Exposure Score

Exposure includes all populations and assets that may be at risk from the natural hazards described above.

The exposures considered were divided into four major groups:

1) **Critical Facilities** includes marinas, emergency shelters, schools, hospitals, fire and rescue stations, police stations, water treatment or sewage processing plants, railroad stations and airports, and government facilities.

2) **Social Vulnerability** includes the population density, as well as tract-wide percentages on the percent of non-whites, of families below the poverty line, of elderly populations, of those with no high schooling, disabled adults, people on public assistance, those with no vehicles, renters, and percentage of non-english speakers. These categories correspond to social groups tracked by the U.S. Census, and were selected on this basis only.

3) **Environmental Resources** include the presence of rare species habitats, scenic vistas, and CERCLIS sites.

4) **Economic Values** include the value of construction, light manufacturing, wholesale, hotels and motels, agricultural lands, professional / technical programs, retail, banking, and domestic properties.

Overview of Scoring Procedure

The exposure score for each subregion was calculated using the following formula:

EXPOSURE SCORE = (EXPOSURE TYPE SCORE) *

(IMPORTANCE FACTOR)

The two factors that make up the exposure score are:

- **Exposure Type Score**. For each type of exposure, a lookup table was developed to relate some measure of the exposure value (such as population, dollar value, or number of facilities) to a common exposure index. In each case, a score of 1 corresponds to the lowest amount of exposure, and a score of 5 corresponds to the highest amount of exposure. Table 14 summarizes the different exposure type scores used in this study.

- **Importance Factor.** A factor, ranging from 0.85 to 1.3, was used to account for the critical nature of some types of exposure. This approach was developed such that it

was consistent with national building code standards, which assign a higher importance factor to critical facilities.

Table 13. Importance Factors for Exposure Scores

Occupancy Category	Importance Factor
I	0.85
II	1
III	1.2
IV	1.3

Table 14. Occupancy Categories

Occupancy	Category
Fire, Police, Medical Facilities	IV
Emergency Shelters (including some school buildings)	IV
Environmental CERCLIS sites	III
Major industrial sites	III
Schools (non-Emergency Shelters)	III
Other public utilities	II
Other structures	II

Once the scores for each sub-category of exposure were calculated, they were added together to evaluate the overall score for the exposure type. For example, to determine the overall Environmental Resources score, the scores of each of its subcomponents (scenic vistas, CERCLIS sites, and endangered species scores) were added. (note: CERCLIS is the online information database that lists sites covered under the CERCLA, or Comprehensive Environmental Response, Compensation, and Liability Act) The end result is an absolute score that allows comparison of relative environmental exposure factors between tracts.

Using this method, summary scores must be normalized by the number of sub-categories considered in order to compare the overall scores from different exposure types. Because each category has a varying number of sub-categories, each of which adds to the tract's final score, the summary scores are higher for those exposure types with more sub-categories considered. In other words, if there were 12 types of critical facilities counted and only 2 social factors counted, the absolute score for critical facilities would be much higher than the social score. Thus, the overall scores were divided by the number of sub-categories considered in order to provide normalized exposure scores for environmental, critical facilities, social vulnerability, and economic exposure.

Table 15. Lookup Tables for Exposure Scoring

Number of Sites	Lookup Table Score
0	0
1	1
2	2
3	3
4	4
5	5

Property Value	Value Score
0	0
500000	1
1000000	2
5000000	3
10000000	4
25000000	5

% Total Population	Lookup Table Score
0.00	0
5.00	1
15.00	2
25.00	3
35.00	4
45.00	5

Population Density (people/sq. mile)	Lookup Table Score
0	0
100	1
500	2
1500	3
5000	4
10000	5

Critical Facilities

- Marinas: The number of marinas was determined from the RIGIS "Marinas.shp" file. The Occupancy Code for marinas is II, resulting in a score of 1 in the ASCE 7-98 modifier column.

- Shelters: Shelter information came from the RIGIS file, "Public Safety.shp". The number of shelters was used to determine the basic exposure score in Table 15. This value was then multiplied by the shelter's Occupancy Code score of 1.3, resulting in a total exposure score.

- Schools: School information came from the RIGIS file, "Schools.shp". The number of schools was used to determine the basic exposure score in Table 15. This value was then multiplied by a school's Occupancy Code modifier score of 1.2, resulting in a total exposure score.

- Hospitals: Hospital information came from the RIGIS file, "Hospitals.shp". The number of hospitals was used to determine the basic exposure score in Table 15. This value was then multiplied by the hospital's Occupancy Code modifier score of 1.3, resulting in a total exposure score.

- Fire and Rescue Stations: Fire and Rescue information came from the RIGIS file, "Public Safety.shp". The number of stations was used to determine the basic exposure score in Table 15. This value was then multiplied by the station's Occupancy Code modifier score of 1.3, resulting in a total exposure score.

- Police Stations: Police Station information came from the RIGIS file, "Public Safety.shp". The number of stations was used to determine the basic exposure score in Table 15. This value was then multiplied by the station's Occupancy Code modifier score of 1.3, resulting in a total exposure score.

- Water Supply Points: Water supply point information came from the RIGIS files, "Sewer Pumping Points.shp" and "Water Pumping Points.shp". The number of points was used to determine the basic exposure score in Table 15. This value was then multiplied by the station's Occupancy Code modifier score of 1.2, resulting in a total exposure score.

- Rail Road Stations and Airports: Railroad station and airport information came from the RIGIS file, "Airports.shp". The number of stations was used to determine the basic exposure score in Table 15. This value was then multiplied by the station's Occupancy Code modifier score of 1.2, resulting in a total exposure score.

- Government Facilities: This information came from the RIGIS file, "Public Safety.shp". It includes local, state, and federal office buildings. The number of facilities was used to determine the basic exposure score in Table 15. This value was

then multiplied by the station's Occupancy Code modifier score of 1.2, resulting in a total exposure score.

Final Scores: The exposure scores for each of these categories was then added up and divided by 10, the total number of Critical Facility subcategories, for a normalized score.

Social Vulnerability

NOTE: All Social Factor scores were derived from the RIGIS file "Census1.shp". Social categories were chosen to represent different types of populations that would be at risk in a natural hazard situation.

- Population Density: Persons per square mile figures were extracted from the RIGIS database. This value was then compared to the Percent Population in Table 15 to yield an exposure score.

- Non-White: This score represents the percentage of non-white persons relative to the total population in each tract. This value was compared to the Percent Population in Table 15 to yield an exposure score.

- Family Below the Poverty Level: This score represents the percentage of families in each tract whom are below the poverty level. This value was compared to the Percent Population in Table 15 to yield an exposure score..

- Over 65: This score represents the percentage of elderly people in each tract. This value was compared to the Percent Population in Table 15 to yield an exposure score.

- Disabled Adults: This score represents the percentage of disabled adults in each tract. This value was compared to the Percent Population in Table 15 to yield an exposure score.

- No High School: This score represents the percentage of the total population in each tract that has not completed high school. This value was compared to the Percent Population in Table 15 to yield an exposure score.

- Public Assistance: This score represents the percentage of the total population of each tract who are on public assistance. This value was compared to the Percent Population in Table 15 to yield an exposure score.

- No Vehicle: This score represents the percentage of the total population of each tract who do not have access to a private vehicle. This value was compared to the Percent Population in Table 15 to yield an exposure score.

- Rental Units: This score represents the percentage of the total population of each tract who live in rental units. This value was compared to the Percent Population in Table 15 to yield an exposure score.

- Non-English Speaking: This score represents the percentage of the total population of each tract who cannot speak English. This value was compared to the Percent Population in Table 15 to yield an exposure score.

Final Scores: The exposure scores for each of these categories was then added up and divided by 10, the total number of Social Factors subcategories, for a normalized score.

Environmental Exposure

- CERCLIS Sites: CERCLIS is the online information database that lists sites covered under the CERCLA, or Comprehensive Environmental Response, Compensation, and Liability Act. Information for this category came from the "CERCLIS.shp" RIGIS file. This value then used the Number of Facilities Lookup in Table 15 to determine a preliminary score. This score was then multiplied by the lookup table value of the ASCE 98 Occupancy Code, which is 1.2 for CERCLIS sites, resulting in a final CERCLIS environmental resources exposure score.

- Rare Species: Information for this category came from the RIGIS file, "Rare Species.shp". This is described as the "estimated habitat and range of rare species and noteworthy natural communities". This file is a polygon file, which often overlapped many census tracts. To quantify this, it was necessary to clip the habitat polygons along the lines of each census tract border, resulting in a number of smaller habitat polygons contained within each tract. The number of polygons was counted and used as a rough proxy for the rare species habitat in a given tract. This value was recorded was compared to the Number of Facilities Lookup in Table 15 to determine the exposure score.

- Scenic Vistas: Information for this category came from the RIGIS file, "Scenic Areas.shp". This file is described as defining "areas in RI designated by the RIDEM as noteworthy or distinctive landscapes or views". Similar to the Rare Species file, this came in polygon format. The same method was used to break it apart and quantify their influence on a given tract as above. These values were recorded, then compared to the Number of Facilities Lookup in Table 15 to determine the exposure score.

Final Scores: The exposure scores for each of these categories was then added up to calculate an absolute Environmental Resources exposure score. This was then divided by 3 to compute a normalized score.

Economic Exposure

NOTE: All of the following information came from the 1997 Rhode Island Economic Census, which uses a Zip Code level of analysis. It was necessary to determine how many and which census tracts were in each zip code and then divide the total figure for a code by the number of tracts within it. Thus if a zip code had $1 million dollars in construction property in it, and it contained 10 census tracts, than the value for each tract would be $100,000 for the purposes of this analysis. Because the resolution of this data is lower, the figures included should not be taken as absolute. The following categories are those used by the U.S. Census Bureau to code business types across the country.

The procedure for calculating the scoring of each sub-category is identical. For each category, there are 4 quantities considered.

- Number of establishments in each tract
- Total value for all establishments in that category, for the entire zip code .
- Total value of establishments divided by the number of census tracts found within the zip code, resulting in a per tract valuation of each category
- The final value is the actual exposure score, which was determined by taking the valuation per tract and using the Property Value Lookup in Table 15 shown above.

Each individual economic category is described below:

- **Construction**: The US Census defines this category as "establishments primarily engaged in the construction of buildings and other structures, heavy construction (except buildings), additions, alterations, reconstruction, installation, and maintenance and repairs."
- **Manufacturing**: The US Census defines this category as "establishments that are engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products."
- **Wholesale**: The US Census defines this category as "establishments engaged in wholesaling merchandise, generally without transformation, and rendering services incidental to the sale of merchandise."

- **Hotels/Motels**: The US Census defines this category as "establishments providing customers with lodging and/or prepared meals, snacks, and beverages for immediate consumption."

- **Agriculture**: This category is defined as businesses that are involved with or dependant upon the growing, harvesting, producing, or processing food and food-stuffs from the land.

- **Professional/Technical Services:** The US Census defines this category as "establishments with payroll that specialize in performing professional, scientific, and technical activities for others. These activities require a high degree of expertise and training. The establishments in this sector specialize according to expertise and provide services to clients in a variety of industries and, in some cases, to households. Activities performed include: legal advice and representation; accounting, bookkeeping, and payroll services; architectural, engineering, and specialized design services; computer services; consulting services; research services; advertising services; photographic services; translation and interpretation services; veterinary services; and other professional, scientific, and technical services."

- **Retail**: The US Census defines this category as "establishments engaged in retailing merchandise, generally without transformation, and rendering services incidental to the sale of merchandise."

- **Financial**: The US Census defines this category as "establishments of firms with payroll primarily engaged in financial transactions (transactions involving the creation, liquidation, or change in ownership of financial assets)and/or in facilitating financial transactions."

- **Domestic**: Domestic property is all privately owned property within which people reside.

Final Scores: The exposure scores for each of these categories were added up to obtain an absolute Economic Value exposure score. This score was then divided by 8 to achieve a normalized score.

Combined Score

Combined scores were determined using the following formula:

COMBINED SCORE = (HAZARD SCORE) * (EXPOSURE SCORE)

A combined score was determined for each hazard/exposure combination at the census tract level. Statewide combined scores for each hazard/exposure combination were then determined by summing the census tract combined scores.

To study combined scores, tables and maps were created for the following quantities in each census tract:

- Total Absolute Hazard Score * Total Absolute Exposure Score
- Individual Hazard Scores * Total Absolute Exposure Score (i.e., seven tables, one for each hazard type)
- Individual Exposure Scores * Total Absolute Hazard Score (i.e., four tables, one for each exposure category)
- Individual Hazard Score * Individual Exposure Score (for several select groupings of hazards/exposures)

These tables allow the user to study the geographic distribution of combined scores for each individual exposure (subjected to all combined hazards), for each individual hazard (impacting all combined exposures), and for several key hazard/exposure combinations.

In addition, the following tables were created for the entire state, aggregating census tract scores to the statewide level:

- Individual Hazard Score * Individual Exposure Score (for every combination)
- Total Absolute Exposure * Total Absolute Hazard

These tables can be sorted and allow the user to determine the maximum individual hazard/exposure combinations on a statewide basis.

Mitigation Opportunities Analysis

The mitigation opportunities analysis is the interpretation of hazard, exposure, and combined score results in order to identify and prioritize actions to lower overall risk and improve preparedness to natural disasters.

Each state or region will have a different approach to this process, which should involve all important stakeholders in government and the private sector. The following approach was employed for this study, and is suggested for application in statewide level studies (higher resolution studies, such as community vulnerability assessments, should employ a more focused mitigation opportunities analysis such as that described in the NOAA CD-ROM):

- Determine the top exposure scores (e.g. the top 5)
- Prepare maps of top exposures multiplied by total hazard scores
- Determine the top hazard scores statewide (e.g. the top 2)
- Prepare maps of top hazards multiplied by total exposure scores
- Determine the top hazard/exposure combinations (e.g., the top 20 combined scores statewide)
- Create maps of top hazard/exposure combinations for the entire state.
- Determine distribution of key hazard/exposure combination scores by subregions.
- Consider statewide preparedness actions to handle social vulnerabilities identified for key hazards
- Consider statewide physical risk reduction measures (such as building code improvements) for hazards affecting critical facilities and economic exposures
- Encourage localized risk mitigation strategy development in high-scoring subregions
- Prepare more detailed studies, such as HAZUS-99 loss estimation models, for high scoring hazard/exposure combinations to better understand risk