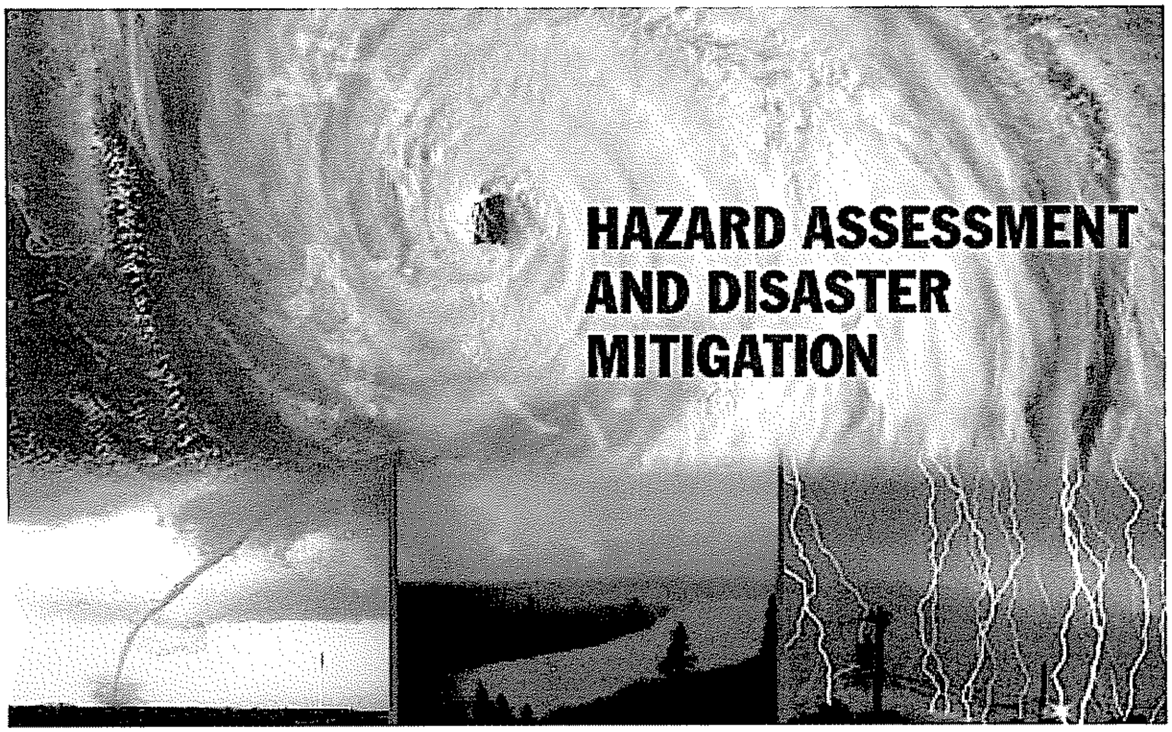
CITY OF WARWICK
RHODE ISLAND



HAZARD MITIGATION STRATEGY

APRIL 2005

Critical Facilities In Warwick

Map 2

Public Infrastructure

- Fire Stations
- Police Stations
- Schools
- Other Roads

Utilities

- Bridges With Utilities

Preparedness

Red Cross Approved Shelters

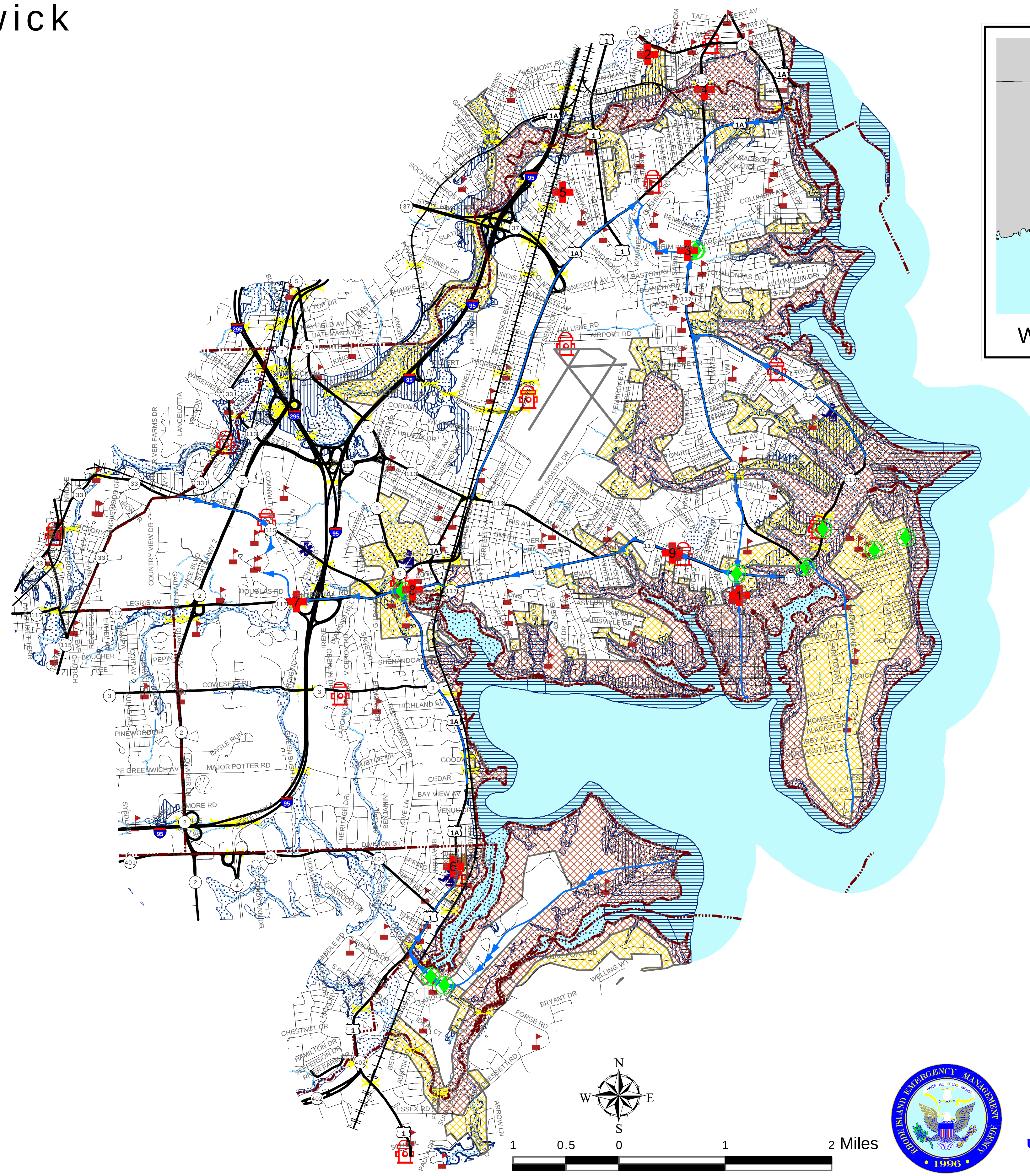
- Evacuation Routes w/ Direction
- Traffic Control Points

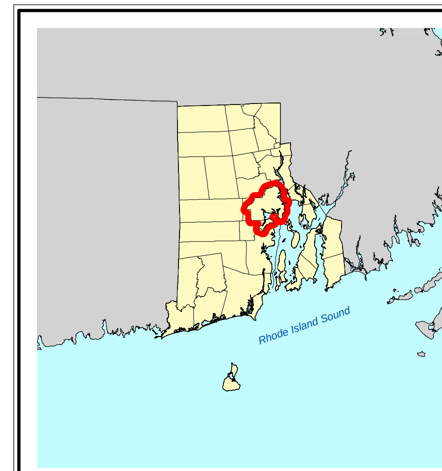
Flood Zones

- A - Zone (100 Year)
- V - Zone (100 Year)
- X - 500 Year

- Rivers and Streams
- Water
- Municipal Boundary

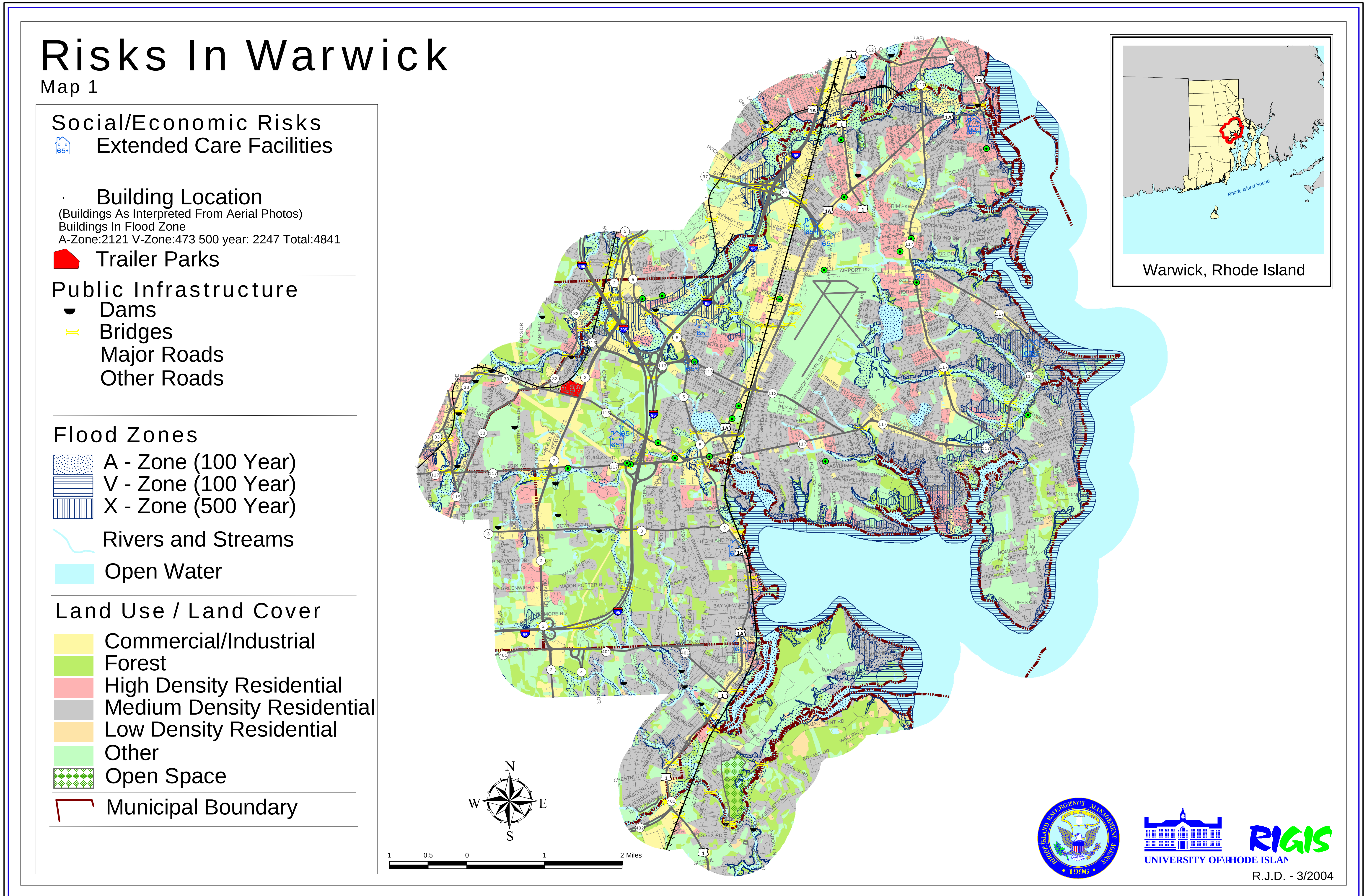
Note: Information has been extended 1 kilometer around the Warwick border. This extension is intended to aid administrators in hazard mitigation. This map confers no legal status to anything hereon.





Warwick, Rhode Island

R.J.D. - 3/2004


Risks In Warwick
Map 1
Social/Economic Risks
Extended Care Facilities
Building Location
(Buildings As Interpreted From Aerial Photos)
Buildings In Flood Zone
A-Zone:2121 V-Zone:473 500 year: 2247 Total:4841
Trailer Parks
Public Infrastructure
Dams
Bridges
Major Roads
Other Roads
Flood Zones
A - Zone (100 Year)
V - Zone (100 Year)
X - Zone (500 Year)
Rivers and Streams
Open Water
Land Use / Land Cover
Commercial/Industrial
Forest
High Density Residential
Medium Density Residential
Low Density Residential
Other
Open Space
Municipal Boundary
N
W
E
S
1
0.5
0
1
2 Miles
Rhode Island Sound
Warwick, Rhode Island
UNIVERSITY OF RHODE ISLAND
RIGIS
R.J.D. - 3/2004

Warwick Hazard Mitigation Strategy

FORWARD

The purpose of the Warwick Hazard Mitigation Strategy is to advocate the concepts of disaster resilient and sustainable communities. Warwick is committed to building a disaster resistant community and achieving sustainable development through the commitment of state and local government and its policymakers to mitigate hazard impacts before disaster strikes. Additionally, Warwick will achieve a disaster resilient, and therefore, safer community, through the implementation of mitigation programs and policies. The City will have the capability to implement and institutionalize hazard mitigation through its human, legal and fiscal resources, the effectiveness of intergovernmental coordination and communication, and with the knowledge and tools at hand to analyze and cope with hazard risks and the outcomes of mitigation planning.

EXECUTIVE CHAMBER

CITY OF WARWICK RHODE ISLAND

SCOTT AVEDISIAN
MAYOR

Executive Order 2005 – 14

Adopting the City of Warwick Hazard Mitigation Strategy

WHEREAS; the City of Warwick has just completed, through our Homeland Security officers, a comprehensive Hazard Mitigation Strategy; and,

WHEREAS; such a strategy will allow the city to utilize federal Department of Homeland Security funds, obtain necessary insurance policies, and allow for better hazard mitigation planning with the State of Rhode Island Emergency Management Agency; and,

WHEREAS; this plan represents a tremendous amount of work and coordination between our public safety and emergency management personnel;

NOW THEREFORE BE IT RESOLVED THAT; the City of Warwick Hazard Mitigation Strategy, as attached hereto, is formally adopted.

Mayor

Date: 21 March 2005

Strategy for Reducing Risks from Natural Hazards in Warwick, Rhode Island

A Multi-Hazard Mitigation Strategy

ACKNOWLEDGEMENTS

City of Warwick

Scott Avedisian
Mayor
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Warwick Emergency Management

Chief Michael Walsh
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Assistant Chief Michael Walsh, Deputy Emergency Management Director
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Michael Rooney, Warwick Recreation Dept.

MAPS

Roland Duhaime, *URI Environmental Data Center*
Daniel Geagan, *City of Warwick Planning Department*

ADDITIONAL ACKNOWLEDGEMENTS

This project was made possible by the efforts of the Warwick Hazard Mitigation Committee, with substantial assistance from Jarrett W. Devine, an Emergency Management Consultant and City resident.

This Project was also made possible with the support of the Warwick City Council.

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Strategy for Reducing Risks from Natural Hazards in Warwick, Rhode Island

A Multi-Hazard Mitigation Strategy

TABLE OF CONTENTS

Chapter 1. Introduction

"The most recent disaster fades from memory just before the next one strikes..."

Ancient Japanese Proverb

The Cost of Disasters

Property damage resulting from natural hazards has become exceedingly costly, for both the disaster victims, and the American taxpayer. From 1989 to 1993, the average annual loss from natural disasters was $3.3 billion nationally, the past 4 years has seen that amount increase to 13 billion annually. (FEMA, IS393, April 1998) Over 6,000 people have been killed and 50,000 injured from natural disasters in the past 25 years. (FEMA, 1998)

(AP PHOTO)

The second most active hurricane season in the United States occurred in 1995. There were a total of 19 named storms, 11 reaching hurricane strength. The end result was 58 people dead and more than $5.2 billion in property losses. Aside from the direct costs of property damage, Americans also suffer from indirect costs, most of which may take much longer to recover from. Recovery from disasters requires resources to be diverted from other public and private programs, adversely affecting the productivity of the economy. Business interruption insurance only covers a small part of actual losses. Loss of economic productivity and downtime in tourism is not fully accounted for by the public or private sector.

Costs of Disasters in Rhode Island
1938 - present

Date	Disaster	Amount of Damage*
1938	Storm of '38	$306 million
1954	Hurricane Carol	$461 million
1978	Blizzard of '78	$??
1991	Hurricane Bob	$1.5 million

*dollars given in the year damage occurred

Table 1.1 Source: NOAA

The purpose of this Hazard Mitigation Plan is to set forth guidelines of short term and long-term actions, which will reduce the actual or potential loss of life or property from hazardous events such as winter storms, flooding, thunderstorms, droughts, hurricanes and earthquakes. This plan is a directive of the Federal Emergency Management Agency and conforms specifically to 44 CFR Parts 201 and 206 Hazard Mitigation Planning and Hazard Mitigation Grant Program: Interim Final Rule. The City of Warwick, upon adoption of this plan, will become an eligible applicant for the Hazard Mitigation Grant Program, HMGP, making the Town eligible to file for resources that may be used to mitigate the effects of natural hazards on both public and private property.

What is Hazard Mitigation?

"Hazard mitigation planning is the process that analyzes a community's risk from natural hazards, coordinates available resources, and implements actions to eliminate risks."

-Tennessee Emergency Management Agency

Hazard mitigation is action taken to permanently reduce or eliminate long-term risk to people and their property from the effects of natural hazards. As the direct and indirect costs of disasters continue to rise, it becomes particularly critical that preparing for the onslaught of damage from these events must be done in order to reduce the amount of damage and destruction. This strategy is commonly known as *mitigation*. The purpose of multi-hazard mitigation is twofold: 1) to protect people and structures from harm and destruction; and 2) to minimize the costs of disaster response and recovery.

To ensure the national focus on mitigation, the Federal Emergency Management Agency (FEMA) introduced a National Mitigation Strategy in 1995. The strategy promotes the partnership of government and the private sector to "build" safer communities. Hazard mitigation encourages all Americans to identify hazards that may affect them or their communities and to take action to reduce risks.

Mitigation Benefits

Mitigation actions help safeguard personal and public safety. Retrofitting bridges, for example, can help keep them from being washed out, which means they will be available to fire trucks and ambulances in the event of a storm. Installing hurricane clips and fasteners can reduce personal and real property losses for individuals and reduce the need for public assistance in the event of a hurricane. Increasing coastal setbacks reduces the risk of deaths and property losses from tsunamis and storm surge. Increased setbacks also reduce the risk of property losses from coastal erosion.

Another important benefit of hazard mitigation is that money spent today on preventative measures can significantly reduce the impact of disasters in the future, including the cost of post-disaster cleanup.

The following is stated under Section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by Section 104 of the Disaster Mitigation Act of 2000:

> *"To obtain Federal assistance, new planning provisions require that each state, local and tribal government prepare a hazard mitigation plan to include sections that describe the planning process, an assessment of the risks, a mitigation strategy, and identification of the plan maintenance and updating process."*

The adoption of this multi-hazard mitigation strategy will enhance Warwick's eligibility for federal grants, which include FEMA's pre-disaster Flood Mitigation Assistance Program (FMAP) and its post-disaster Hazard Mitigation Grant Program (HMGP). Pre-disaster planning will also help post-disaster operations become more efficient. For instance, procedures and necessary permits can be identified prior to the disaster and therefore, permit streamlining procedures can be put into place. Priorities for mitigation during reconstruction can also be identified, helping to reduce the high costs of recovery after a disaster. The State emergency response effort will run more smoothly because of the guidance provided in this strategy.

Sustainable Communities

"A resilient community is one that lives in harmony with nature's varying cycles and processes."

David Godschalk, Timothy Beatley, et. al.

"Disaster resilient" communities employ a long range, community-based approach to mitigation. Mitigation advocates communities to proactively address potential damage that could occur from hurricanes, coastal erosion, earthquakes, flooding and other natural hazards. When natural hazard mitigation is combined with the standards of creating sustainable communities, the long-term beneficial result is smarter and safer development that reduces the vulnerability of populations to natural disasters while reducing poverty, providing jobs, promoting economic activity, and most importantly, improving people's living conditions (Munasinghe and Clarke 1995). In addition to a community's sustainability criteria for social, environmental and economic protection, there is also the criterion that development must be disaster resistant (FEMA 1997; Institute for Business and Home Safety 1997).

Resilient communities may bend before the impact of natural disaster events, but they do not break. They are constructed so that their lifeline systems of roads, utilities, infrastructure, and other support facilities are designed to continue operating in the midst of high winds, rising water and shaking ground. Hospitals, schools, neighborhoods, businesses and public safety centers are located in safe areas, rather than areas prone to high hazards. Resilient and sustainable communities' structures are built or retrofitted to meet the safest building code standards available. It also means that their natural environmental habitats such as wetlands and dunes are conserved to protect the natural benefits of hazard mitigation that they provide.

The Warwick Hazard Mitigation Strategy advocates the concepts of disaster resilient and sustainable communities. Warwick is committed to building a disaster resistant community and achieving sustainable development through the commitment of state and local government and its policymakers to mitigate hazard impacts before disaster strikes. Additionally, Warwick will achieve a disaster resilient, and therefore, safer community, through the process of completing its Hazard Risk and Vulnerability Assessment (RVA), and Multi-Hazard Mitigation Strategy (HMS) and through the implementation of mitigation programs and policies. The City will have the capability to implement and institutionalize hazard mitigation through its human, legal and fiscal resources, the effectiveness of intergovernmental coordination and communication, and with the knowledge and tools at hand to analyze and cope with hazard risks and the outcomes of mitigation planning.

Chapter 2. Mission and Goals

Mission

The purpose of the Warwick multi-hazard Mitigation Strategy is to:

1. Provide a coordinated consistent set of goals for reducing or minimizing: human and property losses; major economic disruption; degradation of ecosystems and environmental critical habitats; destruction of cultural and historical resources from natural disasters;

2. Provide a basis for intergovernmental coordination in natural hazard mitigation programs at the state and local level;

3. Develop partnerships between the City and private sector, local communities and non-profit organizations in order to coordinate and collaborate natural hazard mitigation programs;

4. Identify and establish close coordination with local government departments and agencies responsible for implementing the sound practices of hazard mitigation through building standards and local land use development decisions and practices; and to

5. Provide for a continuing public education and awareness about the risks and losses from natural disasters, in addition to natural hazard mitigation programs, policies and projects.

Goals

The goals of the multi-hazard Warwick Mitigation Strategy are to:

1. Protect public health, safety and welfare;

2. Reduce property damages caused by natural disasters;

3. Minimize social dislocation and distress;

4. Reduce economic losses and minimize disruption to local businesses;

5. Protect the ongoing operations of critical facilities;

6. Reduce the dependence and need for disaster assistance funding after natural disasters;

7. Expedite recovery disaster mitigation efforts during the recovery phase;

8. Promote non-structural flood and coastal erosion measures to reduce the risk of damage to the surrounding properties and environmental habitats;

9. Establish a local Hazard Mitigation Committee to support, implement and revise the Warwick multi-hazard mitigation strategy and to provide the support necessary for an ongoing forum for the education and awareness of multi-hazard mitigation issues, program, policies and projects; and to

10. Provide for adequate financial and staffing resources to implement the Warwick Hazard Mitigation Strategy.

Chapter 3. Methodology

Hazard Mitigation Committee

The development of this mitigation strategy has been a result of countless hours of work by all parties involved over approximately a 2 year period. In order to assure the plan fully encompassed all the aspects of the City of Warwick, a working group was formed in January of 2003 consisting of members of City Government, affiliates of major institutions located in the City, and the general public. This allowed for the demographics of the group to be in line with the overall demographics of the City. Planning in this fashion creates a mitigation strategy that fully encompasses all aspects of disaster impact, from concerns of the residency, business continuity, and local disaster response and recovery activities. The general public was invited to join the planning process by way of general public notice to the populace. As a part of the planning process concerned members from T.F. Green airport, Kent County Hospital, Kent County Court House, and the Community College of Rhode Island, were also invited to attend meetings and play a part in the formulation of the local mitigation strategy. The following is a list of all parties involved in the creation of the Warwick mitigation strategy.

City of Warwick Hazard Mitigation Committee
Chief Jack Chartier, Emergency Management Director
Assistant Chief Michael Walsh, Deputy Emergency Management Director
Col. Stephen McCartney, Warwick Police
Barbara Caniglia, Mayor's Office
Joel Burke, Warwick Sewer Dept.
Juan Mariscal, Warwick Sewer Dept.
John Delucia, Warwick Engineering Dept.
Charles Sapcoe III, Warwick Engineering Dept.
Mark Carruolo, Warwick Planning Dept.
Daniel Geagan, Warwick Planning Dept.
William Facente, Warwick Economic Development
Linda Sullivan, Warwick Human Services Dept.
Daniel O'Rourke, Warwick Water Dept.
John Pagliaro, Warwick Building Dept.
David Picozzi, Warwick Public Works Dept.
Michael Rooney, Warwick Recreation Dept.

The committee met on a monthly basis and discussed any issues encountered in the development of the strategy. Tasks were assigned to appropriate group members and meetings were scheduled to discuss developments as they were made. Although the project was completed by the group as a whole, Assistant Chief Michael E. Walsh of the Warwick Fire Department coordinated the group. Jarrett W. Devine, an emergency management planning specialist, was also brought in to assist in the plan development.

Methodology

The first step in completing a multi-hazard Mitigation Strategy is to identify all of the hazards that have the potential to impact the City of Warwick. The second step is to perform a risk assessment. The risk assessment is a systematic way to quantify the effects of the identified hazards and provides a way to recognize and compare risks. These tasks were assigned to Jarrett Devine and Michael Walsh, the Emergency Management Coordinator for the City, during the early stages of the planning process.

After quantifying the risk, data about population, property, economic and environmental resources were gathered in order to determine how and where Warwick is vulnerable to the impact of various hazards. To more accurately understand the community's vulnerability it was also important to gather information on the existing protection systems, both physical and regulatory currently in place within Warwick. This process was assigned in the October 2003 meeting, where it was decided that each member of the committee shall maintain responsibility of reviewing the impacts of hazards within each of their areas of expertise. The planning department was responsible for gathering data on the impacts to all other areas of the City not publicly owned.

Once the results from the risk assessment and vulnerability analysis were known and an understanding of how and where Warwick is vulnerable to the impacts of these hazards in terms of damage to public infrastructure, critical facilities, as well as environmental, societal and economic components was gained, a clearer picture of the areas at risk was depicted using Geographic Information System (GIS) maps.

Based on the results of the risk assessment and vulnerability analysis, mitigation actions were identified in order to address the various hazards which have the potential to impact Warwick. These actions will allow Warwick to reduce the City's vulnerability to natural hazard losses. This process began in February 2004, once all information was known regarding the potential impact of the hazards. In June 2004, all information that was required to write the plan had been gathered and the group worked on creating the final draft.

Incorporation of mitigation into Planning Mechanisms

In 1988, the *Rhode Island Comprehensive Planning and Land Use Regulation Act* strengthened requirements for municipal plans and created stronger connections between State and local plans. All Rhode Island Cities and Towns must now have a locally approved Comprehensive Community Plan that must be updated at least once every five years. Municipal plans are required to be reviewed by the State for consistency with State goals and policies; in turn, State agency projects and activities are to conform to local plans that have received State approval *(certification)*. Approved local plans also set the basis for the exercise of key local implementing powers for land use – zoning and development review ordinances.

In writing the strategy, the City Comprehensive Community Plan was read, in addition to existing policies and on-going programs. Details of these plans were incorporated into this Multi-hazard Mitigation Strategy along with all other pertinent planning and implementation tools available such as local zoning, building and subdivision ordinances. This Mitigation Plan will allow Warwick to focus on strengthening existing plans, programs, policies and procedures by incorporating mitigation as part of the on-going process of Community Development.

As per the State Land Use Act, the City's Comprehensive Plan will be updated approximately every five-years. As part of each update, the Comprehensive Plan will be amended to include relevant risk reduction measures and recommendations from the Hazard Mitigation Plan. The two Plans will function independently, but will remain consistent with each update.

In addition, the Hazard Mitigation Plan will be incorporated into several other City Plans. Any activity listed in the Hazard Mitigation Plan that is of a relatively long lasting nature and greater than $20,000 in expense is eligible to be included in the City's Capital Improvement Program and Budget. The City Planning Department will see that these items are incorporated into the annual Capital Improvement Plan.

Additionally, the Hazard Mitigation Plan will be incorporated into the Greenwich Bay Special Area Management Plan (SAMP). This plan is specific to the Greenwich Bay watershed and it includes an element on natural hazards. The Hazard Mitigation Plan is referenced in the Greenwich Bay SAMP and some of the policies and risks found in the Hazard Mitigation Plan are incorporated into the SAMP.

Finally, the City of Warwick Harbor Management Plan is updated every 5-year's per Rhode Island law. As part of the required future updates, the Natural Hazards Element of the Harbor Management Plan will also be drafted to be consistent with the Hazard Mitigation Plan.

Incorporation of mitigation into Emergency Management

The Emergency Management Program in the City of Warwick is directed by the City's Fire Chief and coordinated through an Assistant Chief (Deputy EMA Director) that serves under the Chief. The roll of the director is to coordinate the City's emergency management and homeland security program. The position is funded through the City with financial assistance from FEMA's Emergency Management Performance Grant Program (EMPG). Most recently the City's Emergency Operation Plan was rewritten to include Mitigation as a principal means for protecting the City from the impact of Natural Hazards. The use of the mitigation plan in conjunction with the City's Emergency Operation Plan will allow the City to develop response priorities based upon expected damage that is derived from solid research and not just educated guesses.

Once approved, the Mitigation Strategy will be incorporated into the City's emergency management program. This will strengthen the comprehensive nature of the City's Emergency Management Program. Implementation of mitigation actions will allow for a more effective program by protecting the critical infrastructure of the City and increasing the likelihood that this infrastructure will remain functional throughout a hazard event. Further the actions identified in the plan will reduce the possibility of responders becoming victims themselves. Essentially, this plan will allow mitigation to move into the foreground as the best means to reduce disaster impact on the community and to ensure an effective response to damages that are unavoidable.

Chapter 4. Climate, Geography, and Demographics

When preparing a mitigation strategy it is imperative to assure that the plan encompasses all aspects of the City. In order to assure that this was the case, the hazard mitigation committee first studied the current situation of the City of Warwick, namely the climate, geography, and demographics. We also performed a historical review in order to assure that the City of Warwick Mitigation Strategy brings together every aspect of the City. This section will serve as a summery of the foundation upon which the Warwick Mitigation Strategy was written.

City of Warwick – General Information

The City of Warwick was founded January 12, 1642, when Samuel Gorton, and a dozen friends purchased more than 100 square miles of land from the Mahament Indians, a local branch of the great Nanhiganset Nation. These new settlers made their home in what today is referred to as Shawomet , or Old Warwick, at the head of the Old Warwick Cove. The City was reduced in land size by the loss of Coventry in 1741, and West Warwick in 1913. This left Warwick half of its original size, or 50 square miles. The settlement took its name "Warwick" in honor of the Earl of Warwick, who was instrumental in gaining an official charter in 1647.

Today, Warwick is the second largest city in Rhode Island. The city is situated at the center of the state's super-highway system. Theodore Francis Green State Airport is located there and is the state's largest commercial air terminal. Warwick offers many educational, recreational, and cultural opportunities. The Knight Campus of the Community College of Rhode Island, a state supported facility, is located in Warwick.

Goddard Memorial State Park, one of the largest parks in Rhode Island is located in the Potowomut section of Warwick. The park offers picnic areas, accented with activities such as golfing and salt water bathing. Warwick's central location in Rhode Island as well as the easy access for air travel, has made the city a prime area for further industrial, commercial and population growth.

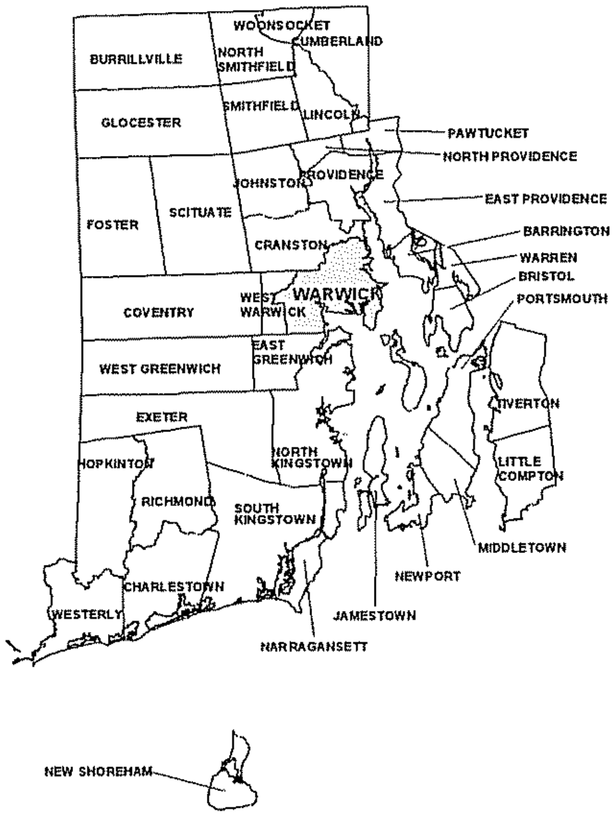


Figure 4.1

Warwick, Rhode Island is located in the east-central Rhode Island along the western coast of Narragansett Bay (Figure 4.1). Warwick has 35 square miles of land area and 14.2 square miles of water area with a population of 87,000 people.

Geography and Climate

Warwick is basically an urban community, dotted throughout by ponds. It is located at the northern tip of Narragansett Bay and has 39 miles of shoreline.

Summer temperatures tend to be in the 53-76 F / 12-24 C range. There are some 90+ F / 32+ C days, mostly in the inland areas of the city in July, but the afternoon sea breeze keeps most summer highs in the low 80s F/27 C. September and October are generally clear, with highs in the mid 60s to mid 70s F/17-23 C. Winter is wet, sometimes snowy, sometimes icy and chilly (18 to 37 F/-8 to -3 C).

Government

Established in 1642
Incorporated in 1931
Form of Government: Mayor and a nine member City Council
Fiscal Year Begins: July 1

City Hall
3275 Post Road
Warwick, RI 02886

General Demographic Characteristics

- **Population:** The population count for The City of Warwick as of April 1, 2000, was 85,808. This represented a 0.45% increase (381 persons) from the 1990 population of 85,427.
- **Rank:** In 2000 Warwick ranks 2nd in population among Rhode Island's 39 cities and towns.
- **Median Age:** In 2000 the median age of the population in Warwick was 40.
- **Age Distribution:** In 2000, 78.1% or 67,028 persons residing in Warwick were 18 years of age or older. 64,478 were 21 and over, 16,664 were 62 and over, and 14,558 were 65 and over.
- **Population Density:** The 2000 population density of Warwick is 2,417 persons per square mile of land area. Warwick contains 35.50 square miles of land area (91,940,953 Sq. meters) (22,719.28 acres) and 14.12 square miles of water area (36,574,361 square meters) (9,036.76 acres).
- **Housing Units:** The total number of housing units in the The City of Warwick as of April 1, 2000, was 37,085. This represented an increase of 1,944 units from the 35,141 housing units in 1990. Of the 37,085 housing units 1,568 were vacant. 493 of the vacant units were for seasonal of recreational use.
- **Households:** In 2000, there are 35,517 households in Warwick with an average size of 2.39 persons. Of these, 22,971 were family households with an average family size of 2.99 persons.
- Race:
  > Total Population of One Race: 84,706
  > White: 81,695
  > Black of African American: 996
  > American Indian and Alaska Native: 213
  > Asian: 1,281
  > Native Hawaiian and Other Pacific Islander: 15
  > Some Other Race: 506
  > Total Population of two or More Races: 1,102
  > Hispanic or Latino: 1,372

Chapter 5. Hazard Identification

Identifying the hazards is the first step in any effort to reduce community vulnerability. For multi-hazard identification, all hazards that may potentially occur in the community should be identified including both natural hazards and cascading emergencies – situations when one hazard triggers others sequentially. For example, severe flooding that damaged buildings storing hazardous water-reactive chemicals could result in critical contamination problems that would dramatically escalate the type and magnitude of events. We must ask ourselves questions like, "What is the possibility of dam failures to occur if a significant rain event resulting in flash flooding or particularly if a significant earthquake were to happen?" In areas of steeper, unstable slopes, identifying the secondary effects of coastal storms may include flood and debris damage resulting in rockslides or landslides.

For the purposes of the Warwick Hazard Mitigation Strategy, the following hazards will be addressed:

PART I – Natural Hazards – Which include:

- Tropical Cyclones
- Nor'easters
- Thunderstorms and Lightning
- Tornados
- Severe Winter Storms
- Hailstorms
- Temperature Extremes
- Floods
- Storm Surges
- Coastal Erosion
- Droughts
- Earthquakes

PART II – Technological Hazards – Which include:

- Dam failures
- Hazardous Materials Events

These hazards, as identified above, are the natural events that have the greatest potential for impacting the City of Warwick. These hazards will serve as the cornerstone for this mitigation strategy.

NATURAL HAZARDS

SUBPART A – ATMOSPHERIC HAZARDS

A.1 Tropical Cyclones

Hurricanes, tropical storms, and typhoons, collectively known as tropical cyclones, are among the most devastating naturally occurring hazards in the United States and its territories. More than 36 million people live in the States along the Gulf of Mexico and Atlantic Ocean coast; they are of the conterminous United States most susceptible to tropical cyclones. These are also the regions with the highest growth rates and rising property values. The trend of increasing development in coastal zones magnifies the exposure of those areas to catastrophic losses from tropical cyclones.

A tropical cyclone is defined as a low pressure area of closed circulation winds that originates over tropical waters. Winds rotate counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. A tropical cyclone begins as a tropical depression with wind speeds below 39 mph. It may develop into a tropical storm as it intensifies, with further development producing a hurricane or typhoon. Tropical cyclones with wind speeds between 39 mph and 74 mph are commonly known as tropical storms. When winds speeds exceed 74 mph they are commonly known as hurricanes. The eye, the storm's core, is an area of low barometric pressure that is generally 10 to 30 nautical miles in diameter. The surrounding storm may be 100 to 500 nautical miles in diameter, with intense windfields in the eastern and northern quadrants.

Hurricanes are classified as Categories 1 through 5 using the Saffir/Simpson Hurricane Scale. The analysis is based on central pressure, wind speed, storm surge height, and damage potential. These storms involve both atmospheric and hydrologic characteristics. Those commonly associated with tropical cyclones include severe winds, storm surge flooding, high waves, coastal erosion, extreme rainfall, thunderstorms, lightning, and, in some cases, tornados.

Hurricane Intensity

Category	Barometric Pressure	Wind Speed	Storm Surge	Damage Potential
1 Weak	> 28.94" > 980.02 mb	75 - 95 mph 65 - 82 kt	4 - 5 ft.	Minimal damage to vegetation. No real damage to other structures. Some damage to poorly constructed signs. Low-lying coastal roads inundated, minor pier damage, some small craft in exposed anchorage torn from moorings.
2 Moderate	28.50" - 28.93" 965.12mb - 979.68mb	96 -110 mph 83 - 95 kt	6 - 8 ft.	Considerable damage to vegetation; some trees blown down. Major damage to exposed mobile homes. Moderate damage to houses. Considerable damage to piers; marinas flooded. Small craft in unprotected anchorages torn from moorings. Evacuation from some shoreline residences and low-lying areas required.
3 Strong	27.91" - 28.49" 945.14mb - 964.78mb	111 - 130 mph 96 -113 kt	9 - 12 ft.	Large trees blown down. Mobile homes destroyed. Extensive damage to small buildings. Poorly constructed signs blown down. Serious coastal flooding; larger structures near coast damaged by battering waves and floating debris.
4 Very Strong	27.17" - 27.90" 920.08mb - 944.80mb	131 - 155 mph 114 - 135 kt	13 -18 ft.	All signs blown down. Complete destruction of mobile homes. Extreme structural damage. Major damage to lower floors of structures due to flooding and battering by waves and floating debris. Major erosion of beaches.
5 Catastrophic	> 27.17" > 920.08 mb	> 155 mph > 135 kt	> 18 ft.	Catastrophic building failures. Devastating damage to roofs of buildings. Small buildings overturned or blown away.

Table 5.1 SAFFIR-SIMPSON HURRICAN SCALE

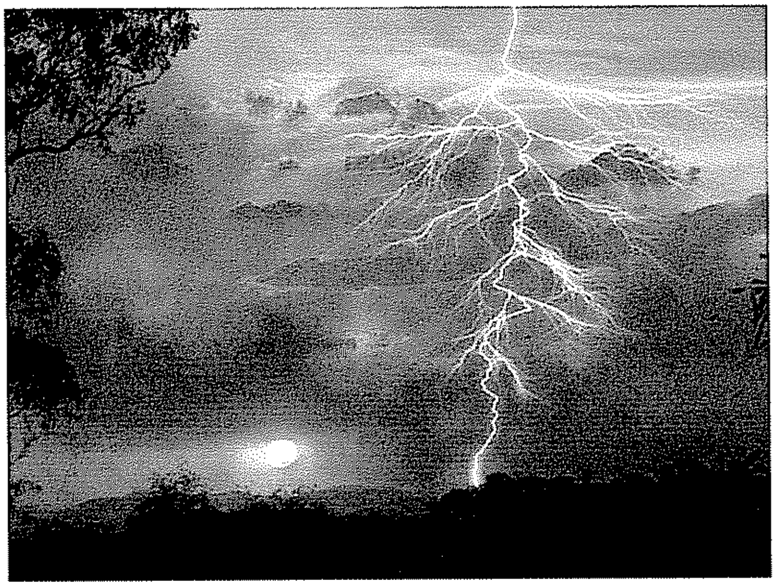
Hurricane intensity is measured by the Saffir-Simpson scale Table 5-1. Storms are categorized by number and range from 1 (low) to 5 (high). A hurricane's approximate damage potential increases as the square of the integer value for the Saffir-Simpson category. (IIPLR, 1994) The wind speed of a hurricane decreases as it moves inland for two reasons. First, the major source of storm energy (warm water) is no longer available to fuel the storm. Second, the land, vegetation, and structures offer frictional resistance to the storm winds. A hurricanes' peak wind speed distribution is a direct function of its rotational wind speed and forward speed. Storms that have a higher traveling speed do not stay in one place for long, minimizing the possibility of damaging buildings and other stationary structures. However, faster moving storms tend to be more destructive further inland. Because they travel further inland causing higher storm surge and stronger winds. (IIPLR, 1994)

A.2 Nor'easters

New Bedford's Fisherman's Wharf after a Nor'Easter

A Nor'easter is defined as a large weather system traveling from South to North, passing along or near the seacoast. As the storm approaches, and its intensity becomes increasingly apparent, the resulting counterclockwise cyclonic winds impact the coast and inland areas from a northeasterly direction. In the winter months, oftentimes blizzard conditions accompany these events. The added impact of the masses of snow and/or ice upon infrastructures often affects transportation and the delivery of goods and service for an extended period of time.

A.3 Thunderstorms and Lightning



Thunderstorm and lightning events are generated by atmospheric imbalance and turbulence due to a combination of conditions. These include unstable warm air rising rapidly into the atmosphere, sufficient moisture to form clouds and rain, and an upward lift of air currents caused by colliding weather fronts (cold and warm), sea breezes, or mountains.

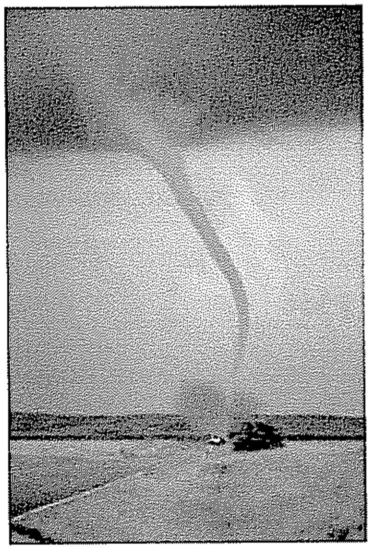
Thunderstorms are recorded and observed as soon as a peal of thunder is heard by an observer as a NWS first-order weather station. A thunder event is composed of lightning and rainfall, and can intensify into a more severe thunderstorm with damaging hail, high winds, tornados, and flash flooding. Strong, concentrated, straight-line winds called downbursts are created by falling rain and sinking air that can reach speeds of 125 mph. Microburst winds, which are more concentrated than downbursts, contain speeds up to 150 mph. These downbursts and microbursts generally last 5 to 7 minutes.

Lightning occurs during all thunderstorms. It can strike anywhere and at anytime during the storm. Generated by the buildup of charged ions in a thundercloud, the discharge of a lightning bolt interacts with the best conducting object or surface on the ground. The air in the channel of a lightning strike reaches temperatures higher than 50,000 degrees F. The rapid heating and cooling of the air near the channel causes a shock wave which produces thunder (NOAA, 1994).

The National Weather Service classifies a thunderstorm as severe if its winds reach or exceed 58 mph, produces a tornado, or drops surface hail at least 0.75 inches in diameter (NWS, National Oceanic and Atmospheric Administration).

Many hazardous weather events are associated with thunderstorms. Fortunately, the area affected by any one of them is fairly small and, most of the time, the damage is fairly light. Lightning is responsible for many fires around the world each year, as well as causing deaths when people are struck. Under the right conditions, rainfall from thunderstorms causes flash flooding, which can change small creeks into raging torrents in a matter of minutes, washing away large boulders and most man-made structures. Hail up to the size of softballs damages cars and windows, and kills wildlife caught out in the open. Strong (up to more than 120 mph) straight-line winds associated with thunderstorms knock down trees and power lines. In one storm in Canada in 1991, an area of forest approximately 10 miles wide and 50 miles long was blown down. Tornados (with winds up to about 300 mph) can destroy all but the best-built man-made structures.

A.4 Tornados



Tornados are violently rotating columns of air extending from within a thundercloud down to ground level. The strongest tornadoes may sweep houses from their foundations, destroy brick buildings, toss cars and school buses through the air, and even lift railroad cars from their tracks. Tornadoes vary in diameter from tens of meters to nearly 2 km (1 mi), with an average diameter of about 50 m (160 ft). Most tornadoes in the northern hemisphere create winds that blow counterclockwise around a center of extremely low atmospheric pressure. In the southern hemisphere the winds generally blow clockwise. Peak wind speeds can range from near 120 km/h (75 mph) to almost 500 km/h (300 mph). The forward motion of a tornado can range from a near standstill to almost 110 km/h (70 mph).

A tornado becomes visible when a condensation funnel made of water vapor (a funnel cloud) forms in extreme low pressures, or when the tornado lofts dust, dirt, and debris upward from the ground. A mature tornado may be columnar or tilted, narrow or broad—sometimes so broad that it appears as if the parent thundercloud itself had descended to ground level. Some tornadoes resemble a swaying elephant's trunk. Others, especially very violent ones, may break into several intense suction vortices—intense swirling masses of air—each of which rotates near the parent tornado. A suction vortex may be only a few meters in diameter, and thus can destroy one house while leaving a neighboring house relatively unscathed ("Tornado, Microsoft, Encarta Online Encyclopedia, 2004.)

Many tornadoes, including the strongest ones, develop from a special type of thunderstorm known as a supercell. A supercell is a long-lived, rotating thunderstorm 10 to 16 km (6 to 10 mi) in diameter that may last several hours, travel hundreds of miles, and produce several tornadoes. Supercell tornadoes are often produced in sequence, so that what appears to be a very long damage path from one tornado may actually be the result of a new tornado that forms in the area where the previous tornado died. Sometimes, tornado outbreaks occur, and swarms of supercell storms may occur. Each supercell may spawn a tornado or a sequence of tornadoes.

Direct measurements of tornado wind speeds are difficult (and dangerous) to obtain. In 1971 Theodore Fujita, a meteorology professor at the University of Chicago, devised a classification system based on damage to manmade structures. His Fujita-scale classification system (F-scale) ranks tornado damage as weak (F0 and Fl), strong (F2 and F3), or violent (F4 and F5). The weakest tornadoes (F0) may damage chimneys and signs, whereas the most violent tornadoes (F5) can blow houses completely off their foundations. Scientists are able to correlate F-scale values roughly using only wind speeds. For instance, a wind speed of 145 km/h (90 mph) might do minor F0 damage to a well-constructed building but significant F2 damage to a poorly constructed building. Scientists estimate that F0 tornadoes may have wind speeds up to 110 km/h (70 mph), while F5 tornadoes may have wind speeds somewhere in the range of 420 to 480 km/h (260 to 300 mph). Despite its drawbacks, the F-scale system is a convenient means for scientists to classify and discuss the intensity of tornadoes. In the United States, it is the official tornado classification system of the National Weather Service.

Table 5.2

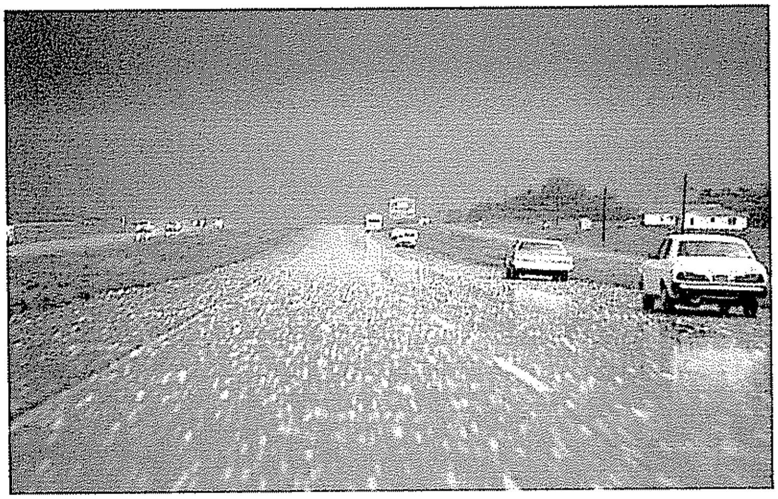
SCALE	WIND ESTIMATE *** (MPH)	TYPICAL DAMAGE
F0	< 73	Light damage. Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	Moderate damage. Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	158-206	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
F4	207-260	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
F5	261-318	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yds); trees debarked; incredible phenomena will occur.

A.5 Severe Winter Storms

Winter storms and blizzards originate as mid-latitude depressions or cyclonic weather systems, sometimes following the path of the jet stream (Weather Defined, 1992). A blizzard combines heavy snowfall, high winds, extreme cold, and ice storms. The origins of such weather patterns are primarily from four sources in the continental United States.

In the Northwestern States, cyclonic weather systems from the North Pacific Ocean or the Aleutian Island region sweep in as massive low-pressure systems with heavy snow and blizzards. In the northeast, lake effect snowstorms develop from the passage of cold air over the relatively warm surfaces of the Great Lakes, causing heavy snowfall and blizzard conditions. In the Midwestern and Upper Plains States, Canadian and Arctic cold fronts push ice and snow deep into the interior region and, in some instances, all the way down to Florida. The Eastern and Northeastern States are affected by extra-tropical cyclonic weather systems in the Atlantic Ocean and the Gulf of Mexico that produce snow, ice storms, and occasional blizzards.

A.6 Hailstorms



A hailstorm is an outgrowth of a severe thunderstorm in which balls or irregularly shaped lumps of ice greater than 0.75 inches in diameter fall with rain (Gokhale, 1975). In the earliest developmental stages of a hailstorm, ice crystals form within a low-pressure front due the rapid rising of warm air into the upper atmosphere, which then causes a subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight, they fall as precipitation.

The size of hailstorms is a direct function of determining the size and severity of the storm. High velocity updraft winds are required to keep hail in suspension in thunderclouds. The strength of the updraft is a function of the intensity of heating at the earth's surface. Higher temperature gradients relative to the elevation above the surface result in increased suspension time and hailstone size (Encarta Online, 2002).

A.7 Temperature Extremes

Extreme summer weather is characterized by a sometimes dangerous combination of very high temperatures and exceptionally humid conditions. When such a pattern persists over an extended period of time, it is known as a heat wave.

The National Weather Service uses a heat index that includes the combined effects of high temperature and humidity when measuring the severity of a heat wave. They also gather and compile information used to estimate the index and then distribute the determined value to the public and the weather broadcasting industry.

The estimation of the heat index is a relationship between dry bulb temperatures (at different humidities) and the skin's resistance to heat and moisture transfer. Because skin resistance is directly related to skin temperature, a relation between ambient temperature and relative humidity versus skin temperature can be determined. If the relative humidity is higher or lower than the base value, then the apparent temperature is higher or lower than the ambient temperature (National Weather Service, 1997).

Extreme winter weather is characterized by very low temperatures and low humidity. When such a pattern persists over an extended period of time, it is known as a cold snap. The average number of deaths attributed to cold is 770 yearly,_substantially higher than the number attributed to heat (Kilbourne, 1997).

When extreme cold temperatures are combined with high winds an effect called wind chill can increase the severity of the temperature extreme. The term "wind chill" goes back to the Antarctic explorer Paul Siple, who coined it a 1939 dissertation, "Adaptation of the Explorer to the Climate of Antarctica." During the 1940s, Siple and Charles Passel conducted experiments on the time needed to freeze water in a plastic cylinder that was exposed to the elements. They found that the time depended on how warm the water was, the outside temperature, and the wind speed. The formulas used to calculate wind chill were based on those experiments.

In the fall of 2001, the U.S. National Weather Service and the Canadian Weather Service replaced the formulas with new ones (one for Fahrenheit temperatures and one for Celsius readings). The new formulas are based on greater scientific knowledge and on experiments that tested how fast the faces of volunteers cooled in a wind tunnel with various combinations of wind and temperature.

The new formula for winds in mph and Fahrenheit temperatures is:

Wind chill temperature = 35.74 + 0.6215T - 35.75V (**0.16) + 0.4275TV (**0.16)

In the formula, V is in the wind speed in statute miles per hour, and T is the temperature in degrees Fahrenheit.

SUBPART B - HYDROLOGIC HAZARDS

B.1 Floods

Flooding is the accumulation of water within a body of water and the overflow of excess water onto adjacent floodplain lands. The flood plain is the land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that is susceptible to flooding (FEMA, Multi Hazard Identification and Risk Assessment, 1997). Flooding is the result of large-scale weather systems generating prolonged rainfall or on-shore winds. Other causes of flooding include locally intense thunderstorms, and dam failures.

Overbank flooding of rivers and streams known as riverine flooding is the most common type of flooding event. Riverine floodplains range from narrow, confined channels in the steep valleys of hilly areas, and wide, flat areas in low-lying coastal regions. Annual spring floods result from snowmelt, and the extent of this flooding depends on the depth of winter snowpack and spring weather patterns.

Coastal flooding can originate from a number of sources. Coastal storms such as hurricanes can generate the most significant flood damage to the outlining coastal areas.

Some other types of floods include flash floods, ice-jam floods, and dam-break floods that occur due to structural failures or overtopping of embankments during flood events.

Flash floods are characterized by a rapid rise in water level, high velocity, and large amounts of debris. Flash floods are capable of tearing out trees, undermining buildings and bridges, and scouring new channels. Warwick is more prone to flash flood events in areas where there is a predominance of clay soils that do not have high enough infiltration capacities to absorb water fast enough from heavy precipitation events.

Flash floods may also result from dam failure, causing the sudden release of a large volume of water in a short period of time. In urban areas, flash flooding is an increasingly serious problem due to the removal of vegetation, and replacement of ground cover with impermeable surfaces such as roads, driveways and parking lots. In these areas, and drainage systems, flash flooding is particularly serious because the runoff is dramatically increased.

The greatest risk involved in flash floods is that there is little to no warning to people who may be located in the path high velocity waters, debris and/or mudflow. The major factors in predicting potential damage are the intensity and duration of rainfall and the steepness of watershed and stream gradients. Additionally, the amount of watershed vegetation, the natural and artificial flood storage areas, and the configuration of the streambed and floodplain are also important

There is often no sharp distinction between these separate types of floods; however, they are widely recognized and helpful in considering not only the range of flood risk but also appropriate responses.

Storm water runoff and debris flows also negatively impacts public infrastructure such as roads and bridges as water collects typically the result of inadequate drainage systems in the immediate area, creating ponding conditions oftentimes making roads impassible. Standing surface water develops after intense rainfall events where poor soil permeability and urbanization prevent adequate water drainage. This may interrupt road transportation and damage low elevation buildings.

B.2 Storm Surges

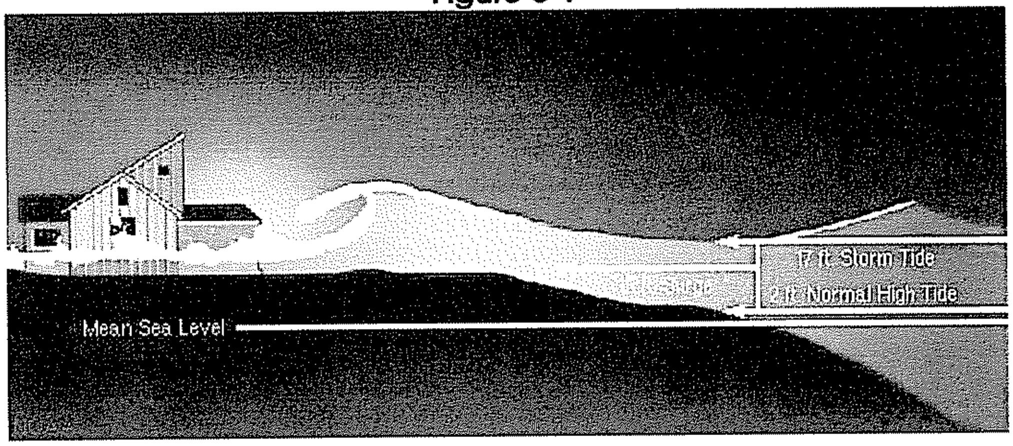
Storm surges occur when the water level of a tidally influenced body of water increases above the normal astronomical high tide. Storm surges commonly occur with coastal storms caused by massive low-pressure systems with cyclonic flows that are typical of hurricanes, nor'easters, and severe winter storms.

Storm surges caused by hurricanes usually begin over deep ocean waters wherein low pressure and strong winds around the hurricane's center raise the ocean surface 1-2 feet higher than the surrounding ocean. This rise in water lever forms a dome of water as wide as 50 miles across (National Science Foundation, 1980). As the storm moves into shallow coastal waters, decreasing water depth transforms the dome of water into a storm surge that can rise 20 feet or more above normal sea level, and cause massive flooding and destruction along the shoreline in its path.

There are certain factors associated with and controlled by coastal storms that attribute to the generation of such storm surges. The low barometric pressures experienced during coastal storms cause the water surface to rise, further increasing the height of storm surges; storms hitting land during peak astronomical tides have higher surge heights and more extensive flood inundation limits; coastal shoreline configurations with concave features or narrowing bays create a resonance within the area as a result of the winds forcing the water higher than experienced along adjacent areas of open coast (FEMA, Multi Hazard Identification and Risk Assessment, 1997).

Those areas most susceptible to storm surge are coastlines that are uniformly flat or only a few feet above mean sea level, the storm surge will spread water rapidly inland. Typically, storm surge diminishes one to two feet for every mile it moves inland. For example, a 20 foot surge in a relatively flat coastal area, where the land may only be 4 to 6 feet above mean sea level, would be felt 7 to 10 miles or more inland.

Figure 5-1



B.3 Coastal Erosion

Coastal erosion is the wearing away of land and loss of beach, shoreline, or dune material as a result of natural coastal processes or manmade influences. It can be manifested as a recession and degradation of major dune systems or development of steep scarps along the nearshore beach face (Encarta Online, 2002). Actions of winds, waves, and currents are natural processes that can cause coastal erosion. Human influences include construction of seawalls, groins, jetties, navigation inlets and dredging, boat wakes, and other interruption of physical processes.

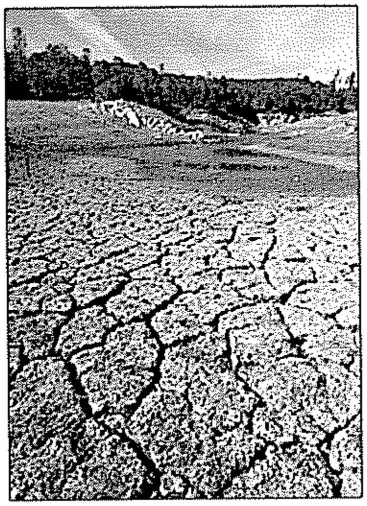
Erosion patterns and severity vary regionally, as they are a result of local geological and environmental factors such as winds, tides, and the frequency and intensity of coastal storms. Some coasts, such as those of the barrier islands in the Southeast, are retreating 25 feet per year, and sections of the Great Lakes coastline have receded by as much as 50 feet per year.

Some scientists believe that global warming will make storms stronger and more frequent. But no one can say yet for sure. It is known, however, that sea level is rising in many regions and that global warming may increase the rate of rise. The sea level has increased by 10 to 25 cm over the past 100 years and Nasa scientists predict that the sea level could rise 40 to 65 cm by the year 2100. Such a sea level rise would threaten coastal cities, forcing them to attempt to hold back the sea or to retreat.

Humans have also significantly increased the rate of coastline erosion. Population pressures, through economic development and recreational use, have exploited even the most remote coastal lands. In the last century, confidence in American technology's ability to engineer solutions has led many coastline property developers to risk placing structures closer and closer to the water (ScienCentral-Coastal Erosion, 2000).

Protecting these structures from eroding away with the shoreline is both expensive and difficult, as is rebuilding or replacing damaged structures. And all Americans bear the cost of this battle with Mother Nature through their State and Federal taxes. Dean says the ultimate solution is to convince communities to adopt a policy of retreating with the coastline—an idea that's unpopular with property owners and communities whose economies depend on beach development.

B.4 Droughts



A drought is defined as "a period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area." - Glossary of Meteorology (1959). It is a normal part of virtually all climatic regimes, including areas with high and low average rainfall.

A drought is a period of unusually persistent dry weather that persists long enough to cause serious problems such as crop damage and/or water supply shortages. The severity of the drought depends upon the degree of moisture deficiency, the duration, and the size of the affected area.

There are actually four different ways that drought can be defined.

1. Meteorological- a measure of departure of precipitation from normal. Due to climatic differences, what might be considered a drought in one location of the country may not be a drought in another location.

2. Agricultural- refers to a situation where the amount of moisture in the soil no longer meets the needs of a particular crop.

3. Hydrological- occurs when surface and subsurface water supplies are below normal.

4. Socioeconomic- refers to the situation that occurs when physical water shortages begin to affect people.

SUBPART C - SEISMIC HAZARDS

C.1 Earthquakes

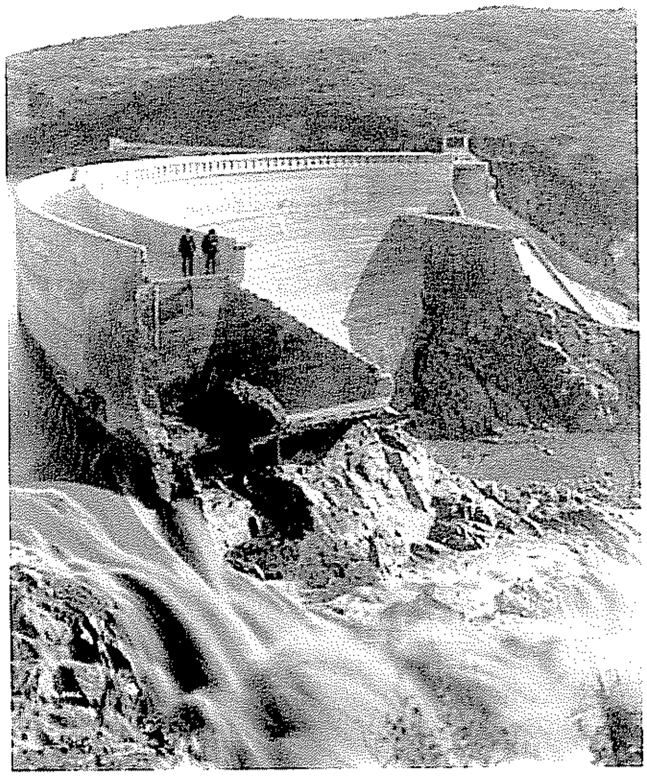
One of the most frightening and destructive phenomena of nature is a severe earthquake and its terrible aftereffects. An earthquake is a sudden movement of the Earth, caused by the abrupt release of strain that has accumulated over a long time. For hundreds of millions of years, the forces of plate tectonics have shaped the Earth as the huge plates that form the Earth's surface slowly move over, under, and past each other. Sometimes the movement is gradual. At other times, the plates are locked together, unable to release the accumulating energy. When the accumulated energy grows strong enough, the plates break free. If the earthquake occurs in a populated area, it may cause many deaths and injuries and extensive property damage.

The theory of plate tectonics, introduced in 1967, holds that the Earth's crust is broken into several major plates. These rigid 50 to 60 mile thick plates move slowly and continuously over the interior of the earth, meeting in some areas and separating in others (FEMA, Multi Hazard Identification and Risk Assessment). As the tectonic plates move together they bump, slide, catch, and hold. Eventually, faults along or near plate boundaries slip abruptly when the stress exceeds the elastic limit of the rock, and an earthquake occurs. Surface faulting, ground failure, and tsunamis are dangerous secondary hazards that can occur after an earthquake.

Although earthquakes have caused much less economic loss annually in the United States than other hazards such as floods, they have the potential for causing great and sudden loss. Within 1-2 minutes, an earthquake can devastate part of an area through ground-shaking, surface fault ruptures, and ground failures.

TECHNOLOGICAL HAZARDS

Dam failures



A dam is defined as a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water. (DAM SAFETY MANUAL) A dam impounds water in the upstream area, or reservoir. The amount of water impounded is measured in acre-feet referring to the volume of water that covers an acre of land to a depth of one foot. (FEMA, Multi-Hazards Risk Assessment, 1997) Two factors influence the potential severity of a full or partial dam failure: the amount of water impounded, and the density, type, and value of development and infrastructure located downstream.

Disastrous floods caused by dam failures, may cause great loss of life and property damage, primarily due to their unexpected nature and release of a high velocity wall of debris-laden water rushing downstream destroying everything in its path. The 1997 FEMA Multi-hazards Identification and Risk Assessment Publication reports that dam failures can result from any one or a combination of the following factors: prolonged periods of rainfall and flooding; inadequate spillway capacity, resulting in excess overtopping flows; internal erosion caused by embankment or foundation leakage or piping; improper maintenance, including failure to remove trees, repair internal seepage problems, replace lost material from the cross section of the dam, or maintain gates, valves and other operational components; improper design, including the use of improper construction material; negligent operation; failure of upstream dams on the same waterway; landslides into reservoirs; high winds causing significant wave action; and earthquakes.

Hazardous Materials Events

Hazardous materials are chemical substances, which if released or misused can pose a threat to the environment or health. These chemicals are used in industry, agriculture, medicine, research, and consumer goods. Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials.

Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals are used and stored in homes routinely. These products are also shipped daily on the nation's highways, railroads, waterways, and pipelines.

Varying quantities of hazardous materials are manufactured, used, or stored at an estimated 4.5 million facilities in the United States--from major industrial plants to local dry cleaning establishments or gardening supply stores.

Under the Emergency Planning and Right to Know Act of 1986, the Unites States Department of Transportation (DOT) identified as hazardous 308 specific chemicals from 20 chemical categories. In small doses, these chemicals may have minimal or no affects on humans. During transportation, DOT classifies HAZMAT in one or more of the following categories: explosive; blasting agent; flammable liquid; flammable solid; oxidizer; organic peroxide; corrosive material; compressed gas; flammable compressed gas; poison (A and B); irritating materials; inhalation hazard; etiological agent; radioactive materials; and other regulated material (FEMA and DOT, 1989).

Chapter 6. Hazards Risk Assessment

What Is Risk Assessment?

Risk assessment is the determination of the likelihood of adverse impacts associated with specific natural hazards to the built, natural, business, and social environments. (Heinz Coastal Hazards Panel Report, 1999, p.110) In order to assess the risk of the City of Warwick to the hazards previously identified, the NOAA Community Risk Assessment Tool was used to determine the frequency, area of impact and potential damage magnitude of each hazard.

Frequency

Evaluating the number of times that the natural hazard has impacted Warwick or a region within Rhode Island in the past provides a measure of the likelihood of the event occurring again in the future. This rating is derived from an investigation of trends in the long-term (30 years at least) data. Examination of past events helps to determine the likelihood of similar events occurring in the future.

TABLE 6.1 FREQUENCY SCORE

Approx. Recurrence (years)	Approx. Annual Probability	Subjective Description	Frequency Score
1	100.0%	Frequently recurring hazards, multiple recurrences in one lifetime	5
50	2.0%	Typically occurs at least once in lifetime of average building	4
250	0.40%	25% chance of occurring at least once in lifetime of average building	3
500	0.20%	10% chance of occurring at least once in lifetime of average building	2
1000	0.10%	Highly infrequent events, like maximum considered earthquake	1
2500	0.04%	Unlikely event	0

Source: David Odeh, Odeh Engineers, North Providence, Rhode Island

Area of Impact

A second criteria used in evaluating the risk of Warwick to natural hazards is to determine the area of impact. Some hazard events impact only a small region, while others can affect the entire area. The area of impact determination indicates how much of the immediate area is impounded by a single event. Again, historical data is used to investigate damage and loss records of previous hazard events to develop an estimate of where expected impacts or the amount of property damage may occur from future events.

TABLE 6.2 AREA OF IMPACT SCORE

Mean Affected Area (sq. miles)/event	Subjective Description	Area Impact Score
0	No affected area	0
1	Highly localized (city block scale)	1
10	Single zip code impact	2
50	City scale impact	3
100	County scale impact	4
500	Regional impact (e.g. statewide)	5

Magnitude

Intensity or magnitude criteria is used to determine the range of the severity of damage (from minor to devastating) expected from a single event. Previous damage reports and other historical data (e.g. newspaper articles, personal accountings, video clips, etc,) are used.

TABLE 6.3 MAGNITUDE SCORING

Magnitude Score	Earthquake MMI	Hurricane SSI	Average Flood Elevation
0	3	0	0
1	4	1	1
2	5	2	8
3	7	3	12
4	9	4	14
5	12	5	24

Based on the results of the cumulative scores, the following formula is used to prioritize the potential threat each hazard poses on Warwick:

(FREQUENCY + AREA OF IMPACT) X POTENTIAL DAMAGE MAGNITUDE = TOTAL SCORE

TABLE 6.4 RISK SCORE FOR WARWICK, RI

Hazard	Frequency	Area Impact	Magnitude	Total
Tropical Cyclone	4	5	4	36
Nor'easters	4	5	4	36
Thunderstorms	5	4	2	18
Tornado	1	2	4	12
Severe Winter Storms	4	5	4	36
Hail Storms	4	4	2	16
Temperature Extremes	5	5	1	10
Flood	3	2	5	25
Storm Surge	3	2	5	25
Coastal Erosion	4	2	1	6
Droughts	4	5	3	27
Earthquake	1	4	4	20
Dam Failures	1	1	4	8
Hazardous Materials Events	2	2	2	8

Total Score = (Frequency + Area Impact) x Potential Damage Magnitude

Table 6.4 above presents the hazard risk score for the City of Warwick. The following section discusses in depth the evidence that allowed us to develop the risk scores for each of our identified hazards.

NATURAL HAZARDS

SUBPART A – ATMOSPHERIC HAZARDS

A.1 Tropical Cyclones – Risk Score 36

Storm Tracks in Rhode Island

Tropical cyclones, including hurricanes and tropical storms, impact Rhode Island from the south and southwest during the summer and fall from June through November. Although an average of 10 storms form each hurricane season in the Atlantic, most do not impact the northeast. Over the past 100 years, five storms have hit or passed near Rhode Island (Figure 6.1).

Despite the fact that most of these storms tracking through the Atlantic Ocean, have not made a direct hit on Rhode Island, the "near misses" generate large swell, storm surge and moderately high winds causing varying degrees of damage. Impacts from these "non-events" frequently result in severe beach erosion, large waves, high winds, and marine overwash.

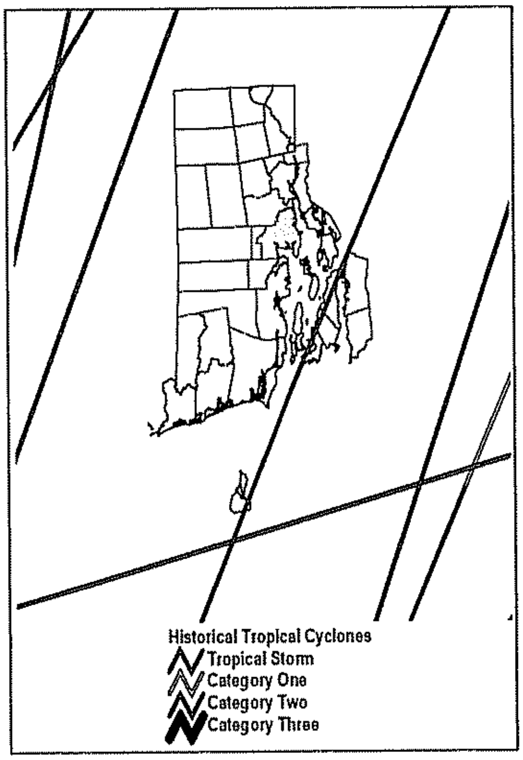
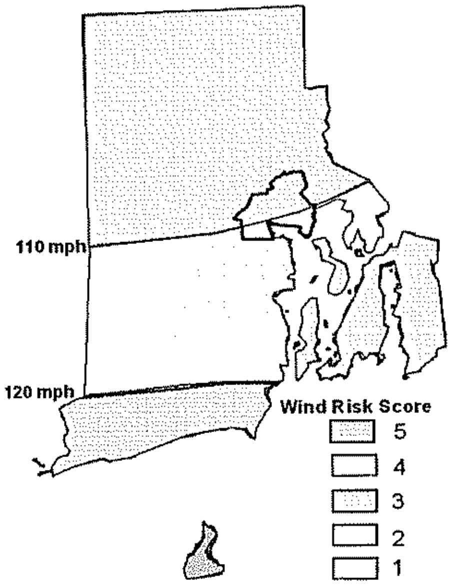


Figure 6.1 Historical Tropical Cyclone Tracks Source: NOAA

Tropical Cyclone Wind Potential



The hurricane events that represent much of the wind hazard for Warwick are coastal systems. As such, wind hazard areas can be prioritized based on the distance from the coast. Figure 6.2 shows the relative wind hazard ranking for Warwick and all of Rhode Island. These rankings are based on the American Society of Civil Engineers (ASCE) *Minimum Design Loads for Buildings and Other Structures, ASCE 7-98*. Coastal regions of Warwick are in the risk category 4, while the remainder of the City is in category 3.

Figure 6.2 Wind Risk Score

Hurricanes Events

While these storms occur infrequently, they have the potential to cause large amounts of damage over a widespread area. Six notable storms have caused damage in Rhode Island since 1900 (Table 6.5).

TABLE 6.5 - HISTORICAL HURRICANE LOSSES FOR RI (NOAA)

Date	Name	Category of Storm	Magnitude (MPH)	Forward Motion	Property Damage ($ million *Actual*)	Deaths
9/21/1938	-	3	121	82	306	262
8/31/1954	Carol	3	110	56	461	19
8/19/1955	Diane	TS	45	24	170	0
9/12/1960	Donna	2	58	39	2.4	0
9/27/1985	Gloria	2	81	72	19.8	1
8/19/1991	Bob	2	100	51	115	0

The Great New England Hurricane of 1938, which originated in the far-eastern Atlantic, was one of the most powerful and devastating storms in New England history. The wind speed of this hurricane reached record highs of over 120 mph and resulted in flood tides of more than 12 feet above the normal high water line in Greenwich Bay (Journal-Bulletin, 1979). At the time of the storm, the phase of the moon and the autumnal equinox combined to produce one of the highest tides of the year and the storm surge coincided almost exactly with it from ebb to flood (Brown, 1979). The combination served to further exacerbate the impact of the storm and its devastating effects. (Boothroyd's hurricane figure showing quadrant hits)

Property losses in and around Greenwich Bay resulting from the Great New England Hurricane of 1938 were substantial. Among these were the loss of more than 700 permanent residences and hundreds of summer homes in Warwick; the devastation of Rocky Point, the oldest resort in Rhode Island; and the destruction of Scalloptown in East Greenwich (Journal-Bulletin, 1979). The Warwick Point lighthouse, which sits on a 20-foot cliff, was undermined by a 38-foot recession due to heavy erosion (Brown, 1979). After the hurricane of 1938, the Warwick Light was moved landward 75 feet. The erosion and changing coastline not only impacted the local infrastructure but has also had an impact on various habitats within the Bay.

Hurricane Carol (1954) was the most destructive storm to hit New England since the Great New England Hurricane of 1938. Sustained winds of 80 to 110 mph resulted in $3,000,000 worth of property damage in Warwick; flash flooding in Apponaug; and an estimated $250,000 worth of damages to Rocky Point. Storm surges were just below the 1938 Hurricane levels. Oakland Beach was the most heavily battered section along the upper Narragansett Bay due to its exposure to southeast winds. Many observers noted that the destruction to Oakland beach was identical to what occurred in the 1938 storm. Apponaug, Chepiwanoxet and Potowomut shores were littered with "houses, industrial structures, docks and stately trees (Providence Journal Company, 1954).' Greenwich Cove escaped the full force of the hurricane due to its location. The fishing and pleasure boats survived the storm with minor battering. The entire State lost electrical power during this storm (Journal-Bulletin, 1979).

Hurricane Bob reached Rhode Island on August 19, 1991 after developing in the Central Bahamas 3 days earlier. This hurricane caused a storm surge of 5 to 8 feet along the Rhode Island shore. Bob's damage in Rhode Island was primarily from the sustained winds of 75 to 100 mph. The winds caused over 60% of the residents across Rhode Island and Southeast Massachusetts to loose electricity due to tree and power line damage. Agricultural losses in peach and apple orchards were substantial. Boat damage from this hurricane was significant, as many boats were torn from their moorings (Vallee and Dion, 1998). The storm path of Bob was quite similar to the destructive 1954 Hurricane Carol. Though the storm hit at high tide as a Category 2 hurricane, its center passed over Massachusetts. Rhode Island suffered over $115 million dollars in damage, with spillage of 100 million gallons of untreated sewage into Narragansett Bay and a resulting nine day shellfish bed closing (RIEMA 1995).

Each of these major storms had significant northward acceleration. The average forward speed at time of landfall was 51 km/hr. The Great New England Hurricane of 1938 registered 82 km/hr.

A.2 Nor'easters – Risk Score 36

Nor'easters are similar to hurricanes in that they are coastal storms that bring heavy precipitation and very powerful winds. However, nor'easters are winter storms often accompanied by dramatic temperature drops and the possibility of frozen precipitation. Southern New England is impacted by nor'easters of varying sizes and intensity once every few years. The area impact of large nor'easters can be dramatic, with some notable storms affecting many hundreds of miles of coastline.

Nor'easter Events

The property damage from serious Nor'easters can be greater than from hurricanes (Table 6.6).

TABLE 6.6 HISTORICAL NOR'EASTER LOSSES IN RI (NOAA)

Year	Deaths	Total Losses (Actual)
1888	400+	Unknown
1978	99	$202M
1991	33	$200M
1992	19	$1,000M-2,000M
1993	270	$3,000M-6,000M
1996	187	$3,000M

A.3 Thunderstorms – Risk Score 18

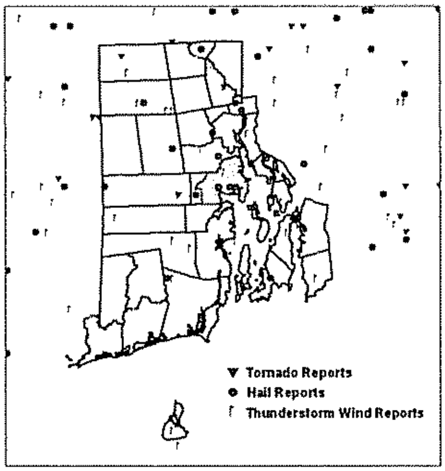


Figure 6.3 Historical severe weather reports in Rhode Island - Source: NOAA

Severe thunderstorms occur across southern New England during the spring and summer months. Accompanied with winds in excess of 75 mph, these storms develop an average of once or twice each year (Figure 6.3).

Each severe thunderstorm affects approximately 25 square miles. The winds in these storms are capable of damaging both buildings and vegetation. However, only the strongest of these storms cause physical damage to well-built structures.

A.4 Tornadoes – Risk Score 12

Tornadoes do not occur frequently across New England, and the Warwick area is no exception. In 46 years (1950 – 1995), approximately 20 tornadoes were reported around Rhode Island (Figure 6.3). A tornado is reported in southern New England once every two to three years.

Tornadoes are among the most destructive forces of nature. Even minor tornadoes have the ability to destroy property and cause injuries or death. While tornadoes can occur in and around the Warwick area, the events are typically small in area. The average tornado impacting the Rhode Island area affects only 2 square miles.

A.5 Severe Winter Storms – Risk Score 36

Warwick, Rhode Island lies outside the heavy snow regions of the northeast. Located along the southern New England coast, Warwick has a maritime climate that is cooler in the summer and warmer in the winter than many inland locations. As a result, Warwick experiences less snowfall, on average, than cities to the northwest (Figure 6.4). During an average year, coastal regions of Rhode Island receive nearly 36 inches of snow. Conversely, Worcester, MA receives over 67 inches of snow annually.

Severe winter storms are spatially expansive. While individual locations can receive varying amounts of snow in a single event, few areas escape the impact entirely.

The two major threats from severe winter storms are snow loading on rooftops, and loss of power due to ice on power lines. The impact of major storms can be quite extreme, with power being out for several days.

Within the city of Warwick, the immediate coastal areas may experience less snow than inland areas. However, local terrain, combined with the size and variability of individual storms makes it difficult to assign relative rankings to the snow & ice hazard.

Figure 6.4 Heavy Snowstorm Probability of Occurrence.
Source: NOAA

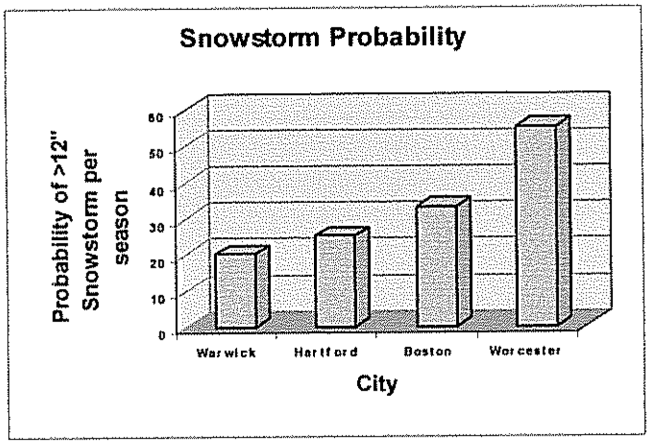
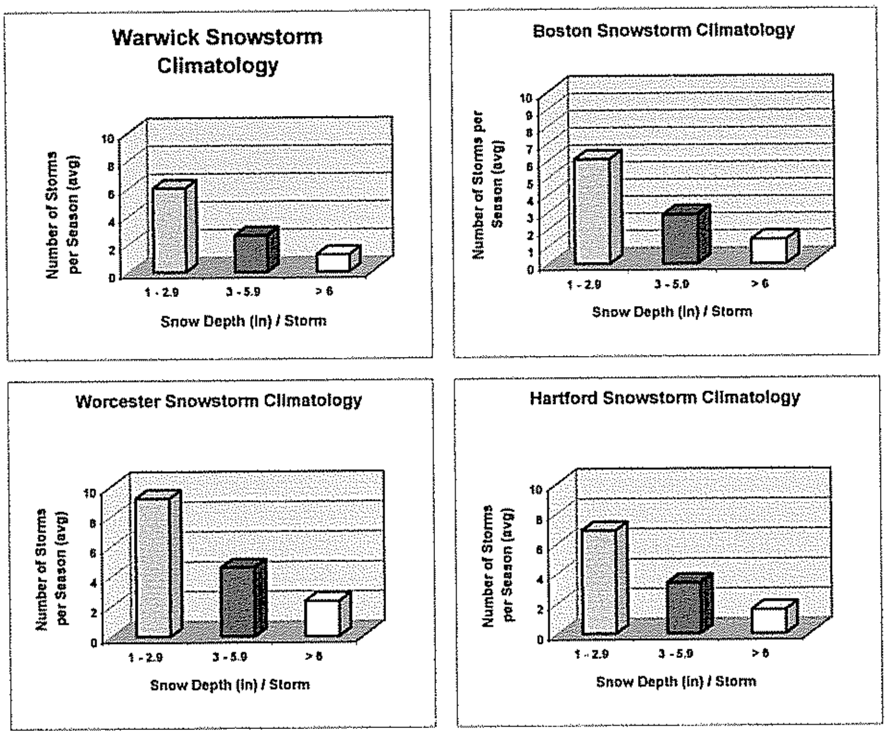


Figure 6.5 New England Seasonal Snowfall.
Source: NWS Boston, MA



A.6 Hail – Risk Score 16

Hail occasionally accompanies severe thunderstorms in Rhode Island. Based on 41 years of data (1955 – 1995), hail of at least 0.75in diameter is reported in the study area approximately once every year (Figure 6.3).

The portion of a thunderstorm that contains hail is relatively small. Less than half of the area impacted by a thunderstorm will experience hail. Hail can cause damage to automobiles and buildings. Unprotected roofing systems can be damaged by hail greater than 1 inch in diameter.

A.7 Temperature Extremes – Risk Score 10

An examination of historical temperature records reveals that Rhode Island lies in an area of varying temperature. Summers can have brief periods of extreme heat, while winters are often quite cold (Figure 6.6). The potential impact of such extremes is primarily economic.

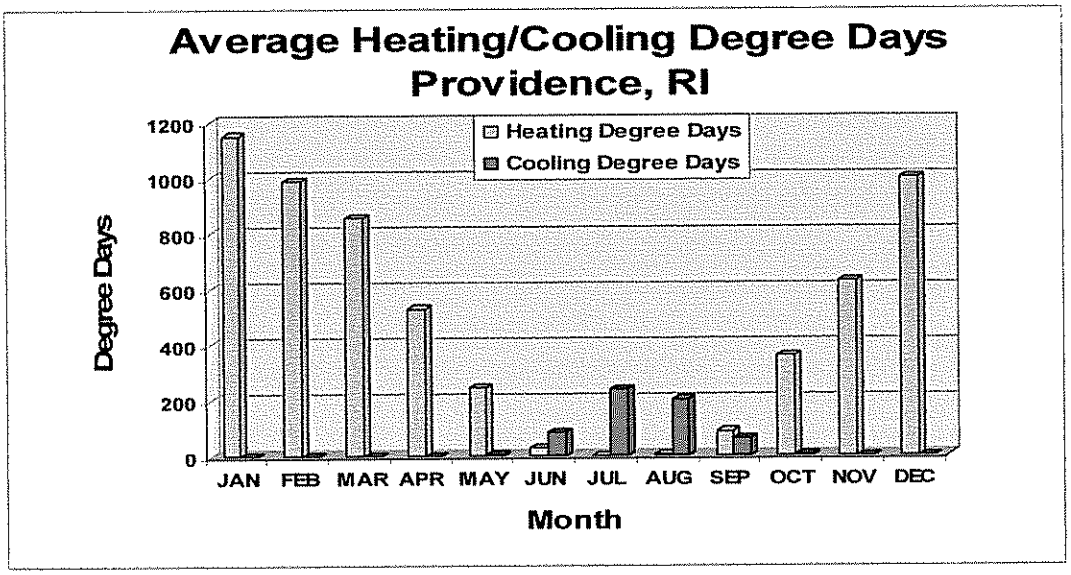


Figure 6.6 Average Heating/Cooling Degrees Days

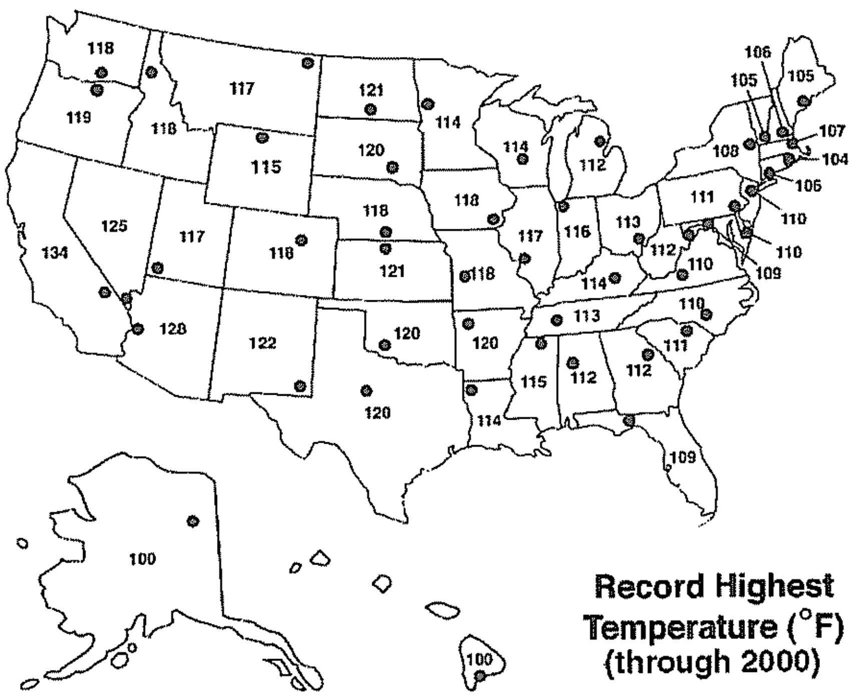


Figure 6.7

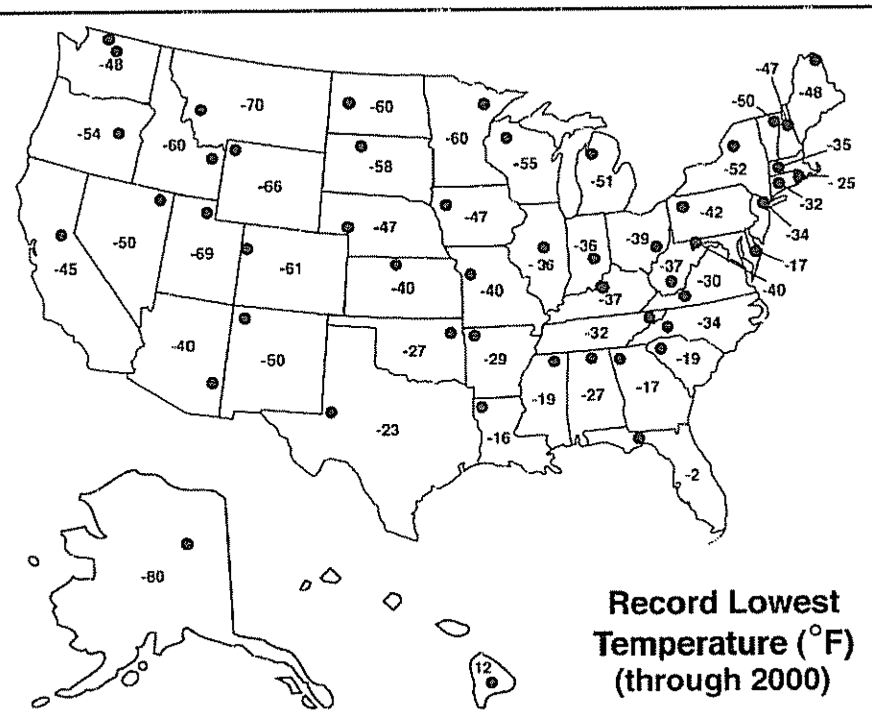


Figure 6.8

SUBPART B – HYDROLOGIC HAZARDS

B.1 Flood – Risk Score 25

Storms

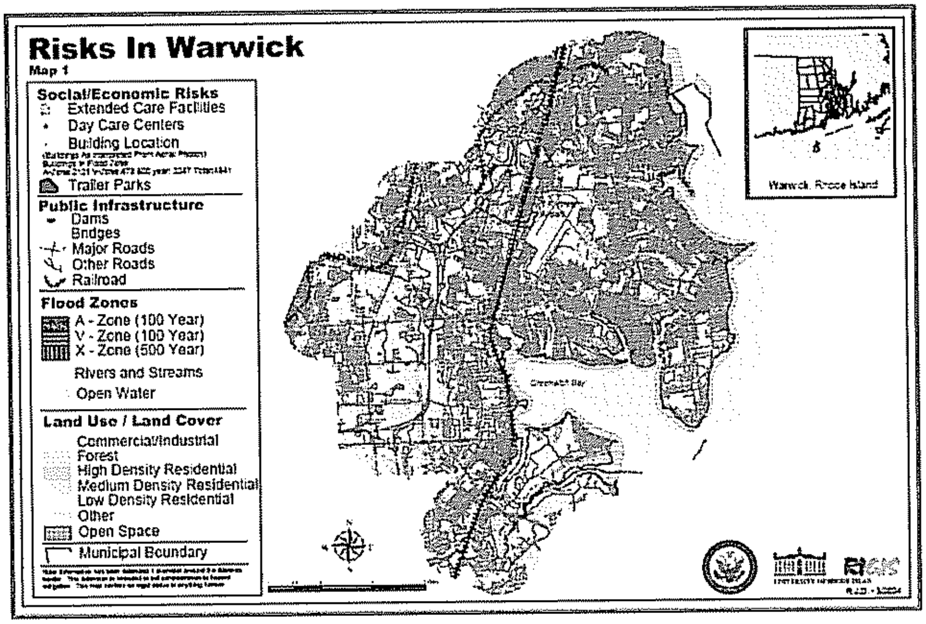
Major flooding events in Rhode Island are caused by storms, storm surge, high surf and riverine flooding. The following storms hold the greatest potential to impact the City of Warwick.

a) *Nor'easters* - Nor'easters are similar to tropical cyclones in that they are coastal storms that bring heavy precipitation and very powerful winds. However, nor'easters are winter storms often accompanied by dramatic temperature drops and the possibility of frozen precipitation.

b) *Hurricanes* - Hurricanes or tropical storms hitting or passing by the New England coast cause heavy rains, storm surge, high winds and surf. Impacts from these events have included coastal erosion, severe inland and coastal flooding. Extensive wind damage can occur from the stronger tropical cyclones (hurricanes and tropical storms).

Flood Prone Areas

The City of Warwick utilizes the FEMA Flood Insurance Rate Map's (FIRM's) to determine the location of flood zones and flood prone areas. These maps were last updated in 1992 – 1993 by the Federal Emergency Management Agency. In Warwick, 3,379 acres, and hundreds of structures are located within a FEMA designated Special Flood Hazard Area (SFHA). A special flood hazard area is delineated on a Flood Insurance Rate Map. The SFHA is mapped as Zone A. In coastal situations, Zone V is also part of the SFHA. The SFHA may or may not encompass all of the community's flood problems.



Map 6.1

Under the National Flood Insurance Program (NFIP), FEMA is required to develop flood risk data for use in both insurance rating and floodplain management. FEMA develops this data through Flood Insurance Studies (FIS). In FIS's, both detailed and approximate analyses are employed. Generally detailed analyses are used to generate flood risk data only for developed or developing areas of communities. For undeveloped areas where little or no development is expected to occur, FEMA uses approximate analyses to generate flood risk data.

FEMA FIRM FLOOD HAZARD RISK CATEGORIES		
FEMA Flood Zone	Amount of Land	Risk Score
VE zones	681	5
A and AE zones	2,698	4
AH and AO zones	288	3
500 year	3,835	2
Remainder of City	22,945	1

Table 6.7

Using the results of the FIS, FEMA prepares a Flood Insurance Rate Map (FIRM) that depicts the Special Flood Hazard Areas (SFHAs) within the studied community. SFHAs are areas subject to inundation by a flood having a one percent chance or greater occurring in any given year. This type of flood, which is referred to as the 100-year flood (or base flood), is the national standard on which the floodplain management and insurance requirements of the NFIP are based. The FIRMS show base flood elevations (BFEs) and flood insurance risk zones. The FIRM also shows areas designated as a regulatory floodway. The regulatory floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 100-year flood discharge can be conveyed without increasing the BFE more than the specified amount. Within the SFHAs identified by approximate analyses, the FIRM shows only the flood insurance zone designation. The FEMA FIRM designations are defined below.

Table 6.8

FEMA Flood Insurance Rate Map Definitions

VE Zones
Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone A
Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE
Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the FIS by detailed methods. In most instances, whole foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH
Zone AO is the flood insurance rate zones that correspond to the areas of 100-year shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO
Zone AO is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-depths derived from the detailed hydraulic analyses are shown within this zone

500-Year Flood Zone (or Zone X)
Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, and to areas of 100-year flooding where average depths are less than 1 foot, areas of flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevations or depths are shown within this zone.

Within the established flood risk areas in Warwick, certain regions are more susceptible to damaging floods than others. In order to identify such regions, the Warwick flood risk areas can be prioritized based on a relative flood risk ranking.

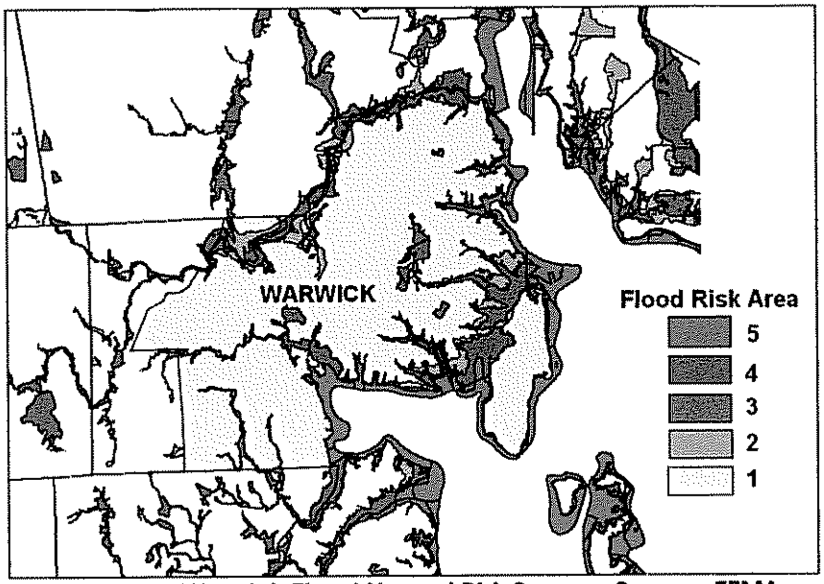
The relative risk rankings presented in Table 6.9 and 6.10 are based on the FEMA flood zones. Zone VE designates areas along coasts subject to inundation by a 100-year flood event in addition to storm-induced velocity wave action. Such areas require mandatory flood insurance. Zones A, AE, AH, & AO are also subject to inundation by the 100-year flood event and also require mandatory flood insurance. However, regions in these zones are susceptible to shallow flooding from ponding and/or sloping terrain. The Zone X500 designation is given to those areas subject to flooding by severe, concentrated rainfall coupled with poor drainage systems.

Table 6.9 Warwick Flood Hazard Risk Scores.

Warwick Flood Hazard Risk Scores	
FEMA Flood Zone	Risk Score
VE Zones	5
A and AE Zones	4
AH and AO Zones	3
X500 Zone	2
Remainder of City	1

Table 6.10 Representation of Warwick by FEMA Flood Zones

FEMA Flood Zone	Acreage	Square Miles	Percent
AE Zones	2,410	3.76	10.5
VE Zones	681	1.06	3.0
X500 Zones	3,835	5.99	16.7
X Zone	15,731	24.57	68.5
A Zone	288	.449	1.25
City of Warwick	22,945	35.88	100



Map 6.2 Warwick Flood Hazard Risk Scores Source: FEMA

Flash Floods, Sheet Flow, and Ponding

Flash floods are characterized by a rapid rise in water level, high velocity, and large amounts of debris. Flash floods are capable of tearing out trees, undermining buildings and bridges, and scouring new channels. Warwick is more prone to flash flood events in areas where there is a predominance of clay soils that do not have high enough infiltration capacities to absorb water fast enough from heavy precipitation events.

Flash floods may also result from dam failure, causing the sudden release of a large volume of water in a short period of time. In urban areas, flash flooding is an increasingly serious problem due to the removal of vegetation, and replacement of ground cover with impermeable surfaces such as roads, driveways and parking lots. In these areas, and drainage systems, flash flooding is particularly serious because the runoff is dramatically increased.

The greatest risk involved in flash floods is that there is little to no warning to people who may be located in the path high velocity waters, debris and/or mudflow. The major factors in predicting potential damage are the intensity and duration of rainfall and the steepness of watershed and stream gradients. Additionally, the amount of watershed vegetation, the natural and artificial flood storage areas, and the configuration of the streambed and floodplain are also important.

Storm water runoff and debris flows also negatively impacts public infrastructure such as roads and bridges as water collects typically the result of inadequate drainage systems in the immediate area, creating ponding conditions oftentimes making roads impassible. Standing surface water develops after intense rainfall events where poor soil permeability and urbanization prevent adequate water drainage.

This may interrupt road transportation and damage low elevation buildings. Road closures can be a critical issue in Warwick - when these events have the potential to isolate communities.

Flash flooding events, resulting from heavy precipitation, sometimes equaling the average annual rainfall, have occasionally occurred throughout the historical record. In Warwick these events are concentrated around the Pawtuxet River watershed.

B.2 Storm Surge – Risk Score 25

One of the most dangerous aspects of a hurricane is a general rise in sea level called storm surge. It begins over the deep ocean; low pressure and strong winds around the hurricane's center ("eye") raise the ocean surface a foot or two higher than the surrounding ocean surface forming a dome of water as much as 50 miles across. (National Science Foundation, 1980) As the storm moves into shallow coastal waters, decreasing water depth transforms the dome of water into a storm surge that can rise 20 feet or more above normal sea level and cause massive flooding and destruction along the shoreline in its path. This problem is even more critical in the event when there is additional impact caused by high, battering waves that occur on top of the surge.

Those areas most susceptible to storm surge are coastlines that are uniformly flat or only a few feet above mean sea level, the storm surge will spread water rapidly inland. Typically, storm surge diminishes one to two feet for every mile it moves inland. For example, a 20 foot surge in a relatively flat coastal area, where the land may only be 4 to 6 feet above mean sea level, would be felt 7 to 10 miles or more inland.

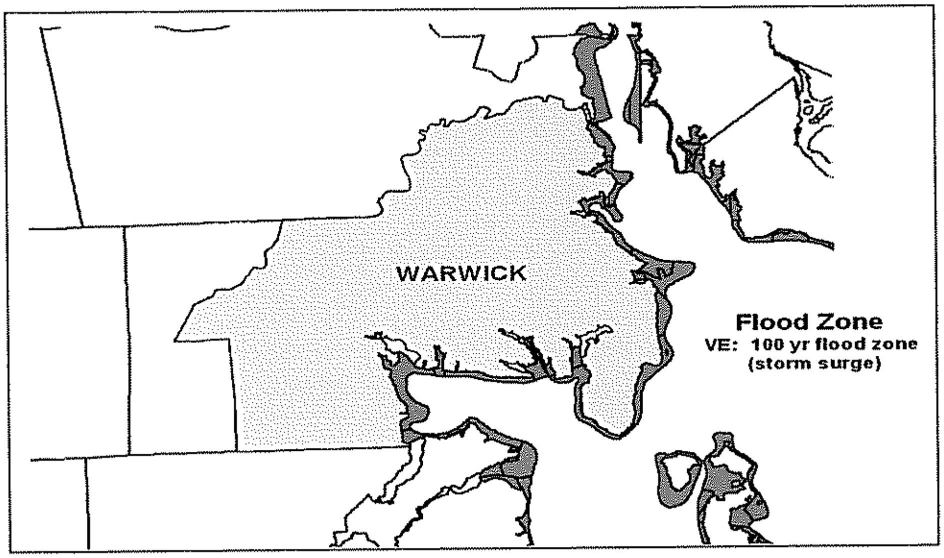
Storm surge floods and erodes coastal areas, salinizes land and groundwater, contaminates the water supply, causes agricultural losses, results in loss of life, and damages structures and public infrastructure. Warwick has over 39 miles of shoreline much of which is susceptible to storm surge. Flooding from storm surge in the immediate coastal areas occurs primarily as a result of tropical storms, hurricanes and seasonal high waves. During these events, high winds and surf can push water several feet and even hundreds of yards inshore. Conditions can be exacerbated by large waves that form on top of rising water. The degree of damage caused by storm surge depends on the tidal cycle occurring at the time of the event. During high tides, water levels can be significantly higher than at low tide. This will cause the surge to push further inland and cause more extensive damage. The area of impact of storm surge flooding is confined to regions along the immediate coastline and typically extends to a few hundred feet inland.

Sea, Lake, and Overland Surges from Hurricanes (SLOSH)

At present, the only widely used inundation model by state and federal agencies to determine the potential of storm surge is the Sea, Lake, and Overland Surges from Hurricanes (SLOSH). The SLOSH model is a computer model developed by the National Weather Service, designed to forecast surges that occur from wind and pressure forces of hurricanes. The National Hurricane Center used the SLOSH model, the bathymetry of Narragansett Bay and the Rhode Island coastal topography to model coastal flooding effects from hurricanes that could be experienced in the region. Combinations of four hurricanes categories (from the Saffir Simpson scale), five storm directions (NW, NNW, N, NNE, and NE) three forward speeds (20, 40 and 60 mph), and storm tracks selected at 15 mile intervals enabled 536 hypothetical situations to be simulated by the SLOSH model.

Maximum envelopes of water for each hurricane category and forward speed were calculated to reduce SLOSH model results to only those surge elevations that could potentially cause the greatest flooding. Further classification of maximum surges enabled three categories and forward speed dependent inundation areas to be developed and presented on each map. The inundation matrix of each community map can be used to determine the corresponding inundation area (A, B, or C) for a given hurricane category and forward speed. The classification of inundation areas by this matrix suggests that, in this region, *Worse Case* hurricane surges are predominantly a function of a hurricane's category and forward speed, and that a hurricane's track and direction have less of an effect on resulting storm surge. The following map is the expected 100 year storm surge for the City of Warwick.

Map 6.3 – Warwick Storm Surge



Worse Case surge tide estimations were based on maximum storm surge elevations derived for each inundation area within each community. The SLOSH model provides estimates of Stillwater surge elevations only and does not consider additional flooding from wave run up. Separate analyses showed that wave run-up effects based on the derived Stillwater estimates do not significantly increase the limits of flooding. Surge elevations corresponding to *Worse Case* surge tides were superimposed on Rhode Island Department of Transportation base maps using U.S. Geological Survey 7.5 minute quadrangle maps. Community specific hurricane surge tides [referenced to the National Geodetic Vertical Datum (NGTVD)] that are depicted for each inundation area are shown in the surge tide profiles provided on Plate iii of the U.S. Army Corps 1993 SLOSH Study.

For the Warwick area, based on the SLOSH model, storm surges are predicted to range from 18 to 23 feet high. (U.S. Army Corps of Engineers, SLOSH Study, 1993, p.ii). Aside from a number of bridges, none of Warwick's critical facilities are located in a flood or SLOSH zone within the Greenwich Bay watershed. In 1999, there were 1,383 at-risk structures in the city of Warwick. Most of these structures are located in the Oakland Beach area, although Buttonwoods Cove is at-risk as well. In the event of a severe hurricane, over 3,379 acres of land in Warwick would be inundated, causing up to $53 million in property damage. Such an event would knock out key assets such as the lumberyard, marinas, and several warehouses.

The Great New England Hurricane of 1938 produced the greatest storm tides this century in southern New England. The storm tide reached 19.01 feet (MLLW) at the State Street Station Dock on the upper part of Narragansett Bay during the 1938 Hurricane, associated with a 13.7 foot storm surge. Hurricane Carol brought a slightly higher storm surge, 14.4 feet over the upper portions of Narragansett Bay, but produced a slightly lower storm tide of 17.51 feet (MLLW), due to its arrival shortly after high tide. Hurricane Bob caused a storm surge of 5 to 8 feet along the Rhode Island shore.

B.3 Coastal Erosion – Risk Score 6

The glacially derived sediments found in the bluffs surrounding Greenwich Bay are highly susceptible to the erosion that occurs when a major storm surge elevates the water level 10 to 20 feet above mean sea level and subjects the unconsolidated sediments of glacial headland bluffs to the direct attack of waves (Providence Journal 1938). The beaches are sand-starved which leaves them susceptible to storm-surge and overwash processes. Oakland Beach and Buttonwoods Cove are especially vulnerable to erosion as they are relatively exposed to waves generated by southwesterly winds (Boothroyd, Personal Communication).
Oakland Beach is designated as a Class A critical erosion area in the CRMP. Setbacks are therefore required in this area. The CRMP defines a setback as the

minimum distance from the inland boundary of a coastal feature at which an approved activity or alteration may take place (CRMC, 1997, *as amended*). Setbacks should extend a minimum of either fifty (50) feet from the inland boundary of the coastal feature or twenty-five (25) feet inland of the edge of a Coastal Buffer Zone, whichever is further landward. In areas designated by the Council as Critical Erosion Areas, the minimum distance of the setback shall be not less than 30 times the calculated average annual erosion rate for less than four dwelling units and not less than 60 times the calculated average annual erosion rate for commercial, industrial or dwellings of more than 4 units. Due to site conditions over time, field verification of a coastal feature or coastal buffer zone may result in a setback determination different than that calculated using a shoreline change rate (CRMC, 1997, *as amended*).

B.4 Droughts – Risk Score 27

The potential for drought is best projected by the Palmer Index. The Palmer Index was developed by Wayne Palmer in the 1960s and uses temperature and rainfall information in a formula to determine dryness. It has become the semi-official drought index.

The Palmer Index is most effective in determining long term drought—a matter of several months—and is not as good with short-term forecasts (a matter of weeks). It uses a 0 as normal, and drought is shown in terms of minus numbers; for example, minus 2 is moderate drought, minus 3 is severe drought, and minus 4 is extreme drought. The Palmer Index can also reflect excess rain using a corresponding level reflected by plus figures; i.e., 0 is normal, plus 2 is moderate rainfall, etc.

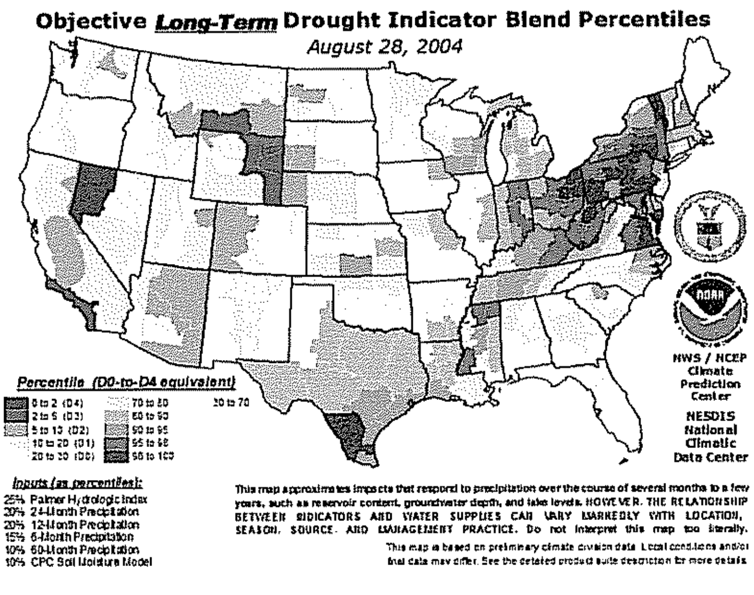


Figure 6.9

As you can see Rhode Island is in the 80-90% range and well out of the potential drought range at the present time. The following graph shows the Palmer Hydrological Drought Index for the Northeast Region over the past 100 years. As you can see, there have been historical periods of drought in this region.

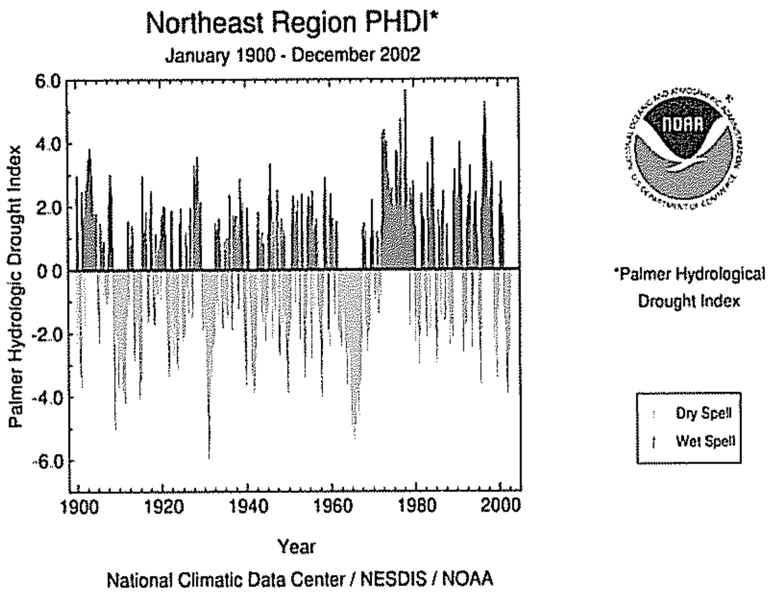


Figure 6.10

SUBPART C - SEISMIC HAZARDS

C.1 Earthquakes – Risk Score 20

Earthquake frequency, impact, and intensity ratings were derived by examining both historical seismicity and probabilistic seismic hazard maps. In general, the region around Warwick does not suffer from frequent earthquakes, however historical events in New England have been of moderate to high intensity and impact area.

A map (Figure 6.11) was created to show the historic earthquake (since 1700) epicenters in relation to the City of Warwick and surrounding areas. The map shows that several minor earthquakes and a moderate earthquake have occurred in and around the City of Warwick and the state of Rhode Island. The entire state of Rhode Island lies within the same earthquake hazard zone.

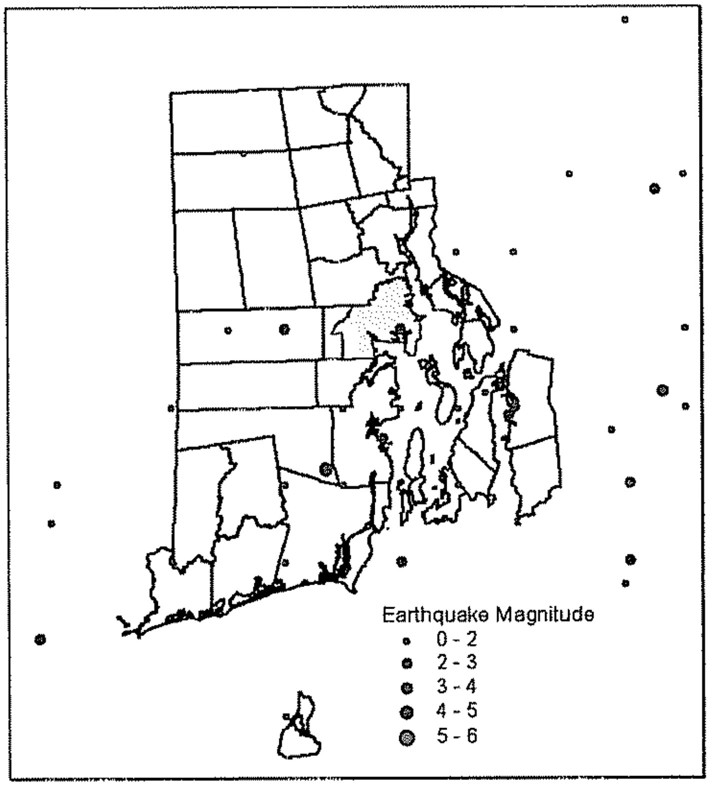


Figure 6.11 Historical earthquakes of southern New England. Source: NEHRP

The National Earthquake Hazard Reduction Program (NEHRP) maps were examined to determine the frequency and intensity of earthquake ground motions affecting the southeastern New England region. Table 6.11 summarizes peak ground acceleration for the Warwick region based on the 1997 NEHRP maps. In this table, peak ground acceleration measures the maximum acceleration on the bedrock in any direction due to an earthquake. Note that higher accelerations would be expected on soils and are required for consideration during building design.

Table 6.11 Peak ground acceleration for Warwick region. Source: USGS

Frequency (P% exceedance in t years)	Return Period (years)	Peak Ground Acceleration on Bedrock (g)
10% exceedance in 50 years	475	.035
5% exceedance in 50 years	975	.065
2% exceedance in 50 years	2475	.13

In the risk and vulnerability assessment, the areas in which the community is vulnerable and what damages are expected if an earthquake occurs need to be identified. Much of the risk from earthquakes is related to life safety; therefore, the occupancy of buildings is an important factor in determining risk.

Other factors to consider when evaluating Warwick's vulnerability to earthquakes are:

- The kind of structures in the community.
- Contents of the structures.
- Structure use and occupancy.

Past Damage

When earthquakes occur, much of the damage is a result of structures falling under the stress created by the earth's movement. Building failure can cause damage to the building, deaths, injuries, and loss of function. Local topography and soil type also affects earthquake severity. Steep slopes composed of loose material may produce large landslides during an earthquake. The type of construction also affects the risks of damages to a property. For these reasons, earthquake hazards are highly localized and difficult to assign regional earthquake boundaries that share the same relative degree of hazard.

Table 6.12 History of Significant Earthquakes Affecting New England – Present

Year	Date	Magnitude	Source
1755	NA	6.25	Cape Ann, MA
1904	NA	5.80	Eastport, ME
1940	NA	5.80	Ossipee, NH
1944	NA	5.90	Massena, NY
1951	June 10th	4.60	Kingstown, RI
1982 – Present	NA	4.5 – 6.0	NH, NY, and New Brunswick

TECHNOLOGICAL HAZARDS

Dam Failures – Risk Score 8

Disastrous floods caused by dam failures, may cause great loss of life and property damage, primarily due to their unexpected nature and release of a high velocity wall of debris-laden water rushing downstream destroying everything in its path. The 1997 FEMA Multi-hazards Identification and Risk Assessment Publication reports that dam failures can result from anyone or a combination of factors:

- Prolonged periods of rainfall and flooding;
- Inadequate spillway capacity;
- Internal erosion resulting in structural failure
- Improper maintenance
- Improper design;
- Negligent operation;
- Failure of upstream dams on the same waterway;
- Landslides into reservoirs which may cause surges resulting in overtopping;
- High winds which can cause significant wave action resulting in substantial erosion; and
- Earthquakes, which cause longitudinal cracks and weaken the entire structure.

Dam Hazard Potential Classification		
Category	Loss of Life	Property Damage
Low	None expected	Minimal (undeveloped to occasional structures or agriculture)
Significant	Few (no urban structures)	Appreciable (notable developments and or inhabitable no more than a small number of inhabitable structures, agriculture, industry
High	More than a five	Excessive (extensive community, industry, or agriculture)

Table 6.13

There is one major dam located in the City of Warwick. It is the Lower Pawtuxet Reservoir Dam owned by the Rhode Island Department of Environmental Management. It was last inspected in 1990 and its condition was rated as "good" and it is considered a "low" hazard dam. There are additional dams in the City of Warwick, however a failure at any or these sites would be much less threatening than a failure of the Lower Pawtuxet Reservoir Dam. The following is a list of all dams and weirs in Warwick.

TABLE 6.14 – RIGIS LISTING OF DAMS AND WEIRS IN WARWICK, RI.

NAME	LOCATION	PLAT	LOT	OUTLET	HEIGHT FT.
CRANBERRY BOG DAM	CRANBERRY POND	295	461	*CRANBERRY BROOK*	7
FEIRING FARM POND	PADDOCK ESTATE	230	6	*MASKERCHUGG RIVER*	7
FORGE BRIDGE AND DAM	OLD FORGE ROAD	211	2	*POTOWOMUT RIVER*	12
FRUIT OF THE LOOM	PONTIAC MILL	274	204	*PAWTUXET RIVER*	10
GORTON POND WEIR	GREENWICH AV. CULVERT	246	ROW	*LITTLE GORTON POND*	4
GREAT POND WEIR	WARWICK POND SOUTH	326	119	*BUCKEYE BROOK*	2
KEITH FARM POND	UPPER YMCA	240	7	*HARDIG BROOK*	12
LITTLE GORTON POND	KETTLE ST. DIKE	246	218	*APPONAUG RIVER*	7
LITTLE POND WEIR	SUTTON AV. DRAIN	350	ROW	*PARSONAGE BROOK*	2
MARY'S POND	AMTRAK DRAINAGE	366	63	*THATCH COVE*	3

NATICK MILL DAM	NATICK VILLAGE - RT 33	262	109	*PAWTUXET RIVER*	25
OKWANESSET CAMP	LOWER YMCA	241	1	*HARDIG BROOK*	15
PAWTUXET DAM	NARRAGANSETT PKWY.	291	33	*PAWTUXET COVE*	9
POTOWOMUT FISHING AREA	POTOWOMUT POND	212	9	*HUNT RIVER*	8
SPRING GREEN POND	WARWICK AV DRAINAGE	312	420	*OCCUPASSTUXET COVE*	11
SQUANTUM POND	SQUANTUM RD DRAINAGE	307	327	*COLD BROOK*	19
THREE PONDS NORTH	METRO CTR-PLAN WAY DRAIN	278	134	*PAWTUXET RIVER*	4
TUSCATUCKET POND	WEST SHORE ROAD	348	742	*TUSCATUCKET BROOK*	4
VALLEY COUNTRY CLUB	COUNTRY CLUB ESTATE	252	2	*HARDIG BROOK*	9
WOLF'S POND	LAKEDELL-BEACHWOOD DRAINS	203	343	*GREENWICH BAY*	2

Hazardous Materials Events – Risk Score 8

There are many sources of Hazardous Materials in and around Warwick. Many of these sources have been documented in government records. Figure 6.12 below depicts the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) sites. These sites have been identified as hazardous sites that have been investigated or are in the process of investigation for contamination risk.

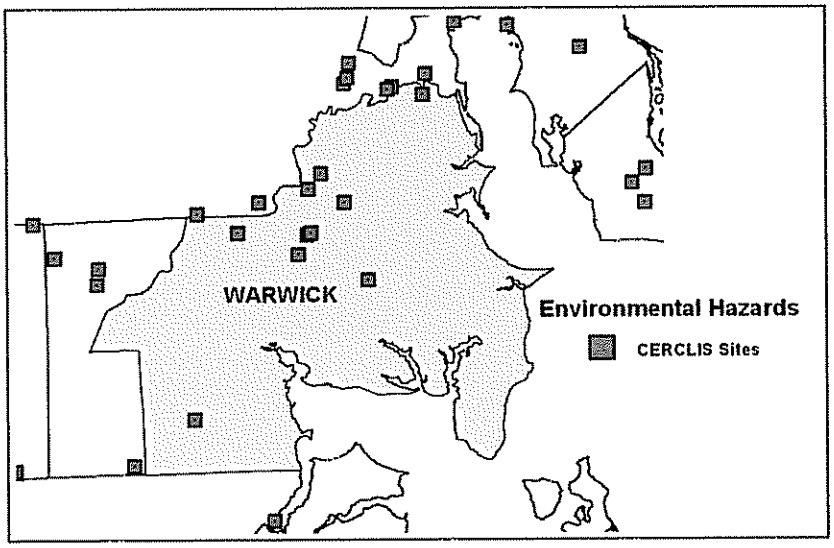


Figure 6.12
Warwick CERCLIS sites.
Source: VISTAInfo

Past Hazard Events That Have Impacted Warwick

Within the past 50 years, a number of moderate and severe natural disasters have impacted Warwick and the surrounding region. The following is a list of all storm events that have occurred in the Kent County area since 1950.

Table 6.14 – Historical Storm Data

Location or County	Date	Time	Type	Mag	Dth	Inj	PrD
1 KENT	7/14/1956	1252	Hail	1.75 in.	0	0	0
2 KENT	7/14/1956	1300	Tstm Wind	0 kts.	0	0	0
3 KENT	9/14/1956	1700	Tstm Wind	64 kts.	0	0	0
4 KENT	7/2/1964	1530	Hail	1.75 in.	0	0	0
5 KENT	3/24/1969	2300	Tstm Wind	0 kts.	0	0	0
6 KENT	8/9/1969	100	Tstm Wind	0 kts.	0	0	0
7 KENT	9/6/1973	1113	Tstm Wind	50 kts.	0	0	0
8 KENT	5/30/1979	1245	Hail	1.75 in.	0	0	0
9 KENT	8/10/1979	1630	Tstm Wind	0 kts.	0	0	0
10 KENT	6/27/1983	1530	Tstm Wind	0 kts.	0	0	0
11 KENT	6/30/1987	1640	Tstm Wind	70 kts.	0	0	0
12 KENT	9/23/1989	1500	Tstm Wind	70 kts.	0	0	0
13 KENT	10/18/1990	2210	Tornado	F1	0	0	250K
14 KENT	10/18/1990	2230	Tstm Wind	50 kts.	0	0	0
15 KENT	6/12/1991	1453	Tstm Wind	0 kts.	0	0	0
16 KENT	7/14/1992	1700	Tstm Wind	0 kts.	0	0	0
17 KENT	7/14/1992	1815	Tstm Wind	0 kts.	0	0	0
18 West Warwick	4/1/1993	1500	Flash Flood	N/A	0	0	0
19 RIZ002 - 004>007	1/4/1994	800	High Winds	0 kts.	0	0	0
20 RIZ001>005	1/7/1994	1200	Heavy Snow	N/A	0	0	5K
21 RIZ001 - 003 - 004 - 006 - 007	1/7/1994	2000	Ice Storm	N/A	0	0	500K
22 West Warwick	6/14/1994	2100	Lightning	N/A	0	0	50K
23 W. Warwick	8/5/1994	1720	Lightning	N/A	0	0	5K
24 Coventry	8/13/1994	1730	Tornado	F0	0	0	0
25 RIZ002>007	1/7/1995	430	High Winds	0 kts.	0	0	0
26 KENT	4/4/1995	1435	Thunderstorm Winds	N/A	0	0	0
27 West Greenwich	6/20/1995	1610	Thunderstorm Winds	N/A	0	0	0
28 West Warwick	6/20/1995	1620	Hail	0.75 in.	0	0	0
29 RIZ002>005	7/15/1995	1400	Record Heat	N/A	0	0	0
30 Warwick	8/4/1995	1727	Hail	0.75 in.	0	0	0
31 Warwick	8/4/1995	1745	Thunderstorm Winds	N/A	0	0	0
32 RIZ001>004	12/14/1995	900	Heavy Snow	N/A	0	0	0
33 Rizall	12/19/1995	1900	Heavy Snow	N/A	0	0	0
34 RIZ001>004	1/2/1996	9:00 PM	Heavy Snow	N/A	0	0	0
35 RIZ001>007	1/7/1996	5:00 PM	Heavy Snow	N/A	0	0	0
36 RIZ001>005	1/12/1996	5:00 PM	Urban Flood	N/A	0	0	0
37 RIZ001>007	1/19/1996	2:00 PM	High Wind	63 kts.	0	0	0
38 RIZ001>007	1/27/1996	1:00 PM	High Wind	55 kts.	0	0	0
39 RIZ001>007	2/2/1996	10:00 PM	Heavy Snow	N/A	0	0	0
40 RIZ001>004 - 006	2/16/1996	12:00 PM	Heavy Snow	N/A	0	0	0
41 RIZ001>007	2/25/1996	7:30 AM	High Wind	70 kts.	0	0	0
42 RIZ001>007	3/2/1996	9:00 AM	Heavy Snow	N/A	0	0	0
43 RIZ001>007	3/3/1996	5:00 AM	Snow Squalls	N/A	0	0	0
44 RIZ001>005	3/7/1996	10:00 AM	Heavy Snow	N/A	0	0	0
45 RIZ001>002 - 004	4/7/1996	6:00 PM	Heavy Snow	N/A	0	0	0

46 RIZ001>006	4/9/1996	6:00 PM	Heavy Snow	N/A	0	0	0
47 Warwick	5/21/1996	3:20 PM	Tstm Wind	52 kts.	0	0	0
48 Countywide	7/13/1996	2:00 AM	Heavy Rain	N/A	0	0	0
49 RIZ001>007	7/13/1996	2:00 PM	High Wind	64 kts.	0	0	0
50 Coventry	7/13/1996	2:00 PM	Flash Flood	N/A	0	0	0
51 Countywide	9/18/1996	12:00 AM	Heavy Rain	N/A	0	0	0
52 Eastern Portions	10/8/1996	7:00 PM	Heavy Rain	N/A	0	0	0
53 RIZ004>007	10/8/1996	10:00 PM	Strong Winds	N/A	0	0	0
54 RIZ001>007	10/20/1996	2:00 AM	Heavy Rain	N/A	0	0	0
55 RIZ001>003	12/6/1996	6:00 AM	Heavy Snow	N/A	0	0	0
56 RIZ001 - 003	12/7/1996	4:00 PM	Heavy Snow	N/A	0	0	0
57 Countywide	12/7/1996	7:00 PM	Heavy Rain	N/A	0	0	0
58 RIZ002>007	12/24/1996	12:00 PM	Strong Wind	N/A	0	0	0
59 RIZ001>005	1/11/1997	4:00 AM	Heavy Snow	N/A	0	0	0
60 RIZ001>005	1/31/1997	4:00 PM	Freezing Drizzle	N/A	0	0	0
61 RIZ001>007	3/6/1997	8:00 AM	Strong Winds	N/A	0	0	0
62 RIZ002>007	3/26/1997	12:00 AM	Strong Winds	N/A	0	0	0
63 RIZ001>007	3/31/1997	2:00 PM	Heavy Snow	N/A	0	0	0
64 RIZ001>007	3/31/1997	3:00 PM	Strong Winds	N/A	0	0	0
65 RIZ001>007	4/1/1997	12:00 AM	Heavy Snow	N/A	0	0	700K
66 RIZ001>007	4/1/1997	12:00 AM	Strong Wind	N/A	0	0	0
67 Coventry	6/22/1997	3:55 PM	Hail	1.00 in.	0	0	0
68 Warwick	6/22/1997	4:35 PM	Lightning	N/A	0	0	250K
69 Warwick	6/22/1997	4:35 PM	Tstm Wind	65 kts.	0	0	0
70 RIZ004>007	7/25/1997	12:00 PM	Gusty Winds	N/A	0	0	0
71 Warwick	8/20/1997	1:35 PM	Funnel Cloud	N/A	0	0	0
72 RIZ002>007	8/21/1997	7:00 AM	Strong Winds	N/A	0	0	0
73 RIZ002>007	11/1/1997	5:00 PM	Strong Winds	N/A	0	0	0
74 RIZ001>007	11/1/1997	12:00 PM	Heavy Rain	N/A	0	0	0
75 Warwick	11/9/1997	7:30 AM	Lightning	N/A	0	0	2K
76 RIZ001>007	11/27/1997	5:00 AM	Strong Winds	N/A	0	0	0
77 RIZ001>007	12/2/1997	2:00 AM	Strong Winds	N/A	0	0	0
78 RIZ001>007	12/14/1997	11:00 AM	Strong Winds	N/A	0	0	0
79 RIZ004	1/3/1998	1:54 PM	Record Warmth	N/A	0	0	0
80 RIZ002>007	2/4/1998	11:00 PM	Strong Winds	N/A	0	0	0
81 RIZ002>007	2/18/1998	12:00 AM	Heavy Rain	N/A	0	0	0
82 RIZ001>005 - 007	2/23/1998	11:00 PM	Heavy Rain	N/A	0	0	0
83 RIZ001>007	2/24/1998	12:00 AM	Strong Winds	N/A	0	0	0
84 RIZ001>007	3/8/1998	5:00 PM	Heavy Rain	N/A	0	0	0
85 West Warwick	3/9/1998	7:00 PM	Lightning	N/A	0	0	50K
86 RIZ001>007	3/9/1998	8:00 AM	Strong Winds	N/A	0	0	0
87 RIZ001>007	3/12/1998	2:00 PM	Strong Winds	N/A	0	0	0
88 RIZ002>007	3/21/1998	6:00 AM	Strong Winds	N/A	0	0	0
89 RIZ002>006	3/26/1998	10:00 AM	Strong Winds	N/A	0	0	0
90 RIZ004	3/27/1998	2:34 PM	Record Warmth	N/A	0	0	0
91 RIZ004	3/28/1998	11:40 AM	Record Warmth	N/A	0	0	0
92 RIZ004	3/31/1998	1:50 PM	Record Warmth	N/A	0	0	0
93 RIZ002>007	4/9/1998	10:00 PM	Strong Winds	N/A	0	0	0
94 RIZ001>005	5/9/1998	9:00 PM	Heavy Rain	N/A	0	0	0
95 Countywide	6/13/1998	12:00 AM	Heavy Rain	N/A	0	0	0
96 Warwick	6/14/1998	7:39 AM	Flood	N/A	0	0	0
97 Coventry	6/19/1998	4:05 PM	Flood	N/A	0	0	0
98 West Greenwich	6/19/1998	4:45 PM	Hail	0.75 in.	0	0	0
99 RIZ004>007	6/27/1998	2:00 PM	Strong Winds	N/A	0	0	0
100 Coventry	9/22/1998	3:00 AM	Heavy Rain	N/A	0	0	0

101 RIZ002 - 004	9/27/1998	12:00 PM	Record Heat	N/A	0	0	0
102 Warwick	10/8/1998	12:00 PM	Heavy Rain	N/A	0	0	0
103 RIZ001>007	11/11/1998	5:00 AM	Strong Winds	N/A	0	0	0
104 RIZ004>007	11/26/1998	12:00 PM	Strong Winds	N/A	0	0	0
105 RIZ004	12/4/1998	2:00 PM	Record Warmth	N/A	0	0	0
106 RIZ004	12/7/1998	12:00 PM	Record Warmth	N/A	0	0	0
107 RIZ001>007	1/3/1999	1:00 PM	Strong Winds	N/A	0	0	0
108 Coventry	1/3/1999	11:00 AM	Heavy Rain	N/A	0	0	0
109 RIZ001>007	1/15/1999	9:00 AM	Strong Winds	N/A	0	0	0
110 Warwick	1/15/1999	9:00 AM	Heavy Rain	N/A	0	0	0
111 RIZ001>007	1/18/1999	7:00 PM	Strong Winds	N/A	0	0	0
112 Coventry	2/2/1999	3:00 PM	Heavy Rain	N/A	0	0	0
113 RIZ002>007	2/2/1999	6:00 PM	Strong Winds	N/A	0	0	0
114 RIZ001>007	2/25/1999	12:00 AM	Heavy Snow	N/A	0	0	0
115 RIZ001>007	3/4/1999	1:00 AM	Strong Winds	N/A	0	0	0
116 RIZ001>007	3/15/1999	12:00 AM	Heavy Snow	N/A	0	0	0
117 RIZ002 - 004	3/18/1999	1:11 PM	Record Warmth	N/A	0	0	0
118 RIZ001>007	3/22/1999	12:00 AM	Strong Winds	N/A	0	0	0
119 Warwick	5/23/1999	5:00 PM	Heavy Rain	N/A	0	0	0
120 RIZ004	6/7/1999	1:00 PM	Record Heat	N/A	0	0	0
121 RIZ004	7/5/1999	12:00 AM	Record Heat	N/A	0	0	0
122 RIZ004	7/6/1999	6:00 AM	Record Heat	N/A	0	0	0
123 RIZ004	7/14/1999	12:00 AM	Record Cold	N/A	0	0	0
124 RIZ004	7/17/1999	1:50 PM	Record Warmth	N/A	0	0	0
125 RIZ004	7/18/1999	2:23 PM	Record Warmth	N/A	0	0	0
126 Coventry	7/23/1999	7:00 PM	Tstm Wind	50 kts.	0	0	0
127 West Greenwich	7/25/1999	1:15 PM	Hail	1.00 in.	0	0	0
128 Warwick	7/25/1999	1:50 PM	Hail	1.00 in.	0	0	0
129 RIZ004	9/7/1999	12:00 AM	Record Warmth	N/A	0	0	0
130 Coventry	9/10/1999	7:00 AM	Heavy Rain	N/A	0	0	0
131 Countywide	9/16/1999	3:00 PM	Heavy Rain	N/A	0	0	0
132 RIZ001 - 003>005	9/16/1999	5:00 PM	Strong Wind	N/A		0	0
133 Warwick	9/16/1999	10:32 PM	Flood	N/A	0	0	0
134 RIZ003>007	9/30/1999	9:00 AM	Strong Wind	N/A	0	0	0
135 RIZ001>007	10/14/1999	10:00 AM	Strong Wind	N/A	0	0	0
136 RIZ001>003	11/2/1999	11:30 PM	High Wind	52 kts.	0	0	0
137 RIZ004>007	11/2/1999	11:30 PM	Strong Wind	N/A	0	0	0
138 RIZ004	1/4/2000	2:00 PM	Strong Wind	N/A	0	0	0
139 RIZ001>004	1/13/2000	6:00 AM	Snow	N/A	0	0	0
140 RIZ001 - 003>006	2/14/2000	11:30 AM	Strong Wind	N/A	0	0	0
141 RIZ001>006	2/18/2000	1:00 PM	Heavy Snow	N/A	0	0	0
142 RIZ001>002 - 004 - 006>007	4/8/2000	11:00 AM	Strong Wind	N/A	0	0	0
143 West Warwick	4/22/2000	4:00 AM	Flood	N/A	0	0	0
144 RIZ004	5/9/2000	12:00 PM	Record Heat	N/A	0	0	0
145 RIZ004 - 006>007	5/18/2000	12:00 PM	Strong Wind	N/A	0	0	0
146 West Greenwich	5/24/2000	7:45 PM	Hail	0.75 in.	0	0	0
147 Warwick	6/11/2000	2:20 PM	Hail	0.75 in.	0	0	0
148 West Warwick	7/18/2000	3:27 PM	Hail	1.75 in.	0	0	0
149 West Warwick	7/18/2000	3:35 PM	Tstm Wind	50 kts.	0	0	0
150 Coventry	8/16/2000	2:40 PM	Hail	0.75 in.	0	0	0
151 RIZ004	10/9/2000	12:00 AM	Record Cold	N/A	0	0	0
152 RIZ004	10/29/2000	12:00 AM	Record Cold	N/A	0	0	0
153 RIZ004	11/10/2000	12:00 AM	Record Rainfall	N/A	0	0	0
154 RIZ001 - 003	11/26/2000	7:00 AM	Freezing Rain	N/A	0	0	0

155 RIZ002>005 - 007	12/12/2000	8:00 AM	Strong Wind	N/A	0	0	0
156 RIZ001>007	12/17/2000	11:00 AM	High Wind	50 kts.	0	2	0
157 RIZ001 - 003	12/30/2000	1:00 PM	Heavy Snow	N/A	0	0	0
158 RIZ001>007	1/20/2001	9:00 PM	Heavy Snow	N/A	0	0	0
159 RIZ001 - 003	1/30/2001	6:00 AM	Freezing Rain	N/A	0	0	0
160 RIZ001>007	2/10/2001	1:00 AM	Strong Wind	N/A	0	0	0
161 RIZ001>002 - 004>005 - 007	2/17/2001	10:00 AM	Strong Wind	N/A	0	0	0
162 RIZ001>007	2/25/2001	6:00 AM	Freezing Rain	N/A	0	0	0
163 RIZ001>004	3/5/2001	1:00 PM	Heavy Snow	N/A	0	0	10.0M
164 Warwick	3/30/2001	10:00 PM	Heavy Rain	N/A	0	0	0
165 RIZ004	5/3/2001	12:00 AM	Record Heat	N/A	0	0	0
166 RIZ004	5/4/2001	12:00 AM	Record Heat	N/A	0	0	0
167 RIZ004	5/12/2001	12:00 AM	Record Heat	N/A	0	0	0
168 Coventry	6/19/2002	1:45 PM	Hail	0.75 in.	0	0	0
169 Coventry	7/23/2002	3:35 PM	Tstm Wind	50 kts.	0	0	2K
170 RIZ001>003	9/11/2002	2:00 PM	High Wind	0 kts.	0	0	55K
171 RIZ001>004	11/27/2002	3:00 AM	Heavy Snow	N/A	0	0	0
172 RIZ002>007	12/5/2002	12:00 PM	Heavy Snow	N/A	0	0	0
173 RIZ004	12/25/2002	10:08 PM	High Wind	35 kts.	0	0	0
174 RIZ001>007	2/7/2003	5:00 AM	Winter Storm	N/A	0	0	0
175 RIZ001>007	2/17/2003	11:00 AM	Winter Storm	N/A	0	0	0
176 RIZ001>007	3/6/2003	11:00 AM	Winter Storm	N/A	0	0	290K
177 Countywide	3/29/2003	6:00 PM	Heavy Rain	N/A	0	0	0
178 East Greenwich	8/13/2003	7:20 PM	Flash Flood	N/A	0	0	10K
179 East Greenwich	8/13/2003	7:20 PM	Tstm Wind	50 kts.	0	0	15K
180 RIZ001>007	11/13/2003	7:00 PM	High Wind	50 kts.	0	0	350K
181 RIZ001>007	12/5/2003	10:00 PM	Winter Storm	N/A	0	0	0
182 RIZ003 - 006	1/27/2004	8:00 PM	Winter Storm	N/A	0	0	0
TOTALS:					0	2	12.534 M

Chapter 7. Asset Identification

The analysis, assessment, and identification of assets within a community is integral to determining what may be at risk for loss from a natural disaster. This chapter examines the assets in five separate categories: Critical Facilities, Vulnerable Populations, Economic Assets, Special Considerations, and Historic/Other Considerations.

Each category lists the address and telephone number(s) where applicable. Also supplied is the hazard to which each particular asset is most susceptible. The hazards listed are primarily natural disasters, but can also include secondary disasters such as sewer/water line rupture, or human-made disasters/emergencies such as automobile accidents.

In Warwick, each asset can be damaged by all of the hazards listed in the Hazard Identification Chapter. The Critical Facilities have been plotted on the large map at the end of this plan. When the asset was not specifically vulnerable to one or more particular hazards, the term "All" was used to signify the asset's vulnerability to all possible hazards.

Critical Facilities

Critical Facilities are categorized as those city or state buildings or services that are the first responders in a disaster. Fire departments, police departments, highway departments, and City/State offices play a pivotal roll in coordinating and implementing emergency services in the event of a disaster. Other critical facilities include hospitals, airports, and schools (schools may be used as shelters). The offices of the Department of Public Works and the Sewer Department are also included as utilities and utility maintenance plays a key role in disaster response. Note – The water department is collocated with the Department of Public Works

Table 7.1 - Key Facilities

FACILITY	PLAT	LOT	FEMA MAP #	EDITION	HAZARD
CITY HALL	245	61	5E	6/16/1992	WIND, SNOW
GREEN AIRPORT	321	4	2D	4/16/1991	WIND, SNOW
KENT HOSPITAL	256	80	2D	4/16/1991	WIND, SNOW
PUBLIC WORKS	349	1	6E	6/16/1992	WIND, SNOW
SEWER DEPT.	280	3	2D	4/16/1991	WIND, SNOW
VETERANS H.S. PRIMARY SHELTER	349	585	6E	6/16/1992	WIND, SNOW
WINMAN J.H. PRIMARY SHELTER	255	2	2D	4/16/1991	WIND, SNOW

Table 7.2 - Fire Stations

NAME	ADDRESS	PHONE	Hazard
FIRE ALARM	915 SANDY LANE	N/A	Wind
STATION 1	140 VETS. MEM. DR.	468-4021	Wind
STATION 2	771 POST RD.	468-4022	Wind
STATION 3	2373 W. SHORE RD.	468-4023	Wind
STATION 4	1501 W. SHORE RD.	468-4024	Wind, Flooding
STATION 5	450 COWESETT RD.	468-4025	Wind
STATION 6	456 W. SHORE RD.	468-4026	Wind
STATION 8	1651 POST RD.	468-4028	Wind
STATION 9	314 COMMONWEALTH AV.	468-4029	Wind

Table 7.3 - Police Stations

ID	FACILITY	ADDRESS	PHONE	Hazard
1	POLICE HEADQUARTERS	99 VETERANS MEM. DR.	468-4200	Any
2	SUBSTANCE ABUSE CTR.	190 RANGE RD.	468-4325	Any
3	CONIMICUT POLICE CTR.	759 W. SHORE RD.	468-4373	Any
4	OAKLAND BEACH POLICE CTR.	732 OAKLAND BEACH AV.	468-4375	Any
5	R.I. MALL POLICE CTR.	650 BALD HILL RD.	468-4371	Any

Table 7.4 - Schools

ID	SCHOOL	PHONE	ADDRESS	HAZARD
1	CEDAR HILL ELEM.	734-3535	35 RED CHIMNEY DR.	All
2	DRUM ROCK ELEM.	734-3490	575 CENTERVILLE RD.	All
3	FRANCIS ELEM.	734-3340	325 MIANTONOMO DR.	All
4	GREENE ELEM.	734-3440	51 DRAPER AVE.	All
5	GREENWOOD ELEM.	734-3290	93 SHARON ST.	All
6	HOLDEN ELEM.	734-3455	61 HOXSIE AVE.	All
7	HOLLIMAN ELEM.	734-3170	70 DEBORAH RD.	All
8	HOXSIE ELEM.	734-3555	55 GLENWOOD DR.	All
9	LIPPITT ELEM.	734-3240	30 ALMY ST.	All
10	NORWOOD ELEM.	734-3525	266 NORWOOD AVE.	All
11	OAKLAND BEACH ELEM.	734-3420	383 OAKLAND BEACH AVE.	All

12	PARK ELEM.	734-3690	40 ASYLUM RD.	All
13	POTOWOMUT ELEM.	734-3545	225 POTOWOMUT RD.	All
14	RHODES ELEM.	734-3515	110 SHERWOOD AVE.	All
15	ROBERTSON ELEM.	734-3470	70 NAUSAUKET RD.	All
16	SCOTT ELEM.	734-3585	833 CENTERVILLE RD.	All
17	SHERMAN ELEM.	734-3565	120 KILLEY AVE.	All
18	WARWICK NECK ELEM.	734-3480	155 ROCKY POINT AVE.	All
19	WICKES ELEM.	734-3575	50 CHILD LANE	All
20	WYMAN ELEM.	734-3180	1 COLUMBIA AVE.	All
21	ALDRICH J.H.S.	734-3500	789 POST RD.	All
22	GORTON J.H.S.	734-3350	69 DRAPER AVE.	All
23	WINMAN J.H.S.	734-3375	575 CENTERVILLE RD.	All
24	PILGRIM S.H.S.	734-3250	111 PILGRIM PKWY.	All
25	TOLL GATE S.H.S.	734-3300	575 CENTERVILLE RD.	All
26	VETERANS S.H.S.	734-3200	2401 WEST SHORE RD.	All

Table 7.5 - Utilities

DEPARTMENT	ADDRESS	OCCUPANCY	HAZARD
SEWER	120 DAVIDSON RD	PUMP ST 32 DAVIDSON	FLOODING
SEWER	6 EMMONS AVE	PUMP ST 6 EMMONS AVE	FLOODING
SEWER	131 HILTON RD	PUMP STATION 8 HILTON RD.	ALL
SEWER	1 JUNIPER AVE	PUMP ST 30 JUNIPER AVE	ALL
SEWER	131 NORTHAMPTON ST	PUMP ST NORTHAMPTON	ALL
SEWER	34 ALTEIRI WAY	PUMP STATION 19ALTERI WAY	ALL
SEWER	34 ALTEIRI WAY	GENERATOR BUILDING	ALL
SEWER	380 ATLANTIC AVE	PUMP ST 27 LAKEWOOD	ALL
SEWER	BAYONE AVE 1 (P361/L302)	PUMP STATION 36 WARWICK VETS	ALL
SEWER	38 BELLOWS ST	PUMP STATION BELLOWS ST	FLOODING
SEWER	902 CEDAR SWAMP RD.	PUMP ST 7 CEDAR SWAMP RD	FLOODING
SEWER	36 CENTERVILLE ROAD	PUMP STATION 13 APPONAUG	FLOODING
SEWER	50 CREEKWOOD DR	PUMP ST 31 CREEKWOOD	ALL
SEWER	187 EDGEHILL RD	PUMP STATION 4 STANMORE RD	ALL
SEWER	271 GORTON LAKE BLVD	PUMP ST 27 GORTON LAKE BLVD	ALL
SEWER	IRVING RD, #29	PUMP STATION 29 IRVING RD	FLOODING
SEWER	440 KILVERT ST	PUMP STATION 11 KILVERT ST.	FLOODING
SEWER	176 KNIGHT ST	PUMP STATION 12 KNIGHT ST.	FLOODING
SEWER	223 LAKESHORE DR	PUMP ST 16 LAKESHORE SOUTH	FLOODING
SEWER	409 LAKESHORE DR	PUMP ST 14 LAKESHORE NORTH	FLOODING
SEWER	6 LOVEDAY ST	PUMP STATION LOVEDAY	ALL
SEWER	641 MEADOWVIEW AVE	PUMP ST 28 WARWICK COVE	ALL
SEWER	17 MIDGET AVE	PUMP ST 33 MIDGET	ALL
SEWER	500 NARRAGANSETT PKWY	PUMP ST 21 SALTER GROVE	FLOODING
SEWER	51 OAK TREE RD	PUMP ST 34 LOCKWOOD	ALL
SEWER	203 POSNEGANSETT	PUMP ST 17 POSNEGANSETT	ALL
SEWER	4322 POST RD	PUMP ST 37 POST RD SOUTH	ALL
SEWER	75 RIVERDALE COURT	PUMP ST 22 EAST NATICK I	FLOODING
SEWER	167 SEFTON AVE	PUMP ST 25 SEFTON AVE	ALL
SEWER	195 SPRING GREEN ROAD	PUMP STATION 20 GASPEE I	ALL
SEWER	227 SUBURBAN PARKWAY	PUMP ST 10 OAKLAND BEACH	FLOODING
SEWER	68 THRUSH RD	PUMP STATION 35 THRUSH RD	ALL
SEWER	3 VERNON ST	PUMP ST 23 HOXIE EAST	ALL

SEWER	1851 WARWICK AVENUE	PUMP STATION 5 WARWICK AVE	ALL
SEWER	248 WARWICK NECK AVENUE	PUMP ST 18 WARWICK NECK	FLOODING
SEWER	45 WATERVIEW AVE	PUMP ST 25 WATERVIEW AVE	ALL
SEWER	2 WEST PONTIAC ST	PUMP STATION 29 EAST NATICK II	FLOODING
SEWER	115 WINCHELL RD	PUMP STATION 15 BROOKWOOD	FLOODING
SEWER	KERRI LYNN RD #171	BARRETTE PLAYGROUND	FLOODING
SEWER	180 COVE AVE	PUMP ST 39 COVE	FLOODING
SEWER	150 INGERSOLL AVE	PUMP ST 40 INGERSOLL	ALL
SEWER	SERVICE RD 300	ADMIN BLDG	FLOODING
SEWER	SERVICE RD 300	DISINFECTION BLDG	FLOODING
SEWER	SERVICE RD 300	CONTROL/LABORATORY	ALL
SEWER	SERVICE RD 300	SEPTAGE/INLET FACILITY	ALL
SEWER	SERVICE RD 300	DIGESTION FACILITY	ALL
SEWER	SERVICE RD 300	UTILITY BUILDING	ALL
SEWER	SERVICE RD 300	BLOWER/WWTP	FLOODING
SEWER	SERVICE RD 300	SOUTH PUMP STATION (CENTER)	ALL
SEWER	SERVICE RD 300	NORTH PUMP STATION	ALL
SEWER	SERVICE RD 300	PRIMARY TREATMENT HOUSE	ALL
WATER	165 PETTACONSETT AVE	METER STATION	ALL
WATER	NATICK AVE/WAKEFIELD ST	METER STATION	ALL
WATER	STATE ST/OAK SIDE	PUMP HOUSE	ALL
WATER	WARWICK NECK AVE	"500,000 GAL WATER STG TANK"	ALL
WATER	BALD HILL RD/UNIVERSAL RD	5.5 MG WATER STORAGE TANK	WIND
WATER	BALD HILL RD/UNIVERSAL RD	6.5 MG WATER STORAGE TANK	WIND

Vulnerable Populations

Areas or neighborhoods that are densely populated, buildings that house people who may not be self-sufficient in a disaster, or areas that include homes which are not very resistant to natural disasters are considered vulnerable. Vulnerable populations include manufactured home parks and elderly housing developments or care facilities.

Table 7.6 - Vulnerable Populations

NAME	ADDRESS	TYPE	HAZARD
PILGRIM SENIOR CTR.	27 PILGRIM PKWY.	SENIOR CENTER	ALL
BUTTONWOODS SENIOR CTR.	3027 WEST SHORE RD.	SENIOR CENTER	ALL
CARROULO COMMUNITY CTR.	830 OAKLAND BEACH AVE.	SENIOR CENTER	ALL
HOUSE OF HOPE SHELTER	65 SHIPPEN AVE.	HOMELESS SHELTER	ALL
WARWICK TERRACE	2215 ELMWOOD AVENUE	SENIOR HOUSING	ALL
WEST SHORE TERRACE	3070 WEST SHORE ROAD	SENIOR HOUSING	ALL
WARWICK TERRACE ANNEX	124 TENNESSEE AVENUE 6	SENIOR HOUSING	ALL
MEADOWBROOK TERRACE	2220 WARWICK AVENUE	SENIOR HOUSING	ALL
FATHER OLSEN TERRACE	2432 POST ROAD	SENIOR HOUSING	ALL
CHARLES FORD TERRACE	25 EASTON AVE	SENIOR HOUSING	ALL
CRANBERRY POND	955 POST ROAD	SECTION 8 SENIOR HOUSING	ALL
GREENWOOD TERRACE	2426 POST ROAD	SECTION 8 SENIOR HOUSING	ALL
GREENWICH VILLAGE	300 LAMBERT LIND HIGHWAY	SECTION 8 SENIOR HOUSING	ALL
HARDIG BROOK VILLAGE	331 CENTERVILLE ROAD	SECTION 8 SENIOR HOUSING	ALL

MATTHEW XXV	359 GREENWICH AVENUE	SECTION 8 SENIOR HOUSING	ALL
SHALOM APARTMENTS	1 SHALOM DRIVE	SECTION 8 SENIOR HOUSING	ALL
SPARROWS POINT I	311 HARDIG ROAD	SECTION 8 SENIOR HOUSING	ALL
SPARROWS POINT II	777 COWESETT ROAD	SECTION 8 SENIOR HOUSING	ALL
SPARROWS POINT III	355 HARDIG ROAD	SECTION 8 SENIOR HOUSING	ALL
WARWICK REST HOME	348 WARWICK NECK AVENUE	NURSING HOMES	ALL
WEST BAY MANOR	2783 WEST SHORE ROAD	NURSING HOMES	ALL
ETHAN PLACE	85 ETHAN PLACE	NURSING HOMES	ALL
GASPEE MANSION	69 FAIR STREET	NURSING HOMES	ALL
GREENWOOD OAKS RETIREMENT CTR.	14 LAKE STREET	NURSING HOMES	ALL
ROOSEVELT MANOR	57 FAIR STREET	NURSING HOMES	ALL
AVALON NURSING HOME	57 STOKES STREET	NURSING HOMES	ALL
BRENTWOOD NURSING HOME	3986 POST ROAD	NURSING HOMES	ALL
BURDICK CONVALESCENT HOME	57 FAIR STREET	NURSING HOMES	ALL
BUTTONWOODS CREST HOME	139 HEMLOCK AVENUE	NURSING HOMES	ALL
GREENWOOD HOUSE NURSING HOME	1139 MAIN AVENUE	NURSING HOMES	ALL
GREENWOOD OAKS REST HOME	14 LAKE STREET	NURSING HOMES	ALL
KENT NURSING HOME	660 COMMONWEALTH AVENUE	NURSING HOMES	ALL
PAWTUXET VILLAGE NURSING HOME	270 POST ROAD	NURSING HOMES	ALL
SUNNY VIEW NURSING HOME	83 CORONA STREET	NURSING HOMES	ALL
WARWICK HEALTH CENTER •	109 WEST SHORE ROAD	NURSING HOMES	ALL
WARWICK REST HOME	348 WARWICK NECK AVENUE	NURSING HOMES	ALL
SENIOR CITY	911 TOLEGATE RD.	MOBILE HOME PARK	ALL
TOLLGATE VILLAGE	979 TOLLGATE RD.	MOBILE HOME PARK	ALL

Economic Assets

Although the City of Warwick contains hundreds of businesses, typically several businesses stand out prominently in a City. These businesses employ the most people in the city (both from Warwick and from outside) and are places where large numbers of people are located and may need to evacuate from in the event of a disaster. In other cases, some large businesses can provide critical services or products to residents in need or may be able to sustain their employees for duration of time.

Table 7.7 - Economic Assets

Economic Assets	Address	Phone	Hazard
Comfort Inn Airport	1940 Post Road	732-0470	Wind
Courtyard by Marriott	55 Jefferson Park Road	467-6900	Wind
Crowne Plaza at the Crossings	801 Greenwich Avenue	732-6000	Wind
Extended Stay America	245 West Natick Road	732-2547	Wind
Fairfiled Inn by Marriott	36 Jefferson Blvd.	941-6600	Wind
Hampton Inn & Suites	2100 Post Road	739-8888	Wind
Holiday Inn Express Hotel & Suites	901 Jefferson Blvd.	736-5000	Wind
Homewood Suites by Hilton	33 International Way	738-0008	Wind
Homestead Studio Suites	268 Metro Center Blvd.	732-6667	Wind
Master Hosts Inn	2138 Post Road	737-7400	Wind

Motel 6	20 Jefferson Blvd.	467-9800	Wind
Open Gate Motel	840 Quaker Lane	884-4490	Wind
Radisson Airport Hotel	2081 Post Road	739-3000	Wind
Residence Inn by Marriott	500 Kilvert Street	737-7100	Wind
Sheraton Airport Hotel	1850 Post Road	738-4000	Wind
Warwick Mall	400 Bald Hill Road	739-7500	Wind
RI Mall	650 Bald Hill Road	828-2700	Wind
Mickey Stevens Sports Complex	975 Sandy Lane	738-2000	Wind, Flood
TF Green Airport	1000 Post Road	734-4000	Wind

Special Considerations

Churches are special considerations for their unique contributions to society. Churches are often natural gathering places for people in disasters and can temporarily provide shelter and accommodation. In addition, businesses that potentially store or use hazardous materials are listed as special considerations due to the potential for leaking or combustion in the event of a disaster.

Table 7.8 – Churches

Church	Address	Phone	Hazard
Warwick Christian Fellowship	430 Buttonwoods Avenue	732-1961	Wind, Snow
All Saints Episcopal Church	111 Greenwich Avenue	739-1238	Wind, Snow
Amazing Grace Church	334 Knight Street	732-5335	Wind, Snow
Apponaug Pentecostal Church	75 Prospect Street	739-2499	Wind, Snow
Asbury United Methodist Church	143 Ann Mary Brown Drive	467-5122	Wind, Snow
Assembly of God Church	425 Sandy Lane	732-0634	Wind, Snow
Bahai Faith	80 Walnut Glen Drive	738-8702	Wind, Snow
Buttonwoods Bible Chapel	311 Buttonwoods Avenue	739-2556	Wind, Snow
Calvary Chapel Christian Fellowship	475 Arnold's Neck Drive	739-8555	Wind, Snow
Chapel by the Sea	29 Elgin Street	739-1620	Wind, Snow
Church of Christ	934 Greenwich Avenue	737-1714	Wind, Snow
Church of Jesus Christ of Latter Day Saints	1000 Narragansett Parkway	463-9308	Wind, Snow
Community of Christ Church	292 West Shore Road	738-0586	Wind, Snow
Cornerstone Church	1990 Elmwood Avenue	781-6121	Wind, Snow
Faith Baptist Church	765 Commonwealth Avenue	738-7664	Wind, Snow
First Baptist Church	550 Cowesett Road	885-3010	Wind, Snow
First Congregational Church of Warwick	715 Oakland Beach Avenue	738-3377	Wind, Snow
Friendship Baptist Church	2945 West Shore Road	737-8564	Wind, Snow
Full Life Christian Fellowship	64 Dewey Avenue	734-9790	Wind, Snow
Greenwood Community Church, Presbyterian	805 Main Avenue	737-1230	Wind, Snow
Heritage Baptist Church	618 Oakland Beach Avenue	738-9409	Wind, Snow
Hillsgrove United Methodist Church	35 Kilvert Street	737-8522	Wind, Snow
Jehovah's Witnesses of Warwick	544 Long Street	739-1781	Wind, Snow
Korean Central Church	336 Norwood Avenue	941-5075	Wind, Snow
Lakewood Baptist Church	255 Atlantic Avenue	781-1136	Wind, Snow
Norwood Baptist Church	48 Budlong Avenue	941-7040	Wind, Snow
Pilgrim Lutheran Church	1817 Warwick Avenue	739-2937	Wind, Snow
Shawomet Baptist Church	1642 West Shore Road	739-7184	Wind, Snow

Spring Green Memorial Baptist Church	1350 Warwick Avenue	463-8328	Wind, Snow
St. Barnabas Episcopal Church	3257 Post Road	737-4141	Wind, Snow
St. Benedict's Church	135 Beach Avenue	737-9492	Wind, Snow
St. Catherine Church	3252 Post Road	737-4455	Wind, Snow
St. Clement Church	111 Long Street	739-0212	Wind, Snow
St. Francis Church	596 Jefferson Blvd.	737-5191	Wind, Snow
St. Gregory the Great Church	360 Cowesett Road	884-1666	Wind, Snow
St. Kevin Church	333 Sandy Lane	737-2638	Wind, Snow
St. Mark's Episcopal Church	111 West Shore Road	737-3127	Wind, Snow
St. Mary's Episcopal Church in Warwick	358 Warwick Neck Avenue	737-6618	Wind, Snow
St. Paul Evangelical Lutheran Church	389 Greenwich Avenue	737-6758	Wind, Snow
St. Peter Church	350 Fair Street	467-4895	Wind, Snow
St. Rita's Church	722 Oakland Beach Avenue	738-1800	Wind, Snow
St. Rose & Clement's Church	171 Inman Avenue	739-0212	Wind, Snow
St. Timothy's Church	1799 Warwick Avenue	739-9552	Wind, Snow
St. William Church	Pettaconsett Avenue	781-7226	Wind, Snow
Temple AM David	40 Gardiner Street	463-7944	Wind, Snow
Warwick Central Baptist Church	3270 Post Road	739-2828	Wind, Snow
Warwick Congregation Community of Christ	292 West Shore Road	738-0586	Wind, Snow
Woodbury Union Presbyterian Church	58 Beach Avenue	737-8232	Wind, Snow

Table 7.9 - Hazardous Materials Facilities

FACILITY	ADDRESS	Hazard
ADVANCED CHEMICAL	105 AND 131 BELLOWS ST.	ALL
CELLINI INC.	215 JEFFERSON BLVD	ALL
HAB TOOL INC	50 COLORADA AVE	ALL
INTERPLEX METALS	1280 JEFFERSON BLVD	ALL
LEVITON MANUFACTURING	745 JEFFERSON BLVD	ALL
PEASE AND CURREN	75 PENSYLVANIA AVE	ALL
PRIME TIME MANUFACTURING	185 JEFFERSON BLVD	ALL
US ARMY RESERVE	885 SANDY LANE	ALL
WARWICK SEWER AUTHORITY	125 AUTHER W DEVINE BLVD	ALL
WOULVERINE JOINING TECH. INC.	235 KILVERT ST.	ALL

Historic/Other Considerations

Historic resources and structures provide that link to the cultural history of a town. They may also be more vulnerable to certain hazards since they often have fewer safety devices installed or have limited access. Recreational facilities are places where large groups of people can and do gather.

Table 7.10 - Historic Structures

NAME	ADDRESS	HAZARD
Apponaug Historic District	Post Road	All
Buttonwoods Beach Historic District	Cooper and Promenade Avenues	All
East Greenwich Historic District	Greenwich Cove	All
Forge Road Historic District	Forge Road	All
Meadows Archaeological District	790 Ives Road	All
Pawtuxet Village Historic District	Pawtuxet RI	All
Warwick Civic Center Historic District	Post Rd	All
Budlong Farm	595 Buttonwoods Avenue	All
Greene-Bowen House	698 Buttonwoods Avenue	All
Caleb Green House	15 Centerville Road	All
Cowesett Pound	Cowesett Road	All
Lambert Farm Site	287 Cowesset Road	All
Knight Estate	486 East Avenue	All
Moses Greene House	11 Economy Avenue	All
Trafalgar Site	Forge Road and Route 1	All
Forge Farm	40 Forge Road	All
Elizabeth Spring	Forge Rd	All
Caleb Gorton House	987 Greenwich Avenue	All
Richard Wickes Greene House	27 Homestead Avenue	All
Greenwich Cove Site	Ives Rd	All
Pontiac Mills	Knight St	All
Oliver Wickes House	Majo Potter Rd	All
Gaspee Point/Namquid Point	Namquid Drive	All
Terminal Building, R.I. State Airport	572 Occupasstuxet Road	All
John R. Waterman House	100 Old Homestead Avenue	All
Christopher Rhodes House	25 Post Rd	All
Captain Oliver Gardiner House	4451 Post Rd	All
Conimicut Lighthouse	Providence River	All
John Waterman Arnold House	11 Roger Williams Avenue	All
Hopelands/Rocky Hill School	Wampanoag Rd	All
Senator Nelson W. Aldrich Estate	836 Warwick Neck Avenue	All
Warwick Lighthouse	1350 Warwick Neck Avenue	All
Peter Greene House	1124 West Shore Road	All
Greene-Durffee House	1272 West Shore Road	All
District Four School	1515 West Shore Road	All

Table 7.11 - Recreational Facilities

MAP #	NAME	PLAT	LOT	ADDRESS	HAZARD
1	OAKLAND BEACH BIKE PATH	375	549	STRAND AV.	FLOODING
2	PONTIAC PLAYGROUND	273	438	145 GREENWICH AV.	FLOODING
3	DELGIUICE PARK	380	69	PALMER AV.	FLOODING
4	PASSEONQUIS BOAT RAMP	304	29	GASPEE POINT DR.	FLOODING

Public infrastructure:

Fire stations, Police Stations, Schools, Town Hall, Hospitals and Bridges with Utilities

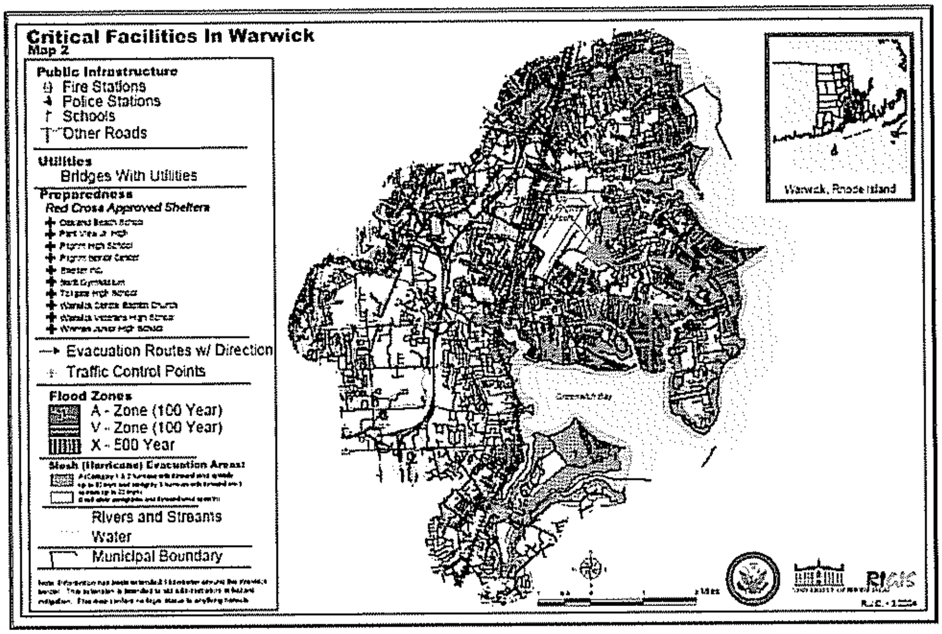
Utilities:

Sewer treatment plants, Sewer lift stations, Water pump stations and Water towers

Preparedness:

Red Cross approved shelters, Evacuation routes and Traffic control points

Map 8.1 Critical Facilities



Aside from a number of bridges, only one of Warwick's critical facilities is located in a flood or SLOSH zone within the Greenwich Bay watershed. This structure is fire station 4. In the event of a 100 year flood, this fire station would be completely unusable and apparatus would have to be relocated. This would impact the residents in the first response district of this fire station by increasing response times dramatically.

The City of Warwick has a total area of 35 square miles and a population of 87,000 people In 1999, there were 1,383 at-risk structures in the City of Warwick. Most of these structures are located in the Oakland Beach area, although Buttonwoods Cove is at-risk as well. In the event of a severe hurricane, over 3,379 acres of land in Warwick would be inundated, causing up to $53 million in property damage. Such an event would knock out key assets such as the lumberyard, marinas, and several warehouses (Raford, 1999).

Evacuation and Mass Care

Evacuation

An evaluation of a number of factors effecting evacuation of the West Bay area, including the roadway system, likely evacuation destinations, traffic, seasonal population, severity of storm, etc., was conducted by the Army Corps of Engineers for the Hurricane Evacuation Study (ACOE 1995). This transportation analysis was utilized to compose an evacuation route map that illustrates evacuation zones and shelters for each affected community. Municipal and state emergency management officials have the Inundation Map Atlas and the Evacuation Map Atlas, both products of this study, for each community. This information would be most useful if it resulted in municipal signs posting appropriate evacuation routes on roadways.

It is recommended by FEMA that coastal communities use an 8 hour clearance time estimate for well-publicized daytime evacuations. Night time evacuations should allot 10 hours for clearance. In addition to the actual evacuation time, officials must add the time required for dissemination of information to the public, which can vary from community to community. It is a community decision to conduct an evacuation based on information made available to municipal officials. The ACOE recommends that the evacuation be complete before the arrival of gale-force winds.

The ACOE, under a weak hurricane scenario, estimates based on 1990 census data that 86,000 people in affected inundation areas for the state. In the Warwick area, estimates for people in vulnerable areas under a weak hurricane scenario are 16,270 people, with an estimated population of 18,990 likely to evacuate the City (Table 7). Estimates for strong hurricane scenarios raised the number to 28,760 people vulnerable, with 28,580 likely to evacuate. Recognizing the population increase in these towns since 1990, slight adjustments need to be made to the estimates by ACOE.

Table 8.1. Town Populations, Evacuation Predictions, & Shelter Capacities based on 1990 Census Data (U.S. Army Corps of Engineers 1995).

CITY	Vulnerable Population	Population Evacuating Surge Areas	Population Evacuating Non-Surge Areas	Shelter Demand	Shelter Capacity
Warwick					
Weak Hurricane	16,270	17,840	1,150	2,420	3,980
Severe Hurricane	28,760	25,700	2,880	3,770	3,980

The Warwick Police Department has a severe weather plan in its emergency operations manual. Emergency transportation and traffic control is a key component of the Department's response to natural disasters. In the event of a disaster, the Department would be assisted by DPW, Warwick Fire, as well as logistical support units such as Narragansett Electric and Providence Gas, in order to maintain access and exit routes throughout the city.

Based on the SLOSH maps the following areas would need to be evacuated during a hurricane: Warwick Neck, Oakland Beach, Buttonwoods, Apponaug Cove, and Potowomet. The primary evacuation routes in Warwick would be the following road system: Post Road, Warwick Avenure, Elmwood Avenue, Bald Hill Road/Route 2, Centerville Road, Toll Gate Road, Division Road, as well as I-95, Route P-37 west, Route 4 and Route 295 north. Within Warwick City, West Shore Road would be a primary connector route to any of the above mentioned roadways.

The Warwick Department of Public Works compiled the following list of Critical roads being used for evacuation routes. The are listed in a spreadsheet according to the shelter that they serve. These roads are as follows:

Table 8.2 Evacuation Routes per Shelter Location

SWIFT GYM - P.E.S.	WINMAN J.H.S.	VETERANS MEM. H.S.	GORTON J.H.S.	PILGRIM H.S.
DIVISION RD.	BALD HILL RD.	BUTTONWOODS AV.	DRAPER AV.	AIRPORT RD.
IVES RD.	CENTERVILLE RD.	MAIN AV.	LONGMEADOW AV.	ELMWOOD AV.
LOVE LN.	COMMONWEALTH AV.	OAKLAND BEACH AV.	PALMER AV.	LAKE SHORE DR.
POST RD.	DIAMOND HILL RD.	SANDY LN.	SAMUEL GORTON AV.	NARRAGANSETT PKWY.
	GREENWICH AV.	STRAWBERRY FIELD RD.	WARWICK NECK AV.	POINT AV.
	QUAKER LN.	WEST SHORE RD.		POST RD.
	TOLL GATE RD.			WARWICK AV.
				WEST SHORE RD.

Any of the above listed roads may be flooded in areas where the routes pass over bridges if there are within the floodplain. The following is a list of any bridge that is located on an evacuation route and that also lies within the 100 year flood plain.

Table 8.3 Bridges on Evacuation Routes

BRIDGE #	NAME	LOCATION	RIVER	OWNED BY:	DOT#
4	MALL BRIDGE	BALD HILL RD. RT 2	PAWTUXET RIVER	STATE	264
9	HARDIG I95 CULVERT	CENTERVILLE RD. RT 117	HARDIG BROOK	STATE	247
11	HERITAGE CULVERT	DIVISION ST. RT 401	MASKERCHUGG RIVER	STATE	217
12	DRAPER CULVERT	DRAPER AV.	WARNER BROOK	CITY	354
13	EAST NATICK BRIDGE	EAST AV. RT. 113	PAWTUXET RIVER	CITY	263
14	ELMWOOD BRIDGE	ELMWOOD AV. US 1	PAWTUXET RIVER	STATE	287
17	GORTON CULVERT	GREENWICH AV. RT 5	GORTON POND OUTLET	STATE	246
18	PONTIAC BRIDGE	GREENWICH AV. RT 5	PAWTUXET RIVER	STATE	271

5	BAY LAWN BOAT RAMP	292	235	BAY LAWN AV.	FLOODING
6	PAWTUXET VILLAGE PARK	292	366	2 E. VIEW ST.	FLOODING
7	O'DONNELL PARK	262	108	PROVIDENCE ST.	FLOODING
8	PORTER FIELD	330	12	4 VERNON ST.	FLOODING
9	POTOWOMUT FISHING AREA	212	9	POTOWOMUT RD.	FLOODING
10	SANDY POINT BEACH	201	188	IVES RD.	FLOODING
11	RUBERY FIELD	296	147	10 FREDERICK ST.	FLOODING
12	SALTER'S GROVE PARK	304	187	470 NARRAGANSETT PKWY.	FLOODING
13	SAND POND BEACH	298	4	SAND POND RD.	FLOODING
14	BARTON FARM	251	18	1351 CENTERVILLE RD.	FLOODING
15	SPRAGUE FIELD	294	90	600 POST RD.	FLOODING
16	WINSLOW PARK	345	304	89 GERTRUDE AV.	FLOODING
17	WARWICK POND RAMP	327		WELLS AV. R.O.W.	FLOODING
18	WHITAKER FIELD	301	375	257 N. COUNTRY CLUB DR.	FLOODING
19	WARWICK COVE BOAT RAMP	376	549	100 BAY AV.	FLOODING
20	WELLS PLAYGROUND	321	4	WELLS AV. [AIRPORT]	FLOODING
21	ADAMS PLAYGROUND	263	670	60 WASHINGTON ST.	FLOODING
22	BELMONT PARK	287	159	FIRST AVE.	FLOODING
23	JOHNSON FIELD	337	439	20 BEND ST.	FLOODING
24	BEND ST. COMPLEX	337	353	76 BEND ST.	FLOODING
25	CHAMPLIN FIELD	360	789	390 OAKLAND BEACH AV.	FLOODING
26	CHEPIWANOXET PARK	221	94	25 JOHN WICKES AV.	FLOODING
27	WARWICK CITY PARK	371	4	185 ASYLUM RD.	FLOODING
28	CLEGG FIELD	332	470	140 WINTER AV.	FLOODING
29	CONIMICUT BEACH	334	459	60 POINT AV.	FLOODING
30	DODGE PLAYGROUND	270	445	221 DODGE ST.	FLOODING
31	DUCHESS PLAYGROUND	238	56	101 DUCHESS ST.	FLOODING
32	FATHER TIROCCHI PLAYGROUND	263	22	7 W. PONTIAC ST.	FLOODING
33	PETRARCA PARK	263	44	BAKER ST.	FLOODING
34	BOYD FIELD	350	586	35 WATERVIEW AV.	FLOODING
35	GODDARD PARK	206	1	1095 IVES RD.	FLOODING
36	GORTON POND BEACH	245	260	33 VETERANS MEMORIAL DR.	FLOODING
37	STANMORE PARK	328	415	187 EDGEHILL RD.	FLOODING
38	LINCOLN PARK	310	1	KENTUCKY AV.	FLOODING
39	LITTLE POND BEACH	349	585	1 ALBERT RD.	FLOODING
40	LONGMEADOW BEACH	355		LONGMEADOW R.O.W.	FLOODING
41	DORR ST. BEACH	355		1 SAMUEL GORTON AV.	FLOODING
42	MASTHEAD WALK	222	139	NEPTUNE ST.	FLOODING
43	MICKEY STEVENS COMPLEX	349	1	176 RANGE RD.	FLOODING
44	VETERANS MEMORIAL PARK	349	551	2435 W. SHORE RD.	FLOODING
45	BIRCHES PARK	346	303	NORMANDY DR.	FLOODING
46	O'BRIEN FIELD	245	61	120 VETERANS MEMORIAL DR.	FLOODING
47	OAKLAND BEACH	376	549	900 OAKLAND BEACH AV.	FLOODING

Chapter 8. Hazards Vulnerability Analysis

What is Vulnerability?

Natural hazards become disasters once they have resulted in the loss of lives and injuries, caused damage to property and interrupted the normal operations of government, community and businesses within those communities.

Heinz Center, The Hidden Cost of Coastal Hazards

The impacts of natural hazard events are measured in terms of the costs that result from the impacts on society. The potential for future costs can be measured through risk and vulnerability assessments. In the Warwick Hazard Mitigation Strategy, *vulnerability* refers to the predicted impact that a hazard could have on people, services, specific facilities and structures in the community.

Vulnerability assessment is concerned with the qualitative or quantitative examination of the exposure of some component of society, economy or the environment to natural hazards. There are several factors to consider when assessing vulnerability, and these include: time, coastal and inland geography, location of community development and whether or not protective measures have been put into place to reduce future vulnerability to disasters.

The vulnerability of the built environment in Warwick to hazards, combined with trends in population growth and the value of insured property, suggests that there is a potential problem of a first order magnitude. Obviously one cannot prevent the storm from occurring; therefore the forces accompanying the hazard –storm surge, wind and flooding—will result in significant damage and destruction. However, much of the coastal hazard vulnerability can be attributed to inappropriately designed, built and located communities—often the result of not using the best available knowledge and practices. (Heinz, 1999) Almost every planning and development decision made at the local level has implications for the vulnerability to, and impact of, a natural hazard event.

A critical first step in assessing the risk and vulnerability of Warwick to natural hazards is to identify the links between the built environment vulnerability and the community's vulnerability to hazard-related business interruptions, disruptions of social structure and institutions, and damage to the natural environment and the flow of economic goods and services.

Vulnerability Analysis: Critical Facilities

Hurricanes, storms and other natural events become "hazards" when they affect human society in adverse ways. Communities are vulnerable to these hazards to the extent that they are subject to potential damage to, or disruption of, normal activities. Societal conditions reflect human settlement patterns, the built environment, and day-to-day activities. These conditions include the institutions established to deal with natural hazards during both preparations and response.

The vulnerability of a community includes the potential for direct damage to residential, commercial, and industrial property as well as schools, government, and critical facilities. It also includes the potential for disruption of communication and transportation following disasters. Any disruption of the infrastructure, such as a loss of electric power or a break in gas lines, can interrupt business activity and cause stress to affected families, particularly if they are forced to evacuate their residences and are subject to shortage of basic supplies. If the destruction of the infrastructure causes additional damage (e.g., property destroyed by fires caused by breaks in the gas lines), then this vulnerability needs to be taken into account. One also has to consider the exposure of the population to each hazard type and the potential number of fatalities and injuries to different socioeconomic groups.

Critical Facilities

Each jurisdiction classifies "critical facilities" based on the relative importance of that facility's assets for the delivery of vital services, the protection of special populations, and other important functions. If flooded, the loss of that critical facility would present an immediate threat to life, public health, and safety. Protection of critical facilities is also important for rapid response and recovery of a community, its neighborhoods and its businesses. In the City of Warwick, critical facilities are classified under the following subsections (see list in Chapter 7):

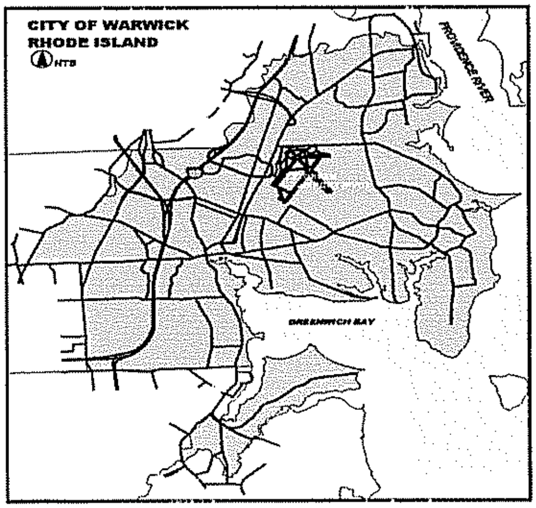
23	LAKESHORE CULVERT	LAKE SHORE DR.	WARWICK POND INLET	*CITY*	327
24	LARCHWOOD CULVERT	MAJOR POTTER RD.	DARK ENTRY BROOK	*CITY*	223
25	PAWTUXET BRIDGE	NARRAGANSETT PKWY.	PAWTUXET COVE	*STATE*	292
26	FORGE BRIDGE	OLD FORGE RD.	HUNT RIVER	*STATE*	211
30	CONIMICUT CULVERT	POINT AV.	SHAWOMET CREEK	*CITY*	334
31	APPONAUG BRIDGE	POST RD US 1	APPONAUG COVE	*STATE*	245
33	QUIDNESSET BRIDGE	POST RD. US 1	HUNT RIVER	*STATE*	214
34	NORWOOD CULVERT	POST RD. US 1A	CRANBERRY BROOK	*STATE*	295
41	RIVERVIEW BRIDGE	TIDEWATER DR.	OLD MILL COVE	*CITY*	336
42	HARDIG BRIDGE	TOLLGATE RD. RT 115	HARDIG BROOK	*STATE*	246
47	BUCKEYE BRIDGE	W. SHORE RD. RT 117	BUCKEYE BROOK	*STATE*	337
49	CARPENTER BRIDGE	W. SHORE RD. RT 117	TUSCATUCKET BROOK	*STATE*	348
52	COTTAGE BRIDGE	WARWICK AV. RT 117A	BUCKEYE BROOK	*STATE*	351
54	SILVER HOOK BRIDGE	WARWICK AV. US 1A	PAWTUXET RIVER	*STATE*	290
55	BAYSIDE CULVERT	WARWICK NECK AV.	MEADOWVIEW CREEK	*CITY*	357

Mass Care

There are currently three Red Cross approved emergency shelters in the Warwick's section of the Greenwich Bay watershed (Toll Gate, Pilgrim, Warwick Veterans high schools). Each of these is capable of accommodating approximately 1,000 people. In the event that the capacity of these shelters is not sufficient in the event of a disaster, other facilities could be used for additional accommodation (Geagan, D., Personal Communication).

According to the American Red Cross, 25% of an evacuated population will seek public shelters in the event of most disasters. FEMA requires that a town provide shelters to accommodate 15% of an evacuated population. In order to evaluate the likely shelter populations for various areas in a jurisdiction, a behavioral analysis is performed by ACOE on the population located within projected inundation zones. This "vulnerable population" categorization obviously varies depending on the strength of the storm. As stated under evacuation information, in the Warwick area, estimates are in a weak hurricane 18,990 people will evacuate and 28,580 in a severe hurricane (Table 8.1). The likely demand on public shelters is 2,420 persons under weak storm conditions, and 3,770 under severe storm conditions. The total shelter capacity for the City of Warwick is 3,980 people.

Vulnerability Analysis: Transportation and Debris Removal



Map 8.2 Warwick Major Road Systems

The City of Warwick evolved from a scattered group of agricultural and maritime settlements. As the industrial revolution developed, factories and textile mills were constructed along the principal waterway, the Pawtuxet River, and resort communities sprang up along the Bay Shore. The scattered maritime, agricultural, industrial, and resort communities were connected by a transportation system of roads, and later in the early 20th century, by a system of trolleys and roads. Although the trolleys have disappeared, the network of roads is very much what is in place today for the City's circulation system.

The construction of the interstate highway system through Warwick has also had a major impact on land use and circulation. Interstate 95 was completed in 1966 and I-295, which connects to I-95 in Warwick, was completed in 1968.

Table 8.4 Length of Roadway by Functional Classification in Warwick

Classification	Length (miles)
Interstate (Urban)	9.20
Other Freeway (Urban)	2.75
Connecting Rural Principal Arterials (Urban)	11.45
Connecting Rural Minor Arterials (Urban)	2.20
Principal Urban Arterials	21.55
Minor Urban Arterials	11.70
Urban Collectors	36.90
Total	95.75
Local	450.00

Interchanges were established in the City to connect major arterials to the interstates at Routes 2, 37, 113 and 117. The airport connector tied the interstate system to the airport, and the Jefferson Boulevard exit connected the interstate to the City's industrial heartland. The interstates created access to Warwick in a totally new manner and the advantages of this were captured by the quick construction on Route 2 of the Rhode Island Mall (formerly the Midland Mall) and the Warwick Mall. This commercial focus on Route 2 has continued, creating a nearly continuous strip of commercial development from Cranston to East Greenwich.

The 1985 inventory of land uses prepared for the 1986-1991 Land Use Plan for the City of Warwick determined that roads totaled more than 3000 acres of the city's land area, or 14.5 percent of the city. This is an increase of 3.74 percent over 1972, and represents the third largest single category of use after single-family housing and vacant/undeveloped land. This is not unusual, especially in a suburban community where the primary means of travel is the automobile.

There are seventy state numbered bridges in Warwick. This represents nearly 10 percent of the 705 bridges statewide. All bridges in Rhode Island greater than 20 feet in lengths are assigned a number by the State Department of Transportation for the purposes of inspection. These bridges may not be all state owned but they are inspected by the state.

There are approximately 450 miles of local streets and roads that are the responsibility of the city of Warwick. The Department of Public Works maintains these streets including: repairing the pavement, striping where necessary, maintaining the integrity of the road shoulder and clearing vegetation along the roadside, plowing and sanding/salting in the winter, and maintaining the drainage systems. If the road is on the functional classification, then the city's responsibilities for repair and/or reconstruction of the roadway may be assisted through funding from the state aid system.

Marinas

The marine trades are a significant economic and social asset to the City of Warwick. Greenwich, Apponaug and Warwick Coves contain some of the most dense marina and boating facilities in the state. In 2003, there were at least 30 marinas/yacht clubs with over 3,662 boat slips. In addition, a substantial proportion of the shoreline around the Bay is characterized by high-density residential development. Personal safety concerns and economic damage could be substantial for both the in water and nearshore land areas. Recreational and commercial boats are at great risk since most of them are located in high velocity (VE) zones. These boats are located at marinas, on moorings, on land and at yacht clubs. Other facilities of concern include the diesel tanks used to fill the boats in Greenwich Cove.

Table 8.5 Number of Recreational Boats in Greenwich Bay in 2003

	Marinas	Docks	Moorings	Slips	Boats with heads >25'	Moored Boats with heads >25'
Greenwich Cove	9	41	368	612	337	320
Apponaug Cove	3	19	112	559	423	90
Greenwich Bay Proper	2	28	33	663	610	25
Buttonwoods Cove	0	0	5	0	0	3
Brushneck Cove	1	1	14	4	0	7
Warwick Cove	16	66	45	1603	761	9
GRAND TOTALS	31	155	577	3441	2131	454

Shorefront Debris Removal

The removal and storage of debris accumulated on the shore during major storms and hurricanes is an important consideration. Massive amounts of debris accumulated along coastal areas during the 1938 and 1954 hurricanes, specifically the shores of Oakland Beach, Apponaug Cove, and Potowomut (Providence Journal Company, 1954). In each event, the result was a large and costly clean up. Highly developed areas have a lower capability to address this consequence, since the capacity of local landfills tends to be exceeded. Warwick stores their debris at several schools, athletic fields and parks locations. The Warwick Harbor Management Plan policy on derelict vessels and debris is for the harbormaster to notify RIDEM of needed cleanups. The plan also recommends that CRMC require tagging of all dock sections in order to determine ownership of debris for cost recovery (Warwick Harbor Plan, 1996).

Vulnerability Analysis: Social Conditions

A number of demographic and societal factors influence an area's potential risks from natural hazards. These include population growth and density, poverty, the number of renters, the numbers of disabled or elderly, non-English speakers, non-mobile people, and homes lacking insurance.

It is estimated that there is approximately 30,000 seniors living in the City of Warwick. As part of the services offered to the senior population, the City of Warwick has 3 Senior Centers (2 municipally operated and 1 privately operated) conveniently located throughout the City. These Centers provide various services to those that participate - including meal programs, transportation, health and wellness programs, and many other recreational and community programs.

Other General Demographic Characteristics:

- Population: The population count for The City of Warwick as of April 1, 2000, was 85,808. This represented a 0.45% increase (381 persons) from the 1990 population of 85,427.
- Rank: In 2000 Warwick ranks 2nd in population among Rhode Island's 39 cities and towns.
- Median Age: In 2000 the median age of the population in Warwick was 40.
- Age Distribution: In 2000, 78.1% or 67,028 persons residing in Warwick were 18 years of age or older. 64,478 were 21 and over, 16,664 were 62 and over, and 14,558 were 65 and over.
- Population Density: The 2000 population density of Warwick is 2,417 persons per square mile of land area. Warwick contains 35.50 square miles of land area (91,940,953 Sq. meters) (22,719.28 acres) and 14.12 square miles of water area (36,574,361 square meters) (9,036.76 acres).

- **Housing Units:** The total number of housing units in the The City of Warwick as of April 1, 2000, was 37,085. This represented an increase of 1,944 units from the 35,141 housing units in 1990. Of the 37,085 housing units 1,568 were vacant. 493 of the vacant units were for seasonal of recreational use.
- **Households:** In 2000, there are 35,517 households in Warwick with an average size of 2.39 persons. Of these, 22,971 were family households with an average family size of 2.99 persons.
- **Race:**
  > Total Population of One Race: 84,706
  > White: 81,695
  > Black of African American: 996
  > American Indian and Alaska Native: 213
  > Asian: 1,281
  > Native Hawaiian and Other Pacific Islander: 15
  > Some Other Race: 506
  > Total Population of two or More Races: 1,102
  > Hispanic or Latino: 1,372

When preparing this mitigation plan the aforementioned demographic information was taken into consideration in order to assure that the plan is as comprehensive as possible. Only then can we assure that all of our residents enjoy equal benefit from our proposed mitigation actions.

Vulnerability Analysis: Economic

Approximately 85% of the City of Warwick's revenue is generated from property tax (59% residential and 26% commercial). The estimated value of boating-related business real estate in Greenwich Bay in 2003 was $10,063,115, which generated $520,449 in tax revenue. In the event that a natural hazard destroys a portion of the tax base, even those property owners not directly impacted by the event would carry the financial burden of increased property taxes. A substantial portion of the revenue generated by Warwick is also from tourism. In this context, it is important that potential economic impacts of a natural disaster be assessed in the hazard mitigation plans so that the resulting policy accounts for these potential impacts. In a declared disaster area, FEMA will only cover those who have addresses in that area. This translates to mean that those who work in the area but don't have real estate, like shell fishermen, will not be covered by FEMA.

Another key element in mitigating possible economic impact in Greenwich Bay is to improve disaster preparedness for businesses – especially small businesses – by creating an alliance among businesses and the public sector. Research shows that 43% of businesses that close after a disaster never reopen, and an additional 29% close for good within two years (IBHS 2003). The Rhode Island Joint Reinsurance

Association, Narragansett Electric and AT&T Wireless Services all contributed to efforts in 1999 to determine small business disaster recovery needs. The Institute for Business and Home Safety (IBHS) used the results of this research to produce Open for Business: A Disaster Planning Toolkit for the Small Business Owner. The toolkit includes preparedness checklists and an employee safety poster.

Vulnerability Analysis: Natural Conditions

Major climatic events, such as severe storms, are part of the natural and ecological processes that constantly shape coastal lands and vegetation. According to the 2000 Heinz Center Study on the costs of coastal hazards, the extent of the risk that coastal hazards pose to natural systems and the built environment is related directly to the degree that land uses alter and degrade the environment. To analyze this risk, it is necessary to assess the characteristics and resilience of the natural environment. More specifically, natural features such as soils, elevations above sea level, and vegetative cover need to be inventoried. The intensity of land use, and the extent that hydrology, water quality, and habitats are altered, must also be evaluated in order to understand vulnerability. Land uses that extensively modify natural systems make these systems much more vulnerable to coastal hazards than do those that preserve and perpetuate natural ecological processes. The natural environment may be affected adversely immediately after the disaster as well as over the long term. Some of the damage may be irreversible, whereas other adverse impacts may be only temporary.

Vulnerability Analysis: Potential Property Loss Estimations

This section estimates the potential loss for each of the hazards identified in the City's Hazard Identification. It is difficult to ascertain the amount of damage caused by a natural hazard because the damage will depend on the hazard's extent and severity, making each hazard event somewhat unique. In addition, human loss of life was not included in the potential loss estimates, but could be expected to occur, depending on the severity of the hazard. It is also important to note that only property values were included. These figures do not include contents of the structures or any other property besides values which are included in the City's tax levy.

Tropical Cyclone

Damage causes by hurricanes can be both severe and expensive. In the past, Warwick has been impacted by wind and flooding as a result of hurricanes. The assessed value of all residential and commercial structures in Warwick is $8,297,106,800.00. Assuming 1% to 5% city-wide damage, a hurricane could result in $82,971,068.00 to $414,855,340.00 in damage.

Nor'easter

Damage causes by Nor'easter's can be both severe and expensive. In the past, Warwick has been impacted by wind and heavy snowfall as a result of Nor'easters. The assessed value of all residential and commercial structures in Warwick is $8,297,106,800. Assuming 1% to 5% city-wide damage, a Nor'easter could result in $82,971,068.00 to $414,855,340.00 in damage.

Thunder and Lightning

In the past, severe thunderstorms that include dangerous lightning activity have caused mild to severe damage to individual residences in Warwick depending on the severity of the storm, and the location of the lightning strikes. In the future, damages will vary according to the value of the home and the contents inside.

Tornados

Damage from tornados is difficult to predict as the damage is fully dependent upon where the tornado touches down. In Warwick we can estimate that a tornado may cause 1% to 2% city-wide damage. This percentage of damage in terms of monetary value would fall in between $82,971,068.00 and $165,942,136.00. This damage estimate may increase if a heavily populated area was impacted by the storm.

Severe Winter Storms

Heavy snow storms typically occur during January and February. New England usually experienced at least one or two nor'easters with varying degrees of severity each year. Power outages, extreme cold, and impacts to infrastructure are all effects of winter storms that have been felt in Warwick in the past. All of these impacts are a risk to the community, including isolation, especially of the elderly, and increased traffic accidents. Damage caused as a result of this type of hazard varies according to wind velocity, snow accumulation, and duration. The assessed value of all residential and commercial structures in Warwick is $8,297,106,800. Assuming 1% to 5% city-wide damage, a winter storm could result in $82,971,068.00 to $414,855,340.00 in damage.

Hail Storms

Hail storms often cause widespread power outages by downing power lines, making power lines at risk in Warwick. They can also cause severe damage to trees. Hail storms in Warwick could be expected to cause damage ranging from a few thousand dollars to several million, depending on the severity of the storm. The assessed value of all residential and commercial structures in Warwick is

$8,297,106,800. Assuming 1% to 5% city-wide damage, an ice storm could result in $82,971,068.00 to $414,855,340.00 in damage.

Temperature Extremes

Temperature extremes have a limited impact on the infrastructure of the City of Warwick. The best estimate for potential damage would be no greater than one percent of the total value of all commercial and residential structures in the City. This would mean that temperature extremes are expected to cause a loss no greater that $82,971,068.00 dollars.

Flooding and Storm Surge

Flooding is often associated with hurricanes, nor'easters, rapid springtime snow melt, and heavy rains. It can be in the form of inland or coastal flooding.

In the following calculations, the average replacement value was calculated by adding up the assessed values of all structures in the 100- and 500-year floodplains and then dividing by the number of structures. In 2004 there are 5,412 residential structures that are in the flood hazard area in the City of Warwick. The Average assessed value of those homes is $143,275. There also is approximately 50 non-residential structures in the flood hazard area. The average assessed value for those structures is $350,000. These figures were used to determine the impact a flood would have on the City of Warwick.

The Federal Emergency Management Agency (FEMA) has developed a process to calculate potential loss for structures during flooding. The potential loss was calculated by multiplying the average replacement value by the percent of damage expected from the hazard event, and then by multiplying that figure by the number of structures. Residential and non-residential structures were separated. The cost for repairing or replacing bridges, railroads, power lines, telephone lines, natural gas pipelines, and the contents of structures have not been included in this estimate.

All of the following estimates were found in the following reference: *Understanding Your Risks, Identifying Hazards and Estimating Losses, FEMA page 4-13.*

Eight Foot Flood – Table 8.6

The following calculation is based on eight-foot flooding and assumes that, on average, one or two story buildings with basements receive 49% damage.

Structure Type	# of Structures	Avg. Replacement Value	Percent Damage	Total Damage
Residential	5412	$143,275	49.00%	$379,948,107.00
Non-Residential	50	$350,000	49.00%	$8,575,000.00

Four Foot Flood – Table 8.7

The following calculation is based on four-foot flooding and assumes that, on average, a one or two story building with a basement receives 28% damage.

Structure Type	# of Structures	Avg. Replacement Value	Percent Damage	Total Damage
Residential	5412	$143,275	28.00%	$217,113,204.00
Non-Residential	50	$350,000	28.00%	$4,900,000.00

Two Foot Flood – Table 8.8

The following calculation is based on two-foot flooding and assumes that, on average, a one or two story building with a basement receives 20% damage.

Structure Type	# of Structures	Avg. Replacement Value	Percent Damage	Total Damage
Residential	5412	$143,275	20.00%	$155,080,860.00
Non-Residential	50	$350,000	20.00%	$3,500,000.00

Coastal Erosion

Coastal Erosion causes very little impact on the City of Warwick on its own as it only makes ocean front structures more vulnerable to storm surge damage. If this erosion is severe enough then the City may choose to rebuild the dunes and coastline in order to protect those homes. It is impossible to estimate the cost of such a project without a complete engineering study.

Droughts

Droughts can be costly to agricultural communities but in the City of Warwick there is little cost associated with these disasters. Water preservation and supplying alternative sources of water during a severe drought may be the only action that is required in the City of Warwick. Supplying emergency water would be a costly endeavor; however the scenario is an unlikely one.

Earthquake

Within one to two minutes, an earthquake can devastate part of an area such as Warwick through ground-shaking, surface fault ruptures, and ground failures. It can also cause buildings and bridges to collapse, disrupt gas lines which can lead to explosions and fires, down power and phone lines, and are often associated with landslides and flash floods. In addition, buildings that are not built to a high seismic design level would be susceptible to severe structural damage. The assessed value of all residential and commercial structures in Warwick is $8,297,106,800. Assuming

1% to 5% city-wide damage, an earthquake could result in $82,971,068.00 to $414,855,340.00 in damage.

Dam Failure

A dam failure could flood .5 to 1 percent of the structures in Warwick. Based upon this percentage, a dam failure could result in $41,485,534.00 to $82,971,068.00 dollars in property damage.

Hazardous Materials Incident

There is no way to estimate the potential property value that may be lost in a Hazmat Incident.

Addressing Our Vulnerabilities

Recognizing the importance of balancing all of these factors: public safety and well being; development and the built environment; social institutions and natural ecosystems; the Warwick Multi-Hazard Mitigation Strategy identifies the risk and vulnerability potential of these components as well as balance the relationships among them. In taking these issues into consideration, the Warwick Hazard Mitigation Committee has created a matrix which outlines the areas in the City of Warwick where mitigation actions should be taken to reduce the impacts of natural hazards. These mitigation actions are discussed in Chapter 12.

Chapter 9. Development Trends

The City of Warwick has seen significant growth over the past 50 years; however that growth has began to stabilize over the past 30 years. Census information provides us with the best view of the overall growth of the City. By examining the development trends in the City of Warwick we can gather a clearer picture of the potential for future growth and create a mitigation strategy that take these trends into account.

Populations and Housing Growth

Table 9.1

Census Year	Population	Net Change #	Net Change %	Housing Units	Net Change #	Net Change %
1950	43,028	NA	NA	14,790	NA	NA
1960	68,504	25,476	59.21%	21,747	6,957	47.04%
1970	83,694	15,190	22.17%	26,219	4,472	20.56%
1980	87,123	3,429	4.10%	32,450	6,231	23.77%
1990	85,427	-1,696	-1.95%	35,141	2,691	8.29%
2000	85,808	381	0.45%	37,085	1,944	5.53%
Total change from 1950 - 2000	NA	42,780	99.42%	NA	22,295	150.74%

In table 9.1, population growth in the City of Warwick has grown .45 percent over the last decade while housing growth has increased 5.5%. In 2000, there was an average of 2.3 people in each housing unit, down significantly from 2.9 in 1950.

As displayed in table 9.2, the population density has increased significantly in terms of persons per square mile, from 1212 in 1950 to 2417 in 2000.

Table 9.2

Community	2000 Population	Area in Square Miles	Persons per square mile					
			1950	1960	1970	1980	1990	2000
Warwick	85,808	35.5	1212	1929.7	2358	2454	2406	2417

From table 9.3, between 1999 and 2003, the number of residential and commercial building permits issued for new construction held constant. This may be a sign that building will slow in the future due to a lack of land zoned for new development.

Table 9.3

Housing Type	1999	2000	2001	2002	2003	Five-Year Total
Single Family	119	94	91	101	77	482
Multi-Family	9	19	15	5	1	49
Commercial	15	21	14	18	13	531
Total	143	134	120	124	91	1062

Land Use

According to geographic information system (GIS) calculations, the City of Warwick is made up of 49 sq miles, to include a land area of 35 sq miles and an inland water area of 14 sq miles with 39 miles of shoreline.

In terms of land use, 51% of the City is in residential use. An additional 15% is in commercial or industrial use and the remaining 34% is a mix of Agricultural, wild land, open space, and undeveloped properties.

Relation to Natural Hazards

Warwick is mostly comprised of suburban neighborhoods. There is limited open space and undeveloped land. Commercial development lines most of the main roads in the City but the densest commercial area is located along Route 2. The coastal areas of Warwick are developed primarily with residential properties. Out of these coastal areas, Connimicut Beach and Oakland Beach, are most susceptible to coastal flooding and storm surge. The City of Warwick may also be susceptible to inland flooding in the areas surrounding the Pawtuxet River basin. There are, however, very few structures located in the Pawtuxet River floodplain.

As you can see in table 9.1 population growth has stabilized over the past 30 years. This is due mainly to the lack of undeveloped land. For this reason, planning for substantial growth is not necessary. Major population increases will only become an issue if there is trend of increased multi-family housing development within the City. If population in the City of Warwick does increase dramatically, evacuation routes and emergency shelters may be taxed.

Chapter 10. Floodplain Management

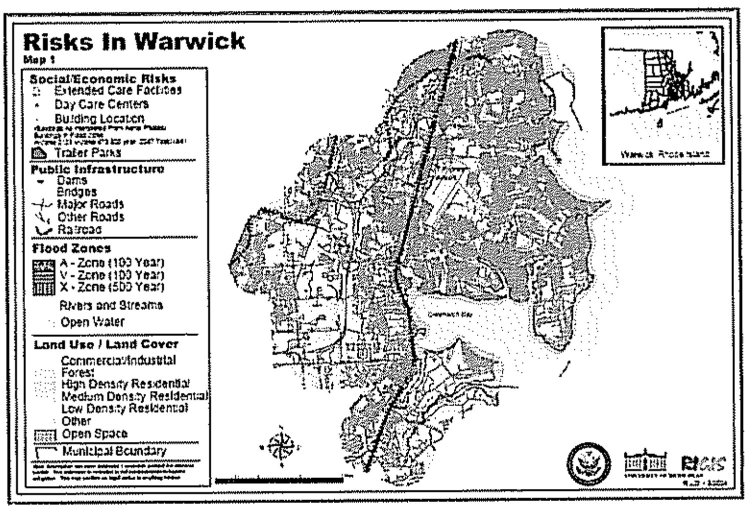
The City of Warwick Risk Assessment ranked flooding as one of the City's greatest potential risk. Flooding is most likely to occur in the spring due to the melting of snow and the increase in rainfall. However, flooding events can occur at anytime of the year as a result of heavy rains, hurricanes, and nor'easters.

Flood mitigation is an essential step in preventing flood damage. This section provides an overview of the past and potential flooding risks in the City of Warwick as well as the City's participation in the National Flood Insurance Program.

Flood Prone Areas

The City of Warwick utilizes the FEMA Flood Insurance Rate Map's (FIRM's) to determine the location of flood zones and flood prone areas. These maps were last updated in 1992 – 1993 by the Federal Emergency Management Agency. In Warwick, 3,379 acres, and hundreds of structures are located within a FEMA designated Special Flood Hazard Area (SFHA). A special flood hazard area is delineated on a Flood Insurance Rate Map. The SFHA is mapped as Zone A. In coastal situations, Zone V is also part of the SFHA. The SFHA may or may not encompass all of the community's flood problems.

Map 10.1



Under the National Flood Insurance Program (NFIP), FEMA is required to develop flood risk data for use in both insurance rating and floodplain management. FEMA develops this data through Flood Insurance Studies (FIS). In FIS's, both detailed and approximate analyses are employed. Generally detailed analysis is used to generate flood risk data only for developed or developing areas of communities. For undeveloped areas where little or no development is expected to occur, FEMA uses approximate analyses to generate flood risk data.

Table 10.1

FEMA FIRM FLOOD HAZARD RISK CATEGORIES

FEMA Flood Zone	Amount of Land	Risk Score
VE zones	681	5
A and AE zones	2,698	4
AH and AO zones	288	3
500 year	3,835	2
Remainder of City	22,945	1

Using the results of the FIS, FEMA prepares a Flood Insurance Rate Map (FIRM) that depicts the Special Flood Hazard Areas (SFHA's) within the studied community. SFHA's are areas subject to inundation by a flood having a one percent chance or greater of occurring in any given year. This type of flood, which is referred to as the 100-year flood (or base flood), is the national standard on which the floodplain management and insurance requirements of the NFIP are based.

The FIRMS show base flood elevations (BFE's) and flood insurance risk zones. The FIRM also shows areas designated as regulatory floodways. The regulatory floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 100-year flood discharge can be conveyed without increasing the BFE more than the specified amount. Within the SFHA's identified by approximate analyses, the FIRM shows only the flood insurance zone designation. The FEMA FIRM designations are defined below.

Table 10.2

FEMA Flood Insurance Rate Map Definitions

VE Zones
Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone A
Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE
Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the FIS by detailed methods. In most instances, whole foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH
Zone AO is the flood insurance rate zones that correspond to the areas of 100-year shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO
Zone AO is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-depths derived from the detailed hydraulic analyses are shown within this zone

500-Year Flood Zone (or Zone X)
Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, and to areas of 100-year flooding where average depths are less than 1 foot, areas of flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevations or depths are shown within this zone.

Within the established flood risk areas in Warwick, certain regions are more susceptible to damaging floods than others. In order to identify such regions, the Warwick flood risk areas can be prioritized based on a relative flood risk ranking.

The relative risk rankings presented in Table 10.3 and Table 10.4 are based on the FEMA flood zones. Zone VE designates areas along coasts subject to inundation by a 100-year flood event in addition to storm-induced velocity wave action. Such areas require mandatory flood insurance. Zones A, AE, AH, & AO are also subject to inundation by the 100-year flood event and also require mandatory flood insurance. However, regions in these zones are susceptible to shallow flooding from ponding and/or sloping terrain. The Zone X500 designation is given to those areas subject to flooding by severe, concentrated rainfall coupled with poor drainage systems.

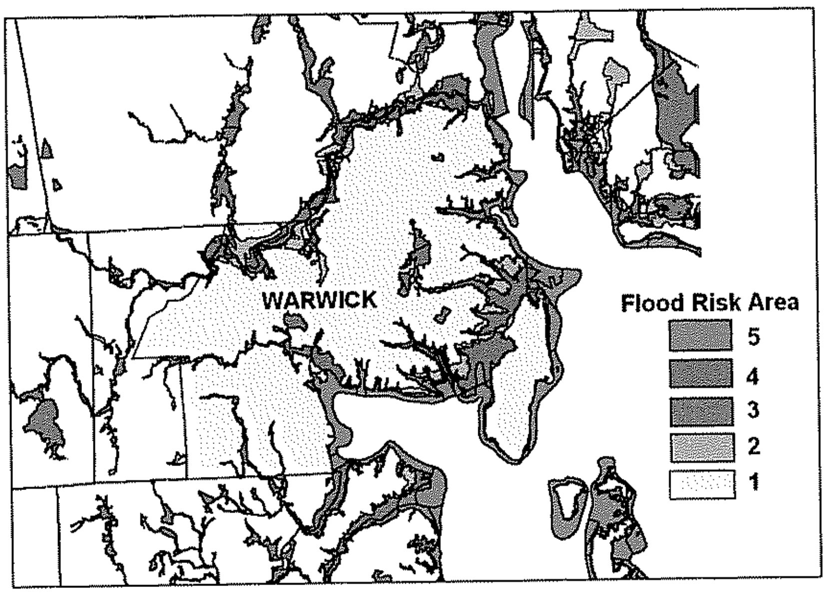
Table 10.3 Warwick Flood Hazard Risk Scores.

Warwick Flood Hazard Risk Scores	
FEMA Flood Zone	**Risk Score**
VE Zones	5
A and AE Zones	4
AH and AO Zones	3
X500 Zone	2
Remainder of City	1

Table 10.4 Representation of Warwick by FEMA Flood Zones

FEMA Flood Zone	Acreage	Square Miles	Percent
AE Zones	2,410	3.76	10.5
VE Zones	681	1.06	3.0
X500 Zones	3,835	5.99	16.7
X Zone	15,731	24.57	68.5
A Zone	288	.449	1.25
City of Warwick	22,945	35.88	100

Map 10.2 Warwick Flood Hazard Risk Scores Source: FEMA



Flash Floods, Sheet Flow, and Ponding

Flash floods are characterized by a rapid rise in water level, high velocity, and large amounts of debris. Flash floods are capable of tearing out trees, undermining buildings and bridges, and scouring new channels. Warwick is more prone to flash flood events in areas where there is a predominance of clay soils that do not have high enough infiltration capacities to absorb water fast enough from heavy precipitation events.

Flash floods may also result from dam failure, causing the sudden release of a large volume of water in a short period of time. In urban areas, such as Warwick, flash flooding is an increasingly serious problem due to the removal of vegetation, and replacement of ground cover with impermeable surfaces such as roads, driveways and parking lots. In these areas, and drainage systems, flash flooding is particularly serious because the runoff is dramatically increased.

The greatest risk involved in flash floods is that there is little to no warning to people who may be located in the path high velocity waters, debris and/or mudflow. The major factors in predicting potential damage are the intensity and duration of rainfall and the steepness of watershed and stream gradients. Additionally, the amount of watershed vegetation, the natural and artificial flood storage areas, and the configuration of the streambed and floodplain are also important.

Storm water runoff and debris flows also negatively impacts public infrastructure such as roads and bridges as water collects. Typically this is the result of inadequate drainage systems in the immediate area, creating ponding conditions oftentimes making roads impassible. Standing surface water develops after intense rainfall events where poor soil permeability and urbanization prevent adequate water drainage. This may interrupt road transportation and damage low elevation buildings. Road closures can be a critical issue in Warwick – as these events have the potential to isolate communities.

Flash flooding events, resulting from heavy precipitation, sometimes equaling the average annual rainfall, have occasionally occurred throughout the historical record. In Warwick these events are concentrated around the Pawtuxet River watershed.

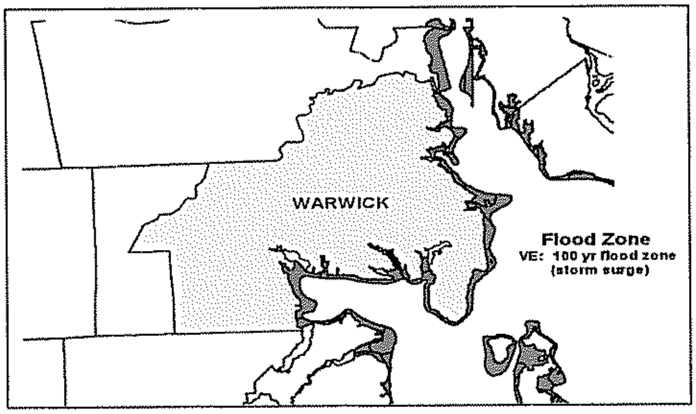
Storm Surge

One of the most dangerous aspects of a hurricane is a general rise in sea level called storm surge. It begins over the deep ocean; low pressure and strong winds around the hurricane's center ("eye") raise the ocean surface a foot or two higher than the surrounding ocean surface forming a dome of water as much as 50 miles across. (National Science Foundation, 1980) As the storm moves into shallow coastal waters, decreasing water depth transforms the dome of water into a storm surge that can rise 20 feet or more above normal sea level and cause massive flooding and destruction along the shoreline in its path. This problem is even more critical in the event when there is additional impact caused by high, battering waves that occur on top of the surge.

Those areas most susceptible to storm surge are coastlines that are uniformly flat or only a few feet above mean sea level, the storm surge will spread water rapidly inland. Typically, storm surge diminishes one to two feet for every mile it moves inland. For example, a 20 foot surge in a relatively flat coastal area, where the land may only be 4 to 6 feet above mean sea level, would be felt 7 to 10 miles or more inland.

Storm surge floods and erodes coastal areas, salinizes land and groundwater, contaminates the water supply, causes agricultural losses, results in loss of life, and damages structures and public infrastructure. Warwick has over 39 miles of shoreline much of which is susceptible to storm surge flooding. Flooding from storm surge in the immediate coastal areas occurs primarily as a result of tropical storms, hurricanes and seasonal high waves. During these events, high winds and surf can push water several feet and even hundreds of yards inshore. Conditions can be exacerbated by large waves that form on top of rising water. The degree of damage caused by storm surge depends on the tidal cycle occurring at the time of the event. During high tides, water levels which can be significantly higher than low tide recede further inland and cause more extensive damage. The area of impact of storm surge flooding is confined to regions along the immediate coastline and typically extends to a few hundred feet inland.

Map 10.3



Sea, Lake, and Overland Surges from Hurricanes (SLOSH)

At present, the only widely used inundation model by State and Federal agencies to determine the potential of storm surge is the Sea, Lake, and Overland Surges from Hurricanes (SLOSH). The SLOSH model is a computer model developed by the National Weather Service, designed to forecast surges that occur from wind and pressure forces of hurricanes. The National Hurricane Center used the SLOSH model, the bathymetry of Narragansett Bay and the Rhode Island coastal topography to model coastal flooding effects from hurricanes that could be experienced in the region. Combinations of four hurricanes categories (from the Saffir Simpson scale), five storm directions (NW, NNW, N, NNE, and NE) three forward speeds (20, 40 and 60 mph), and storm tracks selected at 15 mile intervals enabled 536 hypothetical situations to be simulated by the SLOSH model.

Maximum envelopes of water for each hurricane category and forward speed were calculated to reduce SLOSH model results to only those surge elevations that could potentially cause the greatest flooding. Further classification of maximum surges enabled three categories and forward speed dependent inundation areas to be developed and presented on each map. The inundation matrix of each community map can be used to determine the corresponding inundation area (A, B, or C) for a given hurricane category and forward speed. The classification of inundation areas by this matrix suggests that, in this region, *Worse Case* hurricane surges are predominantly a function of a hurricane's category and forward speed, and that a hurricane's track and direction have less of an effect on resulting storm surge.

Worse Case surge tide estimations were based on maximum storm surge elevations derived for each inundation area within each community. The SLOSH model provides estimates of stillwater surge elevations only and does not consider additional flooding from wave run up. Separate analyses showed that wave run-up effects based on the derived stillwater estimates do not significantly increase the limits of flooding. Surge elevations corresponding to *Worse Case* surge tides were superimposed on Rhode Island Department of Transportation base maps using U.S. Geological Survey 7.5 minute quadrangle maps. Community specific hurricane surge tides [referenced to the National Geodetic Vertical Datum (NGTVD)] that are depicted for each inundation area are shown in the surge tide profiles provided on Plate iii of the U.S. Army Corps 1993 SLOSH Study.

For the Warwick area, based on the SLOSH model, storm surges are predicted to range from 18 to 23 feet high. (U.S. Army Corps of Engineers, SLOSH Study, 1993, p.ii). Aside from a number of bridges, none of Warwick's critical facilities are located in a flood or SLOSH zone within the Greenwich Bay watershed. In 1999, there were 1,383 at-risk structures in the City of Warwick. Most of these structures are located in the Oakland Beach area, although Buttonwoods Cove is at-risk as well. In the event of a severe hurricane, over 3,379 acres of land in Warwick would be inundated, causing up to $53 million in property damage. Such an event would knock out key assets such as the lumberyard, marinas, and several warehouses. The current number of structures located in FEMA designated flood zones has yet to be determined.

Historical Flood Vulnerability

Repetitive Losses

Repetitive losses are those structures that have experienced more than 2 flood losses within 10 years, each loss greater than $1,000. There are about 40,000 buildings across the country currently insured under the NFIP that have been flooded on more than one occasion and that have received flood insurance claims payments of $1000 or more for each loss. The cost of these multiple loss properties over the years to the National Flood Insurance Fund has been $1.8 billion (FEMA 2000).

FEMA mitigation funds are available to States so that the riskiest repetitive flood loss properties can be targeted offering the owners financial help to get their buildings high and dry--either moved to a safer location or elevated well above flood elevations. The National Flood Insurance Agency (FIA) is considering a change in their regulations so that policyholders under the flood insurance program who decline an offer of FEMA's mitigation funds to move or elevate their property would pay full risk premiums for flood coverage. (Currently, consistent with the grandfather provisions of the flood insurance program's authorizing legislation, the FIA charges the owners of properties built before we developed detailed flood risk information less than full-risk premiums.) These older, less-safe buildings that have been eligible for the reduced premiums account for nearly all of the repetitive loss properties insured under the flood insurance program. FEMA's national repetitive loss strategy will make sure that the National Flood Insurance Program's policyholders who own the riskiest properties but refuse mitigation help will have to start paying full-risk premiums for their flood insurance coverage.

Repetitive Loss Summary – Warwick
(May 2000)

Location	# of Claims	Insured	Loss Date	Type	Zone	Total Pd
15 Ring Ave	3	No	4/83; 6/82; 1/79	SF	C	$28,332 98
91 Iona Ave	3	No	4/83; 6/82; 3/80	SF	D	$ 21,407 43
70 Ring Ave	2	No	4/83; 6/82	SF	C	$28,151.08
51 Harris Ave	2	No	1/97; 8/91	SF	AE	$10, 961 69
429 Seaview	2	Yes	8/91; 1/87	SF	A10	$10,768 41
18 Wingate Ave	2	No	6/82; 1/79	SF	C	$ 9,762 35
51 Ring Ave	3	No	4/83; 6/82	SF	D	$ 9,253 72
33 First Avenue	2	No	4/83; 6/82	SF	C	$ 9,233 98
54 Iona Ave	2	No	6/82; 1/79	SF	A	$ 8,109.07
6 Sumner Ave	2	No	4/83; 6/82	SF	C	$ 5,724 25
34 Sumner Ave	2	No	6/82; 1/79	SF	A	$ 5,015 05
45 Sumner Ave	2	No	6/82; 1/79	SF	C	$ 4,396 40
18 Ring Ave	2	No	1/83; 6/82	SF	C	$ 3,830.02
1601 N. Cottage Beach Rd	2	No	1/79; 6/82	SF	D	$2,416.96
14 properties	**31**	**1**				**$152,348.34**

Table 10.5 Source: FEMA, CIS NFIP Data

The National Flood Insurance Program (NFIP)

In 1968, Congress created the National Flood Insurance Program (NFIP) in response to the rising cost of taxpayer funded disaster relief for flood victims and the increasing amount of damage caused by floods. The Federal Insurance and Mitigation Administration (FIMA) a component of the Federal Emergency Management Agency (FEMA) manages the NFIP, and oversees the floodplain management and mapping components of the program.

Communities participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally subsidized flood insurance available to homeowners, renters, and business owners in these communities. Flood insurance, Federal grants and loans, Federal disaster assistance, and Federal mortgage insurance is unavailable for the acquisition or construction of structures located in the floodplain shown on the NFIP maps for those communities that do not participate in the program.

To get secured financing to buy, build, or improve structures in Special Flood Hazard Areas, it is legally required by federal law to purchase flood insurance. Lending institutions that are federally regulated or federally insured must determine if the structure is located in a SFHA and must provide written notice requiring flood insurance. Flood insurance is available to any property owner located in a community participating in the NFIP.

Flood damage is reduced by nearly $1 billion a year through partnerships with communities, the insurance industry, and the lending industry. Further, buildings constructed in compliance with NFIP building standards suffer approximately 80 percent less damage annually than those not built in compliance. Additionally, every $3 paid in flood insurance claims saves $1 in disaster assistance payments.

The NFIP is self-supporting for the average historical loss year, which means that operating expenses and flood insurance claims are not paid for by the taxpayer, but through premiums collected for flood insurance policies. The program has borrowing authority from the U.S. Treasury for times when losses are heavy; however, these loans are paid back with interest.

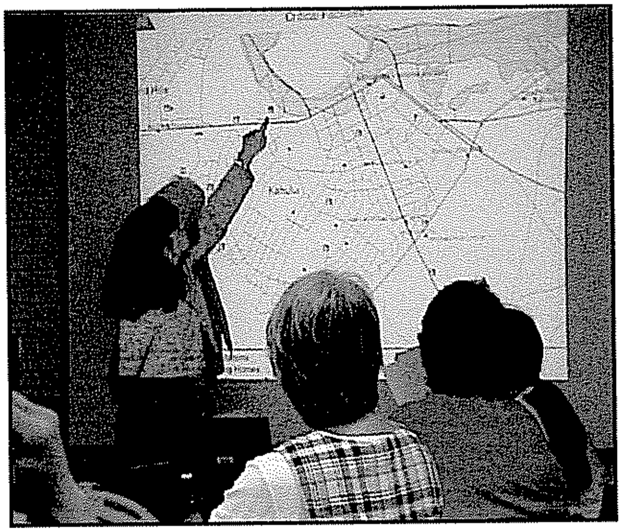
Warwick has been a participant in the National Flood Insurance Program since 1978. 1,718 policies are in force and 382 losses have been paid since 1978 (Table 10.6)

City	NFIP Policies	NFIP Coverage	Total Premiums	Claims since 1978	Total Payments since 1978
Warwick	1,718	$220,393,200	1,186,293	382	$918,783

Table 10.6 Source: FEMA 2003

Community Rating System (CRS)

When communities go beyond the minimum standards for floodplain management, the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP) Community Rating System (CRS) provides discounts up to 45 percent off flood insurance premiums for policyholders in that community. Formal adoption and implementation of this strategy will help Warwick gain credit points under the CRS. For example, points are given to municipalities that form a Local Hazard Mitigation Committee (LHMC). Communities also receive points if they involve the public in the planning process, coordinate with other agencies, assess the hazard and their vulnerability, set goals, draft an action plan (local hazard mitigation strategy), and adopt, implement and revise the plan.



There are many categories to gain credit for public education and awareness activities regarding floodplain management and mitigation. The maintenance of non-federally owned open space land in floodplains can also help a municipality gain credit points under the CRS program. In addition, vegetated open-space land enhances the natural beauty and the beneficial functions that floodplains serve while helping to prevent flood damage.

Benefits of the Community Rating System

Not only do CRS activities save money, they protect the environment and improve the quality of life — even when there's no flood. For example, when the City of Warwick preserves open space in the floodplain, the residents will get to enjoy the natural beauty of the land. If there is a flood, here are some of the many benefits CRS activities bring:

- CRS activities prevent property damage.
- Avoid lost jobs and economic devastation caused by flooding in offices, factories, farms, stores, and other businesses.
- Prevent damage and disruption to roads, schools, public buildings, and other facilities you rely on every day.
- May reduce casualties if setbacks decrease impact of physical structures.

Floodplain Management Goals / Reducing Flood Risks

A major objective for floodplain management is to continue participation in the National Flood Insurance Program. Communities that agree to manage Special Flood Hazard Areas shown on the NFIP maps participate in the NFIP by adopting minimum standards. The minimum requirements are the adoption of the Floodplain Ordinance and Subdivision/Site Plan Review requirements for land designated as Special Flood Hazard Areas.

Under federal law, any structure located in the floodplain is required to have flood insurance. Federally subsidized flood insurance is available to any property owner located in a community participating in the NFIP. Communities that fail to comply with NFIP will be put on probation and/or suspended. Probation is a first warning where all policyholders receive a letter notifying them of a $50 increase in their insurance. In the event of suspension, the policyholders lose their NFIP insurance and are left to purchase insurance in the private sector, which is of significantly higher cost. If a community is having difficulty complying with NFIP policies, FEMA is available to meet with staff and volunteers to work through the difficulties and clear up any confusion before placing the community on probation or suspension.

According to NFIP policies, when an applicant files a request for a building permit in the floodplain, the applicant must include an elevation certificate in order to be in compliance. In addition, if an applicant intends to fill onsite, a letter of map of revision must be submitted along with the application. According to NFIP requirements in the Floodplain Ordinance, building permits should be reviewed to assure sites are reasonably safe from flooding and construction is completed utilizing flood resistant materials and proper anchoring to prevent flotation, collapse, or lateral movement.

In order to reduce flood risks, the Code Enforcement Officer/Building Inspector should be familiar with the Floodplain Ordinance and the NFIP. Additionally, the Planning Board should be familiar with NFIP policies, especially those regulations that are required to be incorporated into the Subdivision/Site Plan Review regulations. A workshop sponsored by the Rhode Island Emergency Management Agency would be appropriate to educate current staff and volunteers.

An essential step in mitigating flood damage is participation in the NFIP. The City of Warwick should work to consistently enforce NFIP compliant policies in order to continue its participation in this program.

Chapter 11. Existing Mitigation Strategies

The Local Hazard Mitigation Committee identified a number of pro-active protection mechanisms that are currently place in the City of Warwick which could reduce the damages and losses in the event of a natural disaster or secondary disaster.

Description of Existing Strategies and Activities

Each program or activity was identified by the Hazard Mitigation Committee. The Committee discussed the effectiveness of each strategy and recommended changes or improvements to their existing programs.

Table 11.1 Existing Mitigation Strategies

EXIST. PROGRAM	DESCRIPTION	COVERAGE	ENFORCEMENT	EFFECTIVENESS	IMPROVEMENTS
DRAIN MAINTENANCE	REPAIR & CLEAN PIPES & STRUCTURES	CITY WIDE	DPW HWY	REFER TO DPW DIR.	MORE BONDS & PERSONNEL
DRAINAGE INVENTORY	HARD COPY MAPS WITH PROJECT LIST	CITY WIDE	DPW ENG	MODERATE	NEED DIGITAL CONVERSION
ROAD INVENTORY*	LIST OF ROAD LENGTHS AND CONDITION	CITY WIDE	DPW ENG	MODERATE	MORE FIELD SURVEY
ROAD RECONSTRUCTION	ANNUAL PAVING PROGRAM THRU BIDDER	CITY WIDE	RIDOT STDS.	VERY EFFECTIVE	INCREASE PAVING BUDGET
SIGNAGE INVENTORY	LIST OF TRAFFIC REGULATIONS @ DPW	CITY WIDE	WPD	MODERATE	INCLUDE WORK ORDERS; DIGITAL CONV.
SLOPE PROTECTION	SOIL EROSION AND SEDIMENT CONTROL PERMITS	CITY WIDE	ORDINANCE	REFER TO BLDG DIR.	NONE
SNOW PLOWING	PLOWING CITY STREETS DURING SNOW STORM	CITY WIDE	DPW HWY	REFER TO DPW DIR.	NONE
STORM WATER	DESIGN AND INSTALL DRAINAGE SYSTEMS	CITY WIDE	RIDEM PHASE II	REFER TO SRICD	MORE FED/STATE GRANTS
VEHICLE MAINTENANCE	MAINTAIN MUNICIPAL VEHICLES; STAFF CALL LIST	CITY WIDE	DPW AUTO.	VERY EFFECTIVE	MORE GARAGE SPACE?

EXIST. PROGRAM	DESCRIPTION	COVERAGE	ENFORCEMENT	EFFECTIVENESS	IMPROVEMENTS
SOIL AND SLOPE PROTECTION REGS	REMOVAL OF SOIL OR CHANGING CONTOUR	CITY WIDE	PUBLIC WORKS AND BLDG. DEPT	HIGH	NONE
BUILDING CODE FOR MULTI-FAMILY, COMMERCIAL AND INDUSTRIAL BUILDINGS	2003 1CC PLMG., MECH., ENERGY, GAS, AND 2002 ELECTRICAL CODE	CITY WIDE	BLDG. DEPT	HIGH	CODE UPDATE EVERY 3 YEARS
RESIDENTIAL 1 & 2 FAMILY CODE	ADOPTED THE INT'L 1 & 2 FAMILY 2003 CODE	CITY WIDE	BLDG. DEPT	HIGH	CODE UPDATE EVERY 3 YEARS
ZONING ORDINANCE MAX. BUILDING HEIGHT	MAX 35 FT. HEIGHT FOR RESIDENTIAL STRUCTURES	CITY WIDE	BLDG. DEPT	HIGH	FOLLOW NATIONAL CODE
MIN. HOUSING CODE PROPTERY MAINTENANCE	REQUIRES MIN MAINTANCE OF RESIDENTIAL AND COMMERCIAL PROPERTY	CITY WIDE	CODE INFORCEMENT DIV.	HIGH	IN PROCESS OF ADOPTING 2003 INT'L PROPERTY MAINTENANCE CODE

Chapter 12. Hazard Risk Management

Risk management is the process by which the results of an assessment are integrated with political, economic, and engineering information to establish programs, projects and policies for reducing future losses and dealing with the damage after it occurs. (Heinz Center, 1999) Managing risks involves selecting various approaches that when applied to the risk area, will reduce the vulnerability. In order to effectively evaluate the true costs associated with natural hazards, the vulnerability of the built environment, social, health and safety, business and natural resources and ecosystems' vulnerability must be determined.

Newly Identified Mitigation Strategies

In addition to the programs and activities that the City of Warwick is currently undertaking to protect its residents and property from a natural disaster, a number of additional strategies were identified by the Hazard Mitigation Committee for consideration. Many of these newly identified mitigation strategies will be considered for further action in the Mitigation Action Plan in the **Evaluation and Implementation of Actions** chapter. Some of them are the result of improvements to the existing strategies identified in **Table 11.1**.

These types of activities were considered when determining new programs and activities which Warwick can develop:

- Prevention
- Property Protection
- Structural Protection
- Emergency Services
- Public Information and Involvement

Table 12.1 Newly Identified Mitigation Strategies

HAZARD TYPE	POTENTIAL PROGRAM	DESCRIPTION OF STRATEGY	AFFECTED LOCATION	TYPE OF ACTIVITY
FLOODING	DRAINAGE INVENTORY	GPS SURVEY TO GIS MAP	CITY WIDE	PREVENTION
FLOOD - EVAC	ROAD INVENTORY	TIE DATABASE TO GIS MAP	CITY WIDE	PLANNING
FLOOD - EVAC	ROAD RECONSTRUCTION	SPECIAL PROJECTS FOR CRITICAL ROADS	CITY WIDE	PREVENTION
FLOODING	RELOCATION OF FIRE STATION 4	FIRE STATION 4 IS LOCATED IN THE 100 YEAR FLOODPLAIN. IN THE EVENT OF A 100 YEAR FLOOD THE WARWICK FIRE DEPARTMENT WOULD HAVE TO RELOCATE APPARATUS, THUS INCREASING RESPONSE TIMES.	WARWICK NECK, BAYSIDE	EMERGENCY SERVICES
FLOODING	INFRASTRUCTURE INVENTORY	INVENTORY ALL STRUCTURES IN FLOODPLAIN	CITY WIDE	PLANNING
SNOW, WIND, RAIN	REPAIR ROOF OF THAYER ARENA	ROOF IS SUSCEPTIBLE TO ALL HAZARDS MAKING THE BUILDING UNUSABLE IN EXTREME WEATHER EVENTS. BUILDING IS IDENTIFIED AS STATE MASS CASUALTY MORGUE AND PET SHELTER.	STATE WIDE	EMERGENCY SERVICES
STORM SURGE	DEBRIS REMOVAL	REMOVAL OF EXISTING DEBRIS IN NARRAGANSETT BAY AND GREENWICH BAY AS WELL AS ALL TRIBUTARIES AND COVES TO PREVENT DAMAGE CAUSED BY STORM SURGE.	CITY VE ZONES	PREVENTION
FLOODING	DEBRIS REMOVAL	MAINTENANCE OF PAWTUXET RIVER TO ELIMINATE FLOODING POTENTIAL DUE TO DEBRIS COLLECTION	PAWTUXET RIVER FLOOD PLAIN	PREVENTION
STORM SURGE	INCREASE BOAT RAMP INVENTORY	INCREASE THE AMOUNT OF BOATS THAT CAN BE REMOVED FROM THE WATER PRIOR TO A HAZARD EVENT BY INCREASING BOAT RAMP INVENTORY AND MAINTAINING EXISTING BOAT RAMPS	MARINAS	PROPERTY PROTECTION
ALL HAZARDS	ELEVATE RT 117 @ TUSCATUCKET BROOK	ELEVATE THE ROAD TO ASSURE THAT EVACUATION ROUTE IS NOT COMPROMISED BY 100 YEAR FLOOD	CITY WIDE	EMERGENCY SERVICES
ALL HAZARDS	ELEVATE DRAPER AVE	ELEVATE THE ROAD TO ASSURE THAT EVACUATION ROUTE IS NOT COMPROMISED BY 100 YEAR FLOOD	BAYSIDE, WARWICK NECK	EMERGENCY SERVICES
STORM SURGE, HURRICANE, NOR'EASTER	ELEVATE STRUCTURES	PROVIDE FINANCIAL ASSISTANCE TO CONIMICUT BEACH AND OAKLAND BEACH RESIDENTS FOR THE ELEVATION OF RESIDENTIAL STRUCTURES TO MEET FLOODPLAIN DEVELOPMENT STANDARDS	CONIMICUT BEACH AND OAKLAND BEACH	PROPERTY PROTECTION

HAZARD TYPE	POTENTIAL PROGRAM	DESCRIPTION OF STRATEGY	AFFECTED LOCATION	TYPE OF ACTIVITY
STORM SURGE	PROTECT CONIMICUT LIGHTHOUSE FROM STROM SURGE	DEVELOP STORM SURGE PROTECTION FOR LIGHTHOUSE.	CONIMICUT LIGHTHOUSE	PROPERTY PROTECTION
ALL HAZARDS	ANNUAL MAILING	PROVIDE OUTREACH TO ALL RESIDENTS IN THE FORM OF AN ANNUAL MAILING PRIOR TO HURRICANE SEASON IN ORDER TO ASSIST RESIDENTS WITH INFORMATION REGARDING PROPERTY PROTECTION AND PREPAREDNESS	CITY WIDE	PUBLIC EDUCATION
FLOODING	PROTECT SEWER PUMPING STATIONS	RETROFIT SEWER PUMPING STATIONS TO REDUCE POSSIBILITY OF SYSTEM FAILURE	CITY WIDE	PROPERTY PROTECTION

Chapter 13. Evaluation and Implementation of Actions

Once all the possible actions are on the table, there must be a way to determine whether they are appropriate measures to solve the identified problems. Using some basic evaluation criteria can help to decide which actions will work best. The most important criterion is whether the proposed action mitigates the particular hazard or potential loss. Each action should also be examined for conflict with other community programs or goals: How does this action impact the environment? It is very important to consider whether the proposed action will meet state and local environmental regulations. Does the mitigation action affect historic structures or archeological areas? Does it help achieve multiple community objectives? Another important issue is timing: How quickly does the action have to take place to be effective? Which actions will produce quick results? It is particularly important to consider if funding sources have application time limits, if it's the beginning of storm season, or if the community is in the post-disaster scenario, where everyone wants to recover at maximum speed.

STAPLE

STAPLE is an acronym for a general set of criteria common to public administration officials and planners. It stands for the Social, Technical, Administrative, Political Legal and Economic/Environmental criteria for making planning decisions. The Warwick Hazard Mitigation Committee decided that the STAPLE criteria are the best way to prioritize mitigation actions.

The Hazard Mitigation Committee ranked each of the new or improved mitigation strategies by utilizing the STAPLE criteria. The Committee asked and then answered questions in order to determine how acceptable the proposed mitigation action is when being viewed in terms of six distinct criteria. See figure 13.1 for further explanation of the STAPLE criteria.

Figure 13.1 STAPLE CRITERIA

STAPLE CRITERIA FOR SELECTING MITIGATION MEASURES

Social: Is the proposed action socially acceptable to the Community? Are there equity issues involved that would mean that one segment of the Community is treated unfairly? Will the action cause social disruption?

Technical: Will the proposed action work? Will it create more problems than it solves? Does it solve a problem or only a symptom? Is it the most useful action in light of other Community goals?

Administrative: Can the Community implement the action? Is there someone to coordinate and lead the effort? Is there sufficient funding, staff, and technical support available? Are there ongoing administrative requirements that need to be met?

Political: Is the action politically acceptable? Is there public support both to implement and to maintain the project? Will the Mayor, his Cabinet, County Council and other decision-making political bodies support the mitigation measure?

Legal: Is the Community authorized to implement the proposed action? Is there a clear legal basis or precedent for this activity? Is enabling legislation necessary? Are there any legal side effects? (e.g., could the activity be construed as a taking?) Will the Community be liable for action or lack of action? Will the activity be challenged?

Economic: What are the costs and benefits of this action? Does the cost seem reasonable for the size of the problem and the likely benefits? Are maintenance and administrative costs taken into account as well as initial costs? How will this action affect the fiscal capability of the Community? What burden will this action place on the tax base or the local economy? What are the budget and revenue effects of this activity? Does the action contribute to other community goals, such as capital improvements or economic development? What benefits will the action provide?

The Committee responded to each of these above listed criteria, with a numeric score of "1" (indicating poor acceptance), a "2" (indicating average acceptance), and a "3" (indicating good acceptance). These numbers were then totaled and developed into an overall priority score. The ranking in the *Priority Score* column in Table 13.1 is merely a guideline for when the City should begin acting on the identified strategies, or Actions.

After each action was given a priority score, the Committee then determined what department would be the point of contact for each action for the development of projected costs of the actions. Since the projected costs may not be accurate, they were not included in this plan. Also listed are a justification of both the project itself and the cost of that project. These details are also listed in table 13.1.

A total of 15 Actions that Warwick can undertake were identified and prioritized. Those Actions which are listed first were given the highest priority by the Hazard Mitigation Committee:

Table 13.1 Mitigation Action Plan

PRIORITY SCORE	POTENTIAL PROGRAM	DESCRIPTION OF STRATEGY	POINT OF CONTACT
18	DRAINAGE INVENTORY	GPS SURVEY TO GIS MAP	PUBLIC WORKS
PROJECT JUSTIFICATION: HAVING A GIS INVENTORY OF DRAINAGE WOULD INCREASE EFFECTIVENESS OF DRAINAGE MAINTENANCE AND IMPROVEMENT PROGRAMS.			
COST JUSTIFICATION: COST OF STAFF TIME TO INPUT DATA AND ENGINEERING STUDY OF DRAINAGE LOCATIONS.			
18	ROAD INVENTORY	TIE DATABASE TO GIS MAP	PUBLIC WORKS
PROJECT JUSTIFICATION: HAVING A GIS INVENTORY OF DRAINAGE WOULD INCREASE EFFECTIVENESS OF ROAD MAINTENANCE AND IMPROVEMENT PROGRAMS.			
COST JUSTIFICATION: COST OF STAFF TIME TO INPUT DATA.			
18	INFRASTRUCTURE INVENTORY	INVENTORY ALL STRUCTURES IN FLOODPLAIN	PUBLIC WORKS
PROJECT JUSTIFICATION: ALLOW FOR BETTER JUSTIFICATION AND STUDY OF POTENTIAL MITIGATION PROJECTS.			
COST JUSTIFICATION: COST OF STAFF TIME TO INPUT DATA.			
18	REPAIR ROOF OF THAYER ARENA	ROOF IS SUSCEPTIBLE TO ALL HAZARDS MAKING THE BUILDING UNUSABLE IN EXTREME WEATHER EVENTS. BUILDING IS IDENTIFIED AS STATE MASS CASUALTY MORGUE AND PET SHELTER.	RECREATION
PROJECT JUSTIFICATION: ROOF REPAIR WOULD INSURE THE USE TO THAYER ARENA AS TEMPORARY MORGUE AND PET SHELTER.			
COST JUSTIFICATION: COST OF CONTRACTED ROOF REPAIR.			
17	ROAD RECONSTRUCTION	SPECIAL PROJECTS FOR CRITICAL ROADS	PUBLIC WORKS
PROJECT JUSTIFICATION: MAINTENANCE OF CRITICAL ROADS WOULD INSURE THE AVAILABILITY OF EVACUATION ROUTES.			
COST JUSTIFICATION: COST OF ROAD REPAIR AND SPECIAL PROJECTS TO REDUCE HAZARD IMPACTS ON CRITICAL ROADS.			

PRIORITY SCORE	POTENTIAL PROGRAM	DESCRIPTION OF STRATEGY	POINT OF CONTACT
17	DEBRIS REMOVAL	MAINTENANCE OF PAWTUXET RIVER TO ELIMINATE FLOODING POTENTIAL DUE TO DEBRIS COLLECTION	PUBLIC WORKS
PROJECT JUSTIFICATION: DEBRIS DAMS HAVE POTENTIAL TO CAUSE FLOODING			
COST JUSTIFICATION: COST OF MANPOWER TO CLEAN AND MAINTAIN PAWTUXET RIVER AND ITS BANKS.			
16	RELOCATION OF FIRE STATION 4	FIRE STATION 4 IS LOCATED IN THE 100 YEAR FLOODPLAIN IN THE EVENT OF A 100 YEAR FLOOD THE WARWICK FIRE DEPARTMENT WOULD HAVE TO RELOCATE APPARATUS, THUS INCREASING RESPONSE TIMES.	FIRE
PROJECT JUSTIFICATION: RELOCATE FIRE STATION 4 OUT OF THE FLOODPLAIN TO ENSURE ITS USAGE DURING 100 YEAR FLOOD.			
COST JUSTIFICATION: COST OF BUILDING A NEW FIRE STATION.			
16	DEBRIS REMOVAL	REMOVAL OF EXISTING DEBRIS IN NARRAGANSETT BAY AND GREENWICH BAY AS WELL AS ALL TRIBUTARIES AND COVES TO PREVENT DAMAGE CAUSED BY STORM SURGE.	PUBLIC WORKS
PROJECT JUSTIFICATION: FLOATING DEBRIS CAN DAMAGE HOMES IN THE VE ZONE AND BOATS MOORED IN THE BAY			
COST JUSTIFICATION: COST FOR CONTRACTED DEBRIS REMOVAL			
16	INCREASE BOAT RAMP INVENTORY	INCREASE THE AMOUNT OF BOATS THAT CAN BE REMOVED FROM THE WATER PRIOR TO A HAZARD EVENT BY INCREASING BOAT RAMP INVENTORY AND MAINTAINING EXISTING BOAT RAMPS	RECREATION
PROJECT JUSTIFICATION: BY INCREASING BOAT RAMP INVENTORY MORE BOATS WOULD BE ABLE TO BE REMOVED FROM THE WATER PRIOR TO A STORM EVENT.			
COST JUSTIFICATION: COST OF CONSTRUCTION NEW BOAT RAMPS AND MAINTENANCE OF OLD RAMPS			
16	ELEVATE RT 117 @ TUSCATUCKET BROOK	ELEVATE THE ROAD TO ASSURE THAT EVACUATION ROUTE IS NOT COMPROMISED BY 100 YEAR FLOOD	PUBLIC WORKS
PROJECT JUSTIFICATION: ELEVATION OF THIS ROAD WOULD INSURE THAT EVACUATION ROUTE WOULD NOT BE COMPROMISED.			
COST JUSTIFICATION: COST OF ENGINEERING STUDY AND ROAD ELEVATION.			
16	ELEVATE DRAPER AVE	ELEVATE THE ROAD TO ASSURE THAT EVACUATION ROUTE IS NOT COMPROMISED BY 100 YEAR FLOOD	PUBLIC WORKS
PROJECT JUSTIFICATION: ELEVATION OF THIS ROAD WOULD INSURE THAT EVACUATION ROUTE WOULD NOT BE COMPROMISED.			
COST JUSTIFICATION: COST OF ENGINEERING STUDY AND ROAD ELEVATION			

PRIORITY SCORE	POTENTIAL PROGRAM	DESCRIPTION OF STRATEGY	POINT OF CONTACT
16	ANNUAL MAILING	PROVIDE OUTREACH TO ALL RESIDENTS IN THE FORM OF AN ANNUAL MAILING PRIOR TO HURRICANE SEASON IN ORDER TO ASSIST RESIDENTS WITH INFORMATION REGARDING PROPERTY PROTECTION AND PREPAREDNESS	EMA
PROJECT JUSTIFICATION: KEEPING THE RESIDENTS INFORMED OF RECOMMENDED PREPAREDNESS MEASURES CAN CUT DOWN OF PROPERTY LOSS.			
COST JUSTIFICATION: COST OF STAFF TIME AND MAILING.			
16	PROTECT SEWER PUMPING STATIONS	RETROFIT SEWER PUMPING STATIONS TO REDUCE POSSIBILITY OF SYSTEM FAILURE	SEWER DEPT.
PROJECT JUSTIFICATION: FLOODED SEWER PUMPING STATIONS MAY BE COMPROMISED CAUSING BACKFLOW POTENTIAL.			
COST JUSTIFICATION: COST OF ENGINEERING STUDY AND PHYSICAL PROTECTION OF THESE STRUCTURES.			
14	PROTECT CONIMICUT LIGHTHOUSE FROM STROM SURGE	DEVELOP STORM SURGE PROTECTION FOR LIGHTHOUSE	RECREATION
PROJECT JUSTIFICATION: THE LIGHTHOUSE IS A HISTORIC LANDMARK RECENTLY PURCHASED BY THE CITY.			
COST JUSTIFICATION: THE COST OF SECURING THE LIGHTHOUSE FROM POTENTIAL STORM SURGE DAMAGE.			
13	ELEVATE STRUCTURES	PROVIDE FINANCIAL ASSISTANCE TO CONIMICUT BEACH AND OAKLAND BEACH RESIDENTS FOR THE ELEVATION OF RESIDENTIAL STRUCTURES TO MEET FLOODPLAIN DEVELOPMENT STANDARDS	PLANNING
PROJECT JUSTIFICATION: CONIMICUT AND OAKLAND BEACH WILL BE A TOTAL LOSS IF STRUCTURES ARE NOT ELEVATED OUT OF THE FLOODPLAIN.			
COST JUSTIFICATION: COST SHARE WITH RESIDENTS FOR ELEVATION OF RESIDENCES.			

Implementation of Actions

The prioritization exercise helped the Committee seriously evaluate the new hazard mitigation strategies that they had brainstormed throughout the Hazard Mitigation Planning process. While the actions would all help improve the City's disaster responsiveness capability, funding availability will be a driving factor in determining what and when new mitigation strategies are implemented. For example, while relocating Fire Station 4 will definitely improve the response capability of the Warwick Fire Department; the cost of this project may require the project be put off until funding is made available. In contrast, the City can distribute preparedness information to the public at a much lesser cost, making this project more reasonable as a short term goal. This type of cost to benefit analysis was taken into account when prioritizing each action.

The Mitigation Action Plan is a comprehensive strategy designed to help the City of Warwick prepare in advance for the impacts of natural disasters. Once implemented, the Action Plan should guide future hazard mitigation efforts.

Chapter 14. Plan Monitoring, Evaluating, and Updating

The completion of a planning document is merely the first step in its life as an evolving tool. The Hazard Mitigation Plan is a dynamic document which should be reviewed on a regular basis as to its relevancy and usefulness and to add new tasks as old tasks are completed. This Chapter will discuss the methods by with the City of Warwick will review, monitor, and update its 2004 Hazard Mitigation Plan.

Maintenance and Update Schedule of the Hazard Mitigation Plan

The City of Warwick Emergency Management Director will be responsible for maintaining a permanent local Hazard Mitigation Committee. The Emergency Management Director will serve as the Chair of the Committee. This Committee will meet quarterly according to the following schedule:

Table 14.1
Hazard Mitigation Committee Annual Future Meeting Schedule

Month	Preliminary Agenda
April	Department reports on Action Items status, Evaluation of Existing Hazard Mitigation Plan
July	Begin to update the Hazard Mitigation Plan, Status of Implementation Action items
October	Update the Hazard Mitigation Plan, Begin writing warrant articles and budget requests for Implementation Action Items
January	Department reports on Action Items status, Finalize warrant articles and budget requests for first Implementation Action items

The Mayor of the City of Warwick will invite all department members to participate in each of the above listed Hazard Mitigation meetings. Public notice of the meetings will be posted in local newspapers, libraries, as well as the City of Warwick website. This will allow for public involvement in the planning process.

The Hazard Mitigation Plan will be updated annually according to the schedule in table 14.1. Funds will be placed into the annual budget for the administrative costs associated with updating the plan such as word processing and map generation, and for printing costs.

Continued Public Involvement

On behalf of the Hazard Mitigation Committee, the Mayor of the City of Warwick, under direction of the City Council, will be responsible for insuring that all City departments and the public have adequate opportunity to participate in the planning process. Other administrative staff may be utilized to assist with the public involvement process.

For each quarterly meeting and for the yearly update process, techniques that will be utilized for public involvement include:

- Provide personal invitations to Budget Committee members;
- Provide personal invitations to City Department heads;
- Post notice of meetings at the City Hall, Fire Departments, Police Departments, and Library;
- Submit newspaper articles for publication to the Warwick Beacon.
- The Local Hazard Mitigation Committee will ensure that the City website is updated with the Hazard Mitigation meeting notices.

Evaluation of Mitigation Actions

During the annual review process and after any disaster situation that may test those actions that have already been implemented, the Warwick Hazard Mitigation committee, under the direction of the emergency management director, will review all proposed and already implemented strategies to determine their effectiveness. The review criteria will test each implemented action to determine the degree of which the action has reduced the vulnerability to the structures it was meant to protect. This review is critical after a hazard event, as the degree of protection offered by the strategy is especially apparent. At this time the original information regarding cost-to-benefit analysis of each action will be reviewed to determine which actions were the most cost effective. If the actions failed, then new actions will be explored to correct the vulnerability. This type of evaluation will help to shape future actions proposed by the hazard mitigation committee. Table 14.2 details the project evaluation process.

Table 14.2 Project Evaluation Process

Project Name and Number:		
Project Budget:		
Project Description:		
Associated Goals:		
Associated Objectives:		
Indicator of Success (eg., losses avoided):		
Was the action implemented?	Yes ▯	No ▯
If NO ⇓		
Why not?		
Was there political support for the action?	Yes ▯	No ▯
Were there enough funds available?	Yes ▯	No ▯
Were workloads equitably or realistically distributed?	Yes ▯	No ▯
Was new information discovered about the risks or community that made implementation difficult or no longer sensible?	Yes ▯	No ▯
Was the estimated time of implementation reasonable?	Yes ▯	No ▯
Were there sufficient resources available?	Yes ▯	No ▯

Table 14.2 Project Evaluation Process Cont.

If Yes ⇓		
What were the results of the implemented action?		
Were the outcomes as expected? If no please explain:	Yes ▯	No ▯
Did the results achieve the goals and objectives? Explain how:	Yes ▯	No ▯
Was the action cost effective? Explain how or how not:	Yes ▯	No ▯
What were the losses avoided after having completed the project?		
If it was a structural project, how did it change the hazard profile?		
Additional comments or other outcomes:		
Date:		
Prepared by:		

Chapter 15. Appendix

The Appendix contains supplemental information to this Hazard Mitigation Plan. The intent of this plan is to provide information about potential disasters, assets and risk, and a means of implementing the actions to help minimize loss to life and property. In addition, the process by which grant and relief money can be obtained and what programs are available to assist the City and its residents are equally important. When the Hazard Mitigation Plan process is repeated in 2005 and subsequent years, materials used for publicity and meetings are exhibited to lay out the process for future Hazard Mitigation Committees.

Process for Disaster Declaration in the City of Warwick

There are two phases to a disaster - first response and recovery. The recovery phase, or clean-up efforts, is where the majority of grant funds could be applied for. Having a Hazard Mitigation Plan in place before a disaster occurs, according to the U.S. Disaster Mitigation Act of 2000 and its amendments, is required after November 2004 in order to be eligible to apply for these recovery funds. These grant programs are briefly explained later in this chapter under the **Grant Programs for Disaster Relief** section.

FEMA Information

The Federal Emergency Management Agency (FEMA) has extensive resources related to disaster prevention and disaster recovery on its website at www.fema.gov. The following is an excerpt from their online library:

The first response to a disaster is the job of local government's emergency services with help from nearby municipalities, the state and volunteer agencies. In a catastrophic disaster, and if the governor requests, federal resources can be mobilized through the Federal Emergency Management Agency (FEMA) for search and rescue, electrical power, food, water, shelter and other basic human needs.

It is the long-term recovery phase of a disaster which places the most severe financial strain on a local or state government. Damage to public facilities and infrastructure, often not insured, can overwhelm even a large city.

A governor's request for a major disaster declaration could mean an infusion of federal funds, but the governor must also commit significant state funds and resources for recovery efforts. A major disaster could result from a hurricane, earthquake, flood, tornado or major fire which the President determines warrants supplemental federal aid. The event must be clearly more than State or local governments could handle alone. If declared, funding comes from the President's Disaster Relief Fund, which is managed by FEMA, and disaster aid programs of other participating federal agencies.

A Presidential Major Disaster Declaration puts into motion long-term federal recovery programs, some of which are matched by state programs, and designed to help disaster victims, businesses and public entities. An Emergency Declaration is more limited in scope and without the long-term federal recovery programs of a Major Disaster Declaration. Generally, federal assistance and funding are provided to meet a specific emergency need or to help prevent a major disaster from occurring.

The Major Disaster Process

A Major Disaster Declaration usually follows these steps:

1. The local government responds, supplemented by neighboring communities and volunteer agencies. If overwhelmed, turn to the state for assistance;

2. The State responds with state resources, such as the National Guard and state agencies;

3. Damage assessment by local, state, federal, and volunteer organizations determines losses and recovery needs;

4. A Major Disaster Declaration is requested by the governor, based on the damage assessment, and an agreement to commit state funds and resources to the long-term recovery;

5. FEMA evaluates the request and recommends action to the White House based on the disaster, the local community and the state's ability to recover;

6. The President approves the request or FEMA informs the governor it has been denied. This decision process could take a few hours or several weeks depending on the nature of the disaster.

Disaster Aid Programs

There are two major categories of disaster aid: *Individual Assistance* is for damage to residences and businesses or personal property losses, and *Public Assistance* is for repair of infrastructure, public facilities and debris removal.

Individual Assistance

Immediately after the declaration, disaster workers arrive and set up a central field office to coordinate the recovery effort. A toll-free telephone number is published for use by affected residents and business owners in registering for assistance. Disaster Recovery Centers are also opened where disaster victims can meet with program representatives and obtain information about available aid and the recovery process

Disaster aid to individuals generally falls into the following categories:

- Disaster Housing may be available for up to 18 months, using local resources, for displaced persons whose residences were heavily damaged or destroyed. Funding also can be provided for housing repairs and replacement of damaged items to make homes habitable.

- Disaster Grants are available to help meet other serious disaster related needs and necessary expenses not covered by insurance and other aid programs. These may include replacement of personal property, and transportation, medical, dental and funeral expenses.

- Low-interest Disaster Loans are available after a disaster for homeowners and renters from the U.S. Small Business Administration (SBA) to cover uninsured property losses. Loans may be for repair or replacement homes, automobiles, clothing or other damaged personal property. Loans are also available to businesses for property loss and economic injury.

- Other Disaster Aid Programs include crisis counseling, disaster-related unemployment assistance, legal aid and assistance with income tax, Social Security and Veteran's benefits. Other state or local help may also be available.

Assistance Process – After the application is taken, the damaged property is inspected to verify the loss. If approved, an applicant will soon receive a check for rental assistance or a grant. Loan applications require more information and approval may take up to several weeks after initial application. The deadline for most individual assistance programs is 60 days following the President's major disaster declaration.

Audits are done later to ensure that aid went only to those who were eligible and that disaster aid funds were used only for their intended purposes. These federal program funds cannot duplicate assistance provided by other sources such as insurance.

After a major disaster, FEMA tries to notify all disaster victims about the available aid programs and urge them to apply. The news media are encouraged to visit a Disaster Recovery Center, meet with disaster officials, and help publicize the disaster aid programs and the toll-free telephone registration number.

Public Assistance

Public Assistance is aid to state or local governments to pay part of the costs of rebuilding a community's damaged infrastructure. Generally, public assistance programs pay for 75% of the approved project costs. Public assistance may include debris removal, emergency protective measures and public services, repair of damaged public property, loans needed by communities for essential government functions, and grants for public schools.

Hazard Mitigation

Disaster victims and public entities are encouraged to avoid the life and property risks of future disasters. Examples include the elevation or relocation of chronically flood damaged homes away from flood hazard areas, retrofitting buildings to make them resistant to earthquakes or strong winds, and adoption and enforcement of adequate codes and standards by local, state and federal government. FEMA encourages and helps fund damage mitigation measures when repairing disaster damaged structures.

Grant Programs for Disaster Relief

Through the Rhode Island Emergency Management Agency, the Federal Emergency Management Agency provides funds for assistance to municipalities in the event of a disaster. The programs are described briefly here; some of them may not be currently active.

Emergency Management Assistance (EMA)

This proactive funding program requires a 50% match from communities. It supports projects that will improve local emergency management preparedness and response in the following areas: planning, training, drills and exercise, and administration. It is designed to fund projects such as Hazard Mitigation Plans, Emergency Management/Action Plans, and other administrative projects.

Mitigation Assistance Program (MAP)

This program requires a 25% match (in-kind or cash) and supports planning and implementation activities that reduce long-term hazard vulnerability and risk under the following categories: public awareness and education; mitigation planning and implementation; and preparedness and response planning.

Pre-Disaster Mitigation Program (PDM)

The Pre-Disaster Mitigation (PDM) program provides technical and financial assistance to States and local governments for cost-effective pre-disaster hazard mitigation activities that complement a comprehensive mitigation program, and reduce injuries, loss of life, and damage and destruction of property. FEMA provides grants to States and Federally recognized Indian tribal governments that, in turn, provide sub-grants to local governments (to include Indian Tribal governments) for mitigation activities such as planning and the implementation of projects identified through the evaluation of natural hazards.

Flood Mitigation Assistance Program (FMA)

This program requires a 25% match (half in-kind and half local cash) and awards funds for Planning Grants, Technical Assistance Grants, and Project Grants. A Flood Mitigation Plan must be in place before funds can be sought for Technical Assistance or Projects. This program awards funding for Flood Mitigation Plans, structural enhancements, acquisition of buildings or land, and relocation projects.

Community Development Block Grant (CDBG)

A disaster must be declared to take advantage of this program, which awards emergency funds to cover unmet needs in a community. At least one of three national objectives must be met: the funds must have a direct benefit to low and moderate income persons; or must prevent or eliminate slums and blight in neighborhoods; or must eliminate conditions which threaten the public health and welfare.

Hazard Mitigation Grant Program (HMGP)

A disaster must be declared to take advantage of this program, which is designed to protect public and private property from future disasters. This program typically awards funding for projects that are structural in nature or for the acquisition of buildings or land.

Chapter 16. Definitions and Acronyms

Definitions

Accretion – the deposition of sediment, sometimes indicated by the seaward advance of a shoreline indicator such as the water line, the berm crest, or the vegetation line.

Active beach – the portion of the littoral system that is frequently (daily or at least seasonally) subject to transport by wind, waves, and currents.

Algal bloom – a sudden increase in the amount of marine algae (seaweed) often caused by high levels of phosphates, nitrates, and other nutrients in the nearshore area.

Armoring - the placement of fixed engineering structures, typically rock or concrete, on or along the shoreline to reduce coastal erosion. Armoring structures include seawalls, revetments, bulkheads, and rip rap (loose boulders).

Backshore – the generally dry portion of the beach between the berm crest and the vegetation line that is submerged only during very high sea levels and eroded only during moderate to strong wave events.

Beach – an accumulation of loose sediment (usually sand or gravel) along the coast.

Beach loss – a volumetric loss of sand from the active beach.

Beach management district – a special designation for a group of neighboring coastal properties that is established to facilitate cost sharing and streamline the permitting requirements for beach restoration projects.

Beach narrowing – a decrease in the useable beach width caused by erosion.

Beach nourishment – the technique of placing sand fill along the shoreline to widen the beach.

Beach profile – a cross-sectional plot of a shore-normal topographic and geomorphic beach survey, usually in comparison to other survey dates to illustrate seasonal and longer-term changes in beach volume.

Berm – a geomorphologic feature usually located at mid-beach and characterized by a sharp break in slope, separating the flatter backshore from the seaward-sloping foreshore.

Building setback – the country-required seaward limit of major construction for a coastal property. Building setbacks on Maui vary from 25 feet to 150 feet landward of the certified shoreline.

Coastal dunes – dunes within the coastal upland, immediately landward of the active beach.

Coastal erosion – the wearing away of coastal lands, usually by wave attack, tidal or littoral currents, or wind. Coastal erosion is synonymous with shoreline (vegetation line) retreat.

Coastal plain – the low-lying, gently-sloping area landward of the beach often containing fossil sands deposited during previously higher sea levels.

Coastal upland – the low-lying area landward of the beach often containing unconsolidated sediments. The coastal upland is bounded by the hinterland (the higher-elevation areas dominated by bedrock and steeper slopes).

Day-use mooring – a buoy or other device to which boats can be secured without anchoring.

Deflation – a lowering of the beach profile.

Downdrift – in the direction of net longshore sediment transport.

Dune – a landform characterized by an accumulation of wind-blown sand, often vegetated.

Dune restoration – the technique of rebuilding an eroded or degraded dune through one or more various methods (sand fill, drift fencing, re-vegetation, etc.).

Dune walkover – light construction that provides pedestrian access without trampling dune vegetation.

Dynamic equilibrium – a system in flux, but with influxes equal to outfluxes.

Erosion – the loss of sediment, sometimes indicated by the landward retreat of a shoreline indicator such as the waterline, the berm crest, or the vegetation line.

Erosion hotspots – areas where coastal erosion has threatened shoreline development or infrastructure. Typically, the shoreline has been armored and the beach has narrowed considerably or been lost.

Erosion watchspots – areas where the coastal environment will soon be threatened if shoreline erosion trends continue.

Foreshore – the seaward sloping portion of the beach within the normal range of tides.

Hardening – see Armoring.

Inundation – the horizontal distance traveled inland by a tsunami.

Improvement districts – a component of a beach management district established to help facilitate neighborhood-scale improvement projects (e.g., beach nourishment).

Land banking – the purchase of shoreline properties by a government, presumably to reduce development pressure or to preserve the parcel as a park or as open space.

Littoral budget – the sediment budget of the beach consisting of sources and sinks.

Littoral system – the geographical system subject to frequent or infrequent beach processes. The littoral system is the area from the landward edge of the coastal upland to the seaward edge of the near-shore zone.

Longshore transport – sediment transport down the beach (parallel to the shoreline) caused by longshore currents and/or waves approaching obliquely to the shoreline.

Lost beaches – a subset of erosion hotspots. Lost beaches lack a recreational beach, and lateral shoreline access is very difficult if not impossible.

Monitoring – periodic collection of data to study changes in an environment over time.

Nutrient loading – the input of fertilizing chemicals to the nearshore marine environment, usually via non-point source runoff and sewage effluent. Nutrient loading often leads to algal blooms.

Offshore – the portion of the littoral system that is always submerged.

Overwash – transport of sediment landward of the active beach by coastal flooding during a tsunami, hurricane, or other event with extreme waves.

Revetment – a sloping type of shoreline armoring often constructed from large, interlocking boulders. Revetments tend to have a rougher (less reflective) surface than seawalls.

Risk – refers to the predicted impact that a hazard would have on people, services, specific facilities and structures in the community.

Risk management – the process by which the results of an assessment are integrated with political, economic, and engineering information to establish programs, projects and policies for reducing future losses and dealing with the damage after it occurs.

Scarp – a steep slope usually along the foreshore and/or at the vegetation line, formed by wave attack.

Scarping – the erosion of a dune or berm by wave-attack during a storm or a large swell.

Sea bags – large sand-filled geotextile tubes used in coastal protection projects.

Seawall – a vertical or near-vertical type of shoreline armoring characterized by a smooth surface.

Shoreline setback – see Building setback.

Siltation – the input of non-calcareous fine-grained sediments to the nearshore marine environment, or the settling out of fine-grained sediments on the seafloor.

Storm surge – a temporary rise in sea level associated with a storm's low barometric pressure and onshore winds.

Urban runoff – the input of hydrocarbons, heavy metals, pesticides and other chemical to the near shore marine environment from densely populated areas.

Vulnerability – the characteristics of the society or environment affected by the event that resulted in the costs from damages.

Vulnerability assessment – the qualitative or quantitative examination of the exposure of some component of society, economy or the environment to natural hazards.

Acronyms

FEMA	Federal Emergency Management Agency
HUD	Housing and Urban Development
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

Chapter 17. References

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Strategy for Reducing Risks from Natural Hazards in Warwick, Rhode Island

A Multi-Hazard Mitigation Strategy

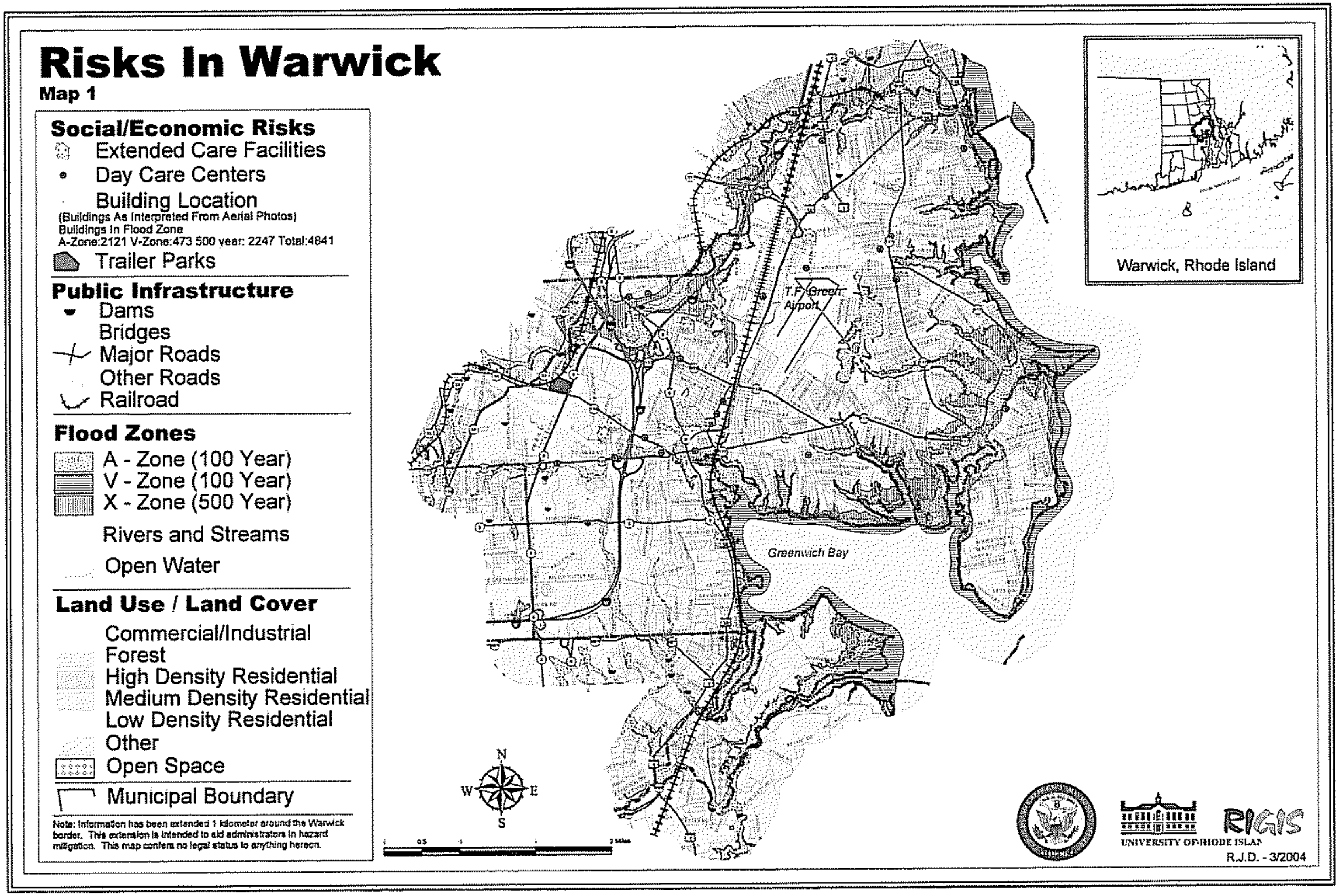
ATTACHMENT 1. MAPS

Map 1 – Risks in Warwick

This map depicts the land use in the City of Warwick; the social and economic risks; and the public infrastructure; and how these three factors relate with the flood zones in the City.

Map 2 – Critical Facilities in Warwick

This map depicts the critical facilities overlaid on a City of Warwick flood map. These two maps were combined to show the anticipated impact a 100-year flood would have on the critical infrastructure in the City.


Risks In Warwick
Map 1
Social/Economic Risks
Extended Care Facilities
Day Care Centers
Building Location
(Buildings As Interpreted From Aerial Photos)
Buildings In Flood Zone
A-Zone:2121 V-Zone:473 500 year: 2247 Total:4841
Trailer Parks
Public Infrastructure
Dams
Bridges
Major Roads
Other Roads
Railroad
Flood Zones
A - Zone (100 Year)
V - Zone (100 Year)
X - Zone (500 Year)
Rivers and Streams
Open Water
Land Use / Land Cover
Commercial/Industrial
Forest
High Density Residential
Medium Density Residential
Low Density Residential
Other
Open Space
Municipal Boundary
Note: Information has been extended 1 kilometer around the Warwick border. This extension is intended to aid administrators in hazard mitigation. This map confers no legal status to anything hereon.
T.F. Green Airport
Greenwich Bay
N
W
E
S
Warwick, Rhode Island
UNIVERSITY OF RHODE ISLAN
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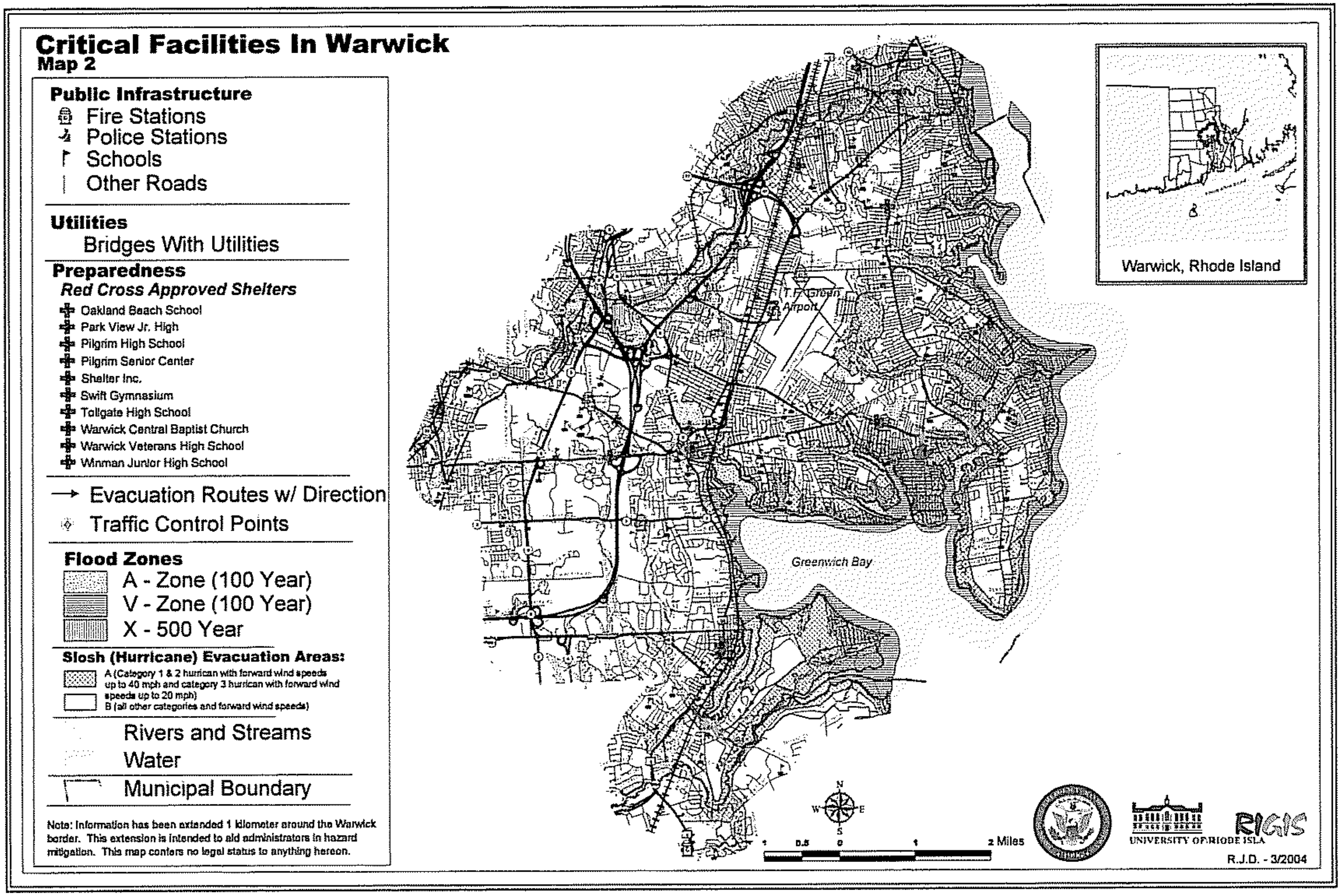
R.J.D. - 3/2004


Critical Facilities In Warwick
Map 2
Public Infrastructure
Fire Stations
Police Stations
Schools
Other Roads
Utilities
Bridges With Utilities
Preparedness
Red Cross Approved Shelters
Oakland Beach School
Park View Jr. High
Pilgrim High School
Pilgrim Senior Center
Shelter Inc.
Swift Gymnasium
Tollgate High School
Warwick Central Baptist Church
Warwick Veterans High School
Winman Junior High School
Evacuation Routes w/ Direction
Traffic Control Points
Flood Zones
A - Zone (100 Year)
V - Zone (100 Year)
X - 500 Year
Slosh (Hurricane) Evacuation Areas:
A (Category 1 & 2 hurrican with forward wind speeds up to 40 mph and category 3 hurrican with forward wind speeds up to 20 mph)
B (all other categories and forward wind speeds)
Rivers and Streams
Water
Municipal Boundary
Note: Information has been extended 1 kilometer around the Warwick border. This extension is intended to aid administrators in hazard mitigation. This map confers no legal status to anything hereon.
T.F. Green Airport
Greenwich Bay
Warwick, Rhode Island
N
W
E
S
1
0.5
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1
2 Miles
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RIGIS
R.J.D. - 3/2004