inches of snow. FEMA DR-1083 (January 1996) - Blizzard resulting in \$21.3 M in eligible losses to the State. Westchester County received between 20 and 30 inches of snow. FEMA EM-3184 (February 2003) - Snowstorm resulting in over \$20 M in losses to the State. Westchester County received between 20 and 30 inches of snow from this event and experienced approximately \$1.8 M in property damages. Snowfall totals in Westchester County ranged from 14.5 inches at Croton-On-Hudson to 26.0 inches at Thornwood. FEMA DR-1692 (April 2007 Nor'Easter) - Flooding and coastal erosion, debris, damage to residential and commercial structures, utility lines, roads and other infrastructure throughout New York State. FEMA gave out more than \$61 M in assistance to affected counties within the State. Losses in Westchester County are unknown; however, disaster assistance to the County totaled \$30 M as of July 23, 2007. Note: DR-974 and DR-1692 were classified as Nor'Easters by various sources; therefore, they are included with this Hazard category but also mentioned under flood). Various sources indicated that many other severe winter storm events impacted Westchester County, including, but not limited to: <ul style="list-style-type: none"> February 1961 (Snowstorm) - Westchester County received between 20 and 30 inches of snow from this even and experienced approximately \$80 K in property damages. 	<ul style="list-style-type: none"> NYSDPC NYSEMO FEMA NOAA-NCDC Hazards & Vulnerability Research Institute (SHELDUS) Kocin and Uccellini The Weather Channel



SECTION 5.2: RISK ASSESSMENT – IDENTIFICATION OF HAZARDS OF CONCERN

Hazard	Step 1	Step 2	Step 3	
	Is this a hazard that may occur in the City of New Rochelle?	If yes, does this hazard pose a significant threat to the City of New Rochelle?	Why was this determination made?	Source(s)
			<ul style="list-style-type: none"> o February 13, 2006 (Record Snowstorm) – Snow fell in New Rochelle totaling 24.5 inches. • Westchester County and the City of New Rochelle has been impacted by many extreme cold events, including: <ul style="list-style-type: none"> o December 1950 - Record cold event for the month of December in New Rochelle: -5°F. o January 1961 - Record cold event for the month of January in New Rochelle: -10°F. o March 1967 - Record cold event for the month of March in New Rochelle: -3°F o February 1979 - Record cold event for the month of February in New Rochelle: -14°F. o November 1989 - Record cold event for the month of November in New Rochelle: 12°F. • NOAA’s NCDC storm events database indicates that Westchester County was impacted by approximately 59 winter storm events and 6 extreme cold / windchill events between 1950 and 2009. However, most events are of a regional extent rather than localized to just one county. 	
Tornado	Yes	Yes	Please see Severe Storm	
Tsunami	No	No	<ul style="list-style-type: none"> • Tsunami is not identified as a hazard of concern in the NYS HMP. 	<ul style="list-style-type: none"> • NYSDPC
Volcano	No	No	<ul style="list-style-type: none"> • Volcanoes are not identified as a hazard of concern in the NYS HMP, because there are no known volcanoes located in the state. 	<ul style="list-style-type: none"> • NYSDPC
Wildfire	Yes	No	<ul style="list-style-type: none"> • The NYS HMP does identify wildfire as a hazard of concern for New York State. • Low reported incidences of wildfires within Westchester County. • Westchester County is located within the New York State Forest Ranger Fire Danger Rating Area 3. This is based on vegetation, fire climate and topography. • The NRPD indicates that no records of wildfire incidences have been recorded for Westchester County. • GeoMac indicates that all of the City of New Rochelle is located within the Wildland-Urban Interface. However, no wildfires were experienced in Westchester County and the City between 2001 and 2009. • USGS indicates that no wildfires greater than 250 acres were experienced in Westchester County and the City of New Rochelle between 1980 and 2003. 	<ul style="list-style-type: none"> • NYSDPC • NRPD • GeoMAC • USGS



SECTION 5.2: RISK ASSESSMENT – IDENTIFICATION OF HAZARDS OF CONCERN

Hazard	Step 1	Step 2	Step 3	
	Is this a hazard that may occur in the City of New Rochelle?	If yes, does this hazard pose a significant threat to the City of New Rochelle?	Why was this determination made?	Source(s)
Windstorm	Yes	Yes	Please see Severe Storm	
AAA	American Avalanche Association		NPDP	National Performance of Dams Program
CRREL	Cold Regions Research and Engineering Laboratory		NWPD	National Wildfire Programs Database
DR	Presidential Disaster Declaration Number		NYCEM	New York City Area Consortium For Earthquake Loss
EM	Presidential Emergency Declaration		Mitigation	
FEMA	Federal Emergency Management Agency		NYS	New York State
GeoMAC	Geospatial Multi-Agency Coordination		NYSDEC	New York State Department of Environmental Conservation
HMP	Hazard Mitigation Plan		NYSDPC	New York State Disaster Preparedness Commission
K	Thousand (\$)		NYSEMO	New York State Emergency Management Office
M	Million (\$)		SHELDUS	Spatial Hazard Events and Losses Database for the U.S.
MMI	Modified Mercalli Scale		TSTM	Thunderstorm
NAC	National Avalanche Center		U.S.	United States
NCDC	National Climatic Data Center		USACE	U.S. Army Corp of Engineers
NFIP	National Flood Insurance Program		USGS	U.S. Geologic Survey
NOAA	National Oceanic and Atmospheric Administration			



According to input from the City, and review of all available resources, a total of five hazards of concern were identified as significant hazards affecting the City, to be addressed within this plan:

- Coastal Erosion
- Coastal and Severe Storms (windstorms, thunderstorms, hail, tornadoes, Nor'Easters, and hurricanes/tropical storms)
- Earthquake
- Flood (riverine, flash, ice jam and dam failure)
- Severe Winter Storm (heavy snow, blizzards, ice storms) / Extreme cold

Other natural hazards of concern have occurred within the City, but typically have a low potential to result in significant impacts within the City. The City deemed these hazards as minor in comparison to those bulleted above; therefore, these hazards will not be further addressed within this version of the Plan. However, if deemed necessary by the City, these hazards may be considered in future versions of the Plan.

5.3 HAZARD RANKING

After the hazards of concern were identified for the City of New Rochelle, the hazards were ranked to describe their probability of occurrence and their impact on population, property (general building stock including critical facilities) and the economy. This section describes factors that influence the ranking including the probability of occurrence and impact; it also presents the ranking process and outcome.

HAZARD RANKING METHODOLOGY

The methodology used to rank the hazards of concern for the City of New Rochelle is described below. Estimates of risk for the City were developed using methodologies promoted by FEMA's hazard mitigation planning guidance and generated by FEMA's HAZUS-MH risk assessment tool.

Probability of Occurrence

The probability of occurrence is an estimate of how often a hazard event occurs that has caused measurable impact to your community. "Measurable impact" means that the event required response and incurred expenses and/or losses beyond usual levels. A review of historic events assists with this determination. Each hazard of concern is rated in accordance with the numerical ratings and definitions in Table 5.3-1. These definitions are consistent with the New York State Plan's ranking methodology; however the rating of zero (0), an event is not likely to occur, is not used because these hazards were screened out during the hazard identification process.

Table 5.3-1. Probability of Occurrence Ranking Factors

Rating	Probability	Definition
0	None	Hazard event is not likely to occur.
1	Rare	Hazard event is not likely to occur within 100 years
2	Occasional	Hazard event is likely to occur within 100 years.
3	Frequent	Hazard event is likely to occur within 25 years.

Impact

The impact of each hazard is considered in three categories: impact on population, impact on property (general building stock including critical facilities), and impact on the economy. Based on documented historic losses and a subjective assessment by the Planning Committee, an impact rating of high, medium, or low is assigned with a corresponding numeric value for each hazard of concern. In addition, a weighting factor is assigned to each impact category: three (3) for population, two (2) for property, and one (1) for economy. This gives the impact on population the greatest weight in evaluating the impact of a hazard.

Table 5.3-2 presents the numerical rating, weighted factor and description for each impact category. The impact rating definitions for population and property are also consistent with the New York State Hazard Mitigation Plan (NYS HMP) ranking methodology with minor modifications. Impact to the economy is also being evaluated.

Table 5.3-2. Numerical Values and Definitions for Impacts on Population, Property and Economy

Category	Weighting Factor	Low Impact (1)	Medium Impact (2)	High Impact (3)
Population*	3	14% or less of your developed land area is exposed to a hazard due to its extent and location	15% to 29% of your developed land area is exposed to a hazard due to its extent and location	30% or more of your developed land area is exposed to a hazard due to its extent and location
Property*	2	Property exposure is 14% or less of the total replacement cost for your community	Property exposure is 15% to 29% of the total replacement for your community	Property exposure is 30% or more of the total replacement cost for your community
Economy	1	Loss estimate is 9% or less of the total replacement cost for your community	Loss estimate is 10% to 19% of the total replacement cost for your community	Loss estimate is 20% or more of the total replacement cost for your community

Note: A numerical value of zero is assigned if there is no impact.

*For the purposes of this exercise, "impacted" means exposed for population and property and loss for economy.

Risk Ranking Value

The risk ranking for each hazard is then calculated by multiplying the numerical value for probability of occurrence by the sum of the numerical values for impact. The equation is as follows: Probability of Occurrence Value (1, 2, or 3) × Impact Value (6 to 18) = Hazard Ranking Value. Based on the total for each hazard, a priority ranking is assigned to each hazard of concern (high, medium, or low).

HAZARD RANKING RESULTS

Using the process described above, the risk ranking for the identified hazards of concern was determined for the City of New Rochelle. Based on the combined risk values for probability of occurrence and impact to the City, a priority ranking of “high”, “medium” or “low” risk was assigned. The hazard ranking for the City of New Rochelle, from high to low risk, is summarized below:

1. Coastal Storm
2. Severe Winter Storm
3. Flood
4. Coastal Erosion
5. Earthquake

The following tables present the step-wise process for the ranking. Table 5.3-3 shows the probability ranking assigned for likelihood of occurrence for each hazard that has causes measurable impact.

Table 5.3-3. Probability of Occurrence Ranking for Hazards of Concern for the City of New Rochelle

Hazard of Concern	Probability	Numeric Value
Coastal Erosion	Frequent	3
Coastal Storm	Frequent	3
Earthquake	Occasional	2
Flood	Frequent	3
Severe Winter Storm	Frequent	3

Table 5.3-4 shows the impact evaluation results for each hazard of concern, including impact on property, structures, and the economy. The weighting factor results and a total impact for each hazard also are summarized.

Table 5.3-4. Impact Ranking for Hazards of Concern for the City of New Rochelle

Hazard of Concern	Population			Property			Economy			Total Impact Rating (Population + Property + Economy)
	Impact	Numeric Value	Numeric Value Multiplied by Weighting Factor (3)	Impact	Numeric Value	Numeric Value Multiplied by Weighting Factor (2)	Impact	Numeric Value	Numeric Value Multiplied by Weighting Factor (1)	
Coastal Erosion	Low	1	$1 \times 3 = 3$	Low	1	$1 \times 2 = 2$	Medium	2	$2 \times 1 = 2$	7
Coastal Storm	High	3	$3 \times 3 = 9$	High	3	$3 \times 2 = 6$	Medium	2	$2 \times 1 = 2$	17
Earthquake	Low	1	$1 \times 3 = 3$	High	3	$3 \times 2 = 6$	Low	1	$1 \times 1 = 1$	10
Flood	High	3	$3 \times 3 = 9$	Medium	2	$2 \times 2 = 4$	Medium	2	$2 \times 1 = 2$	15
Severe Winter Storm	High	3	$3 \times 3 = 9$	High	3	$3 \times 2 = 6$	Low	1	$1 \times 1 = 1$	16

Table 5.3-5 presents the total ranking value for each hazard.

Table 5.3-5. Total Risk Ranking Value for Hazards of Concern for the City of New Rochelle

Hazard of Concern	Probability	Impact	Total = (Probability x Impact)
Coastal Erosion	3	7	21
Coastal Storm	3	17	51
Earthquake	2	10	20
Flood	3	15	45
Severe Winter Storm	3	16	48

Table 5.3-6 presents the hazard ranking category assigned for each hazard of concern. The ranking categories are determined by an evaluation of the total risk ranking score into three categories, low, medium, and high whereby a total score of below 20 is categorized as low, 21 to 40 is medium, and 41 and over is considered a high risk category.

Table 5.3-6. Hazard Ranking Results for Hazards of Concern for the City of New Rochelle

Hazard Ranking	Hazard of Concern	Category
4	Coastal Erosion	Medium
1	Coastal Storm	High
5	Earthquake	Low
3	Flood	High
2	Severe Winter Storm	High