PB 294681

NATURAL HAZARDS

SOCIO-ECONOMIC IMPACT ASSESSMENT MODEL

j.h.wiggins company

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50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. NSF/PRA-7509998/5	2.	3. Recipient's Accession No. PB294681

4. Title and Subtitle Natural Hazards: Socio-Economic Impact Assessment Model	5. Report Date July 1978
	6.
7. Author(s) J.C. Hirschberg, P. Gordon, W.J. Petak	8. Performing Organization Rept. No.
9. Performing Organization Name and Address J.H. Wiggins Company 1650 South Pacific Coast Highway Redondo Beach, California 90277	10. Project/Task/Work Unit No. 11. Contract(C) or Grant(G) No. (C) ERS7509998 (G) AEN7423992
12. Sponsoring Organization Name and Address Scientific, Technological, and International Affairs (STIA) National Science Foundation 1800 G Street, N.W. Washington, D.C. 20550	13. Type of Report & Period Covered 14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

The study reports on models that were used to measure the expected losses that could be associated with a variety of natural disasters. Data sources and data manipulations that were required to make the models operational are reviewed. The tenets of cost benefit analysis were adopted as a framework. The models are built on the premise that the probabilities of various disasters and the intensities of these disasters can be jointly predicted for future time periods for small regions. Values-at-risk are to be multiplied by the probabilities of each loss, for all levels of loss, with the results summed to yield "expected loss". The wealth-at-risk, once determined, had to be projected into the future using reasonable rate of wealth growth. At the same time, future losses had to be discounted to the present using similar rates. Secondary economic effects play a role on the demand side as well as on the supply side. It is presumed that the loss of productive capacity has an effect throughout the regional economy because of a removal of demand. The study reports on detailed multiplier effects which are computed from a set of regional and interregional input-output tables. On the supply side, it is suggested that many sellers will have to expand the range of their marketing. The study also reports on tests and applications of the methodology: sensitivity tests; tests on known historical disaster events; and actual cost-benefit analysis of selected mitigation measures

17. Document Analysis a. Descriptors

Hazards	Socioeconomic factors	Disasters
Mathematical models	Economic impact	Benefit cost analysis

b. Identifiers/Open-Ended Terms

Natural hazards

c. COSATI Field/Group

18. Availability Statement NTIS	19. Security Class (This Report)	21. No. of Pages 320
	20. Security Class (This Page)	22. Price A14 - A01

(See ANSI-Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

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NATURAL HAZARDS

SOCIO-ECONOMIC IMPACT ASSESSMENT MODEL

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ACKNOWLEDGEMENTS

The authors would like to express their appreciation to many who helped in the development and production of this report. Mark Thayer provided a complete technical review and technical editing support. Dorothy Kennedy performed much of the computational work used to support our findings and recommendations. Artist Shirley Kay and Chris Burch painstakingly prepared the many tables contained in the report. And Nancy Mulford worked diligently to ensure the typed document was without distracting errors and inconsistencies.

SUMMARY

This part of the study reports on models that were used to measure the expected losses that could be associated with a variety of natural disasters. Also reported on are data sources and data manipulations that were required to make the models operational. The tenets of cost benefit analysis were adopted as a framework and, as always, the actual accounting required methods tailored to the problem at hand. Finally, some non-economic indices of loss were also suggested. These were not added to the benefit cost framework since double-counting could have resulted; they are simply suggested as alternative measures of loss which might be useful to specific policy makers.

The models are built on the premise that the probabilities of various disasters and the intensities of these disasters can be jointly predicted for future time periods for small regions. That is, a probability distribution of the various intensities is presumed to be known and stable. Values-at-risk are to be multiplied by the probabilities of each loss, for all levels of loss, with the results summed to yield "expected loss."

This approach requires that the complete stock of wealth-at-risk, for all regions and all years, be tabulated. This is an immense task, made manageable by the methodologies that were put forward in the course of the study. The report details many of these approaches as well as the many data sources that had to be consulted.

The wealth-at-risk, once determined, had to be projected into the future using reasonsble rate of wealth growth. At the same time, future losses had to be discounted to the present using similar rates.

Yet, there are further economic effects. These were also considered. The secondary effects play a role on the demand side (of damaged facilities) as well as on the supply side. It is presumed that the loss of productive capacity has an effect throughout the regional economy because of a removal of demand. The study reports on detailed multiplier effects which are computed from a set of regional and interriongal input-output tables.

On the supply side, it is suggested that many sellers will have to expand the

range of their marketing if some customers are removed by the disaster event. Using standard market area analysis, it is shown that the transport costs of affected suppliers will approximately double. This is presented as a further secondary economic loss.

If we can presume that event trees can be used, then it follows that the probabilities to be placed on the branches and the associated losses that go with each branch can be determined from what has been outlined so far. Thus, a set of actual expected loss figures, in dollars, is obtainable.

The many data sources consulted, with minor additions, give rise to a number of alternate indicators. These are lives lost, levels of homelessness, levels of unemployment and homes lost. No attempt was made to place a dollar value on these items nor are they integrated into the overall benefit-cost study. Rather, expected events are measured on each of these four scales in order to present losses from a variety of angles.

The study also reports on tests and applications of the methodology. Sensitivity tests were accomplished by varying the geographic levels of data aggregation for some of the key model parameters. Changes in outcome that arose when national relationships were substituted for regional relationships were quite small. Given the enormous heterogeneity of the data base, this result was significant.

The models were also tested by applying them to known historical disaster events. Many of the model inputs for these events and, of course, the actual losses, are known. Comparisons of model predictions with actual outcomes were also encouraging.

Finally, the models were used to conduct actual cost-benefit analysis of selected mitigation measures The benefits are determined in terms of reduced losses from given intensities of a disaster event. An investment in mitigation, then, reduces the expected damage to any structure. The study suggests that if discounted benefits over a horizon period of fifty years or less after the improvement equal the cost of the mitigation, then that mitigation should be undertaken.

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Chapter One

A METHODOLOGY FOR EVALUATING THE IMPACTS OF NATURAL HAZARDS

Introduction

This chapter discusses a procedure for estimating and analyzing several quantifiable economic and social effects of natural disasters. The methodology presented here is a general procedure for all nine hazards studied and includes the following components:

- Statement of Methodology
- Projection of economic losses from extreme natural events
  - Probabilities of hazard intensity
  - Overview of risks under analysis
    - physical wealth at risk and probability of loss
    - income loss calculations
    - market area effects
    - life loss
    - housing impacts
    - unemployment

In subsequent chapters, the methodology is elaborated upon and is applied to nine specific hazards.

Statement of Methodology

The effects associated with the occurrence of an extreme natural event, such as an earthquake or hurricane, range from unnoticed to disastrous. The primary planning consideration for natural hazard mitigation is therefore some knowledge of expected hazard intensity.

Descriptive scenarios of particular events and annual loss figures are the two methods used most often for estimating the intensity and effects of future natural hazard events. They also provide the means for assessing the comparative benefits of various mitigation strategies. Since extreme natural events are rare but may be severe when they occur, they can be described through the use of a scenario of a specific historical event or hypothetical event in a particular location. The scenario approach can explore linkages between the natural hazard and the socio-economic system so that measures for the mitigation of future losses may be designed. For example, Ericksen [1975] presents an extensive discussion of natural hazard scenario methodology, and develops a flood scenario for Boulder, Colorado.

Scenario analysis alone, however, is subject to two shortcomings. First, the scenario portrays only unique events, and the probability of that event in magnitude can only be an arbitrary one. Historic information concerning natural hazards is limited in its ability to establish the periodicity of specific events. Therefore the scenario cannot provide data needed in preparing long term natural hazard mitigation policies which cover a broad enough range of disaster possibilities, although it does provide insight into the potential sudden loss.

Second, a scenario is location-specific. Knowing the impact of an earthquake of a particular intensity in one location is no assurance that it will have identical effects in another. Once again, the scenario alone is insufficient as a basis for policy formulation over an extended area and time.

This study, which primarily utilizes the annual loss methodology, overcomes the problem of specificity to some extent by first employing an annual probability of occurrence of a natural disaster at varying magnitudes. Over the long run, these probabilities would closely approximate intensity and frequency levels approaching those of real events. The limitations of such location specificity are overcome in the present project by deriving expected annual losses for each county in the United States for annual increments to the year 2000. Thus, the largest geographical unit for which any potential hazard is examined is the county--except for tsunami, where computations are made on a coastal community basis; and riverine flooding, whose regional computations are constructed based upon a model developed by Friedman [1975].

It must be noted, however, that in contrast to a scenario analysis the relative infrequency and discontinuity in scale of many natural events makes annual average losses somewhat difficult to relate to specific past events. The differences in the frequency and magnitude of occurrence of two major hazards are depicted in Figures 1-1 and 1-2, in which losses from particular earthquakes and hurricanes are shown in constant dollars lost since 1929. Figure 1-1 illustrates that earth-

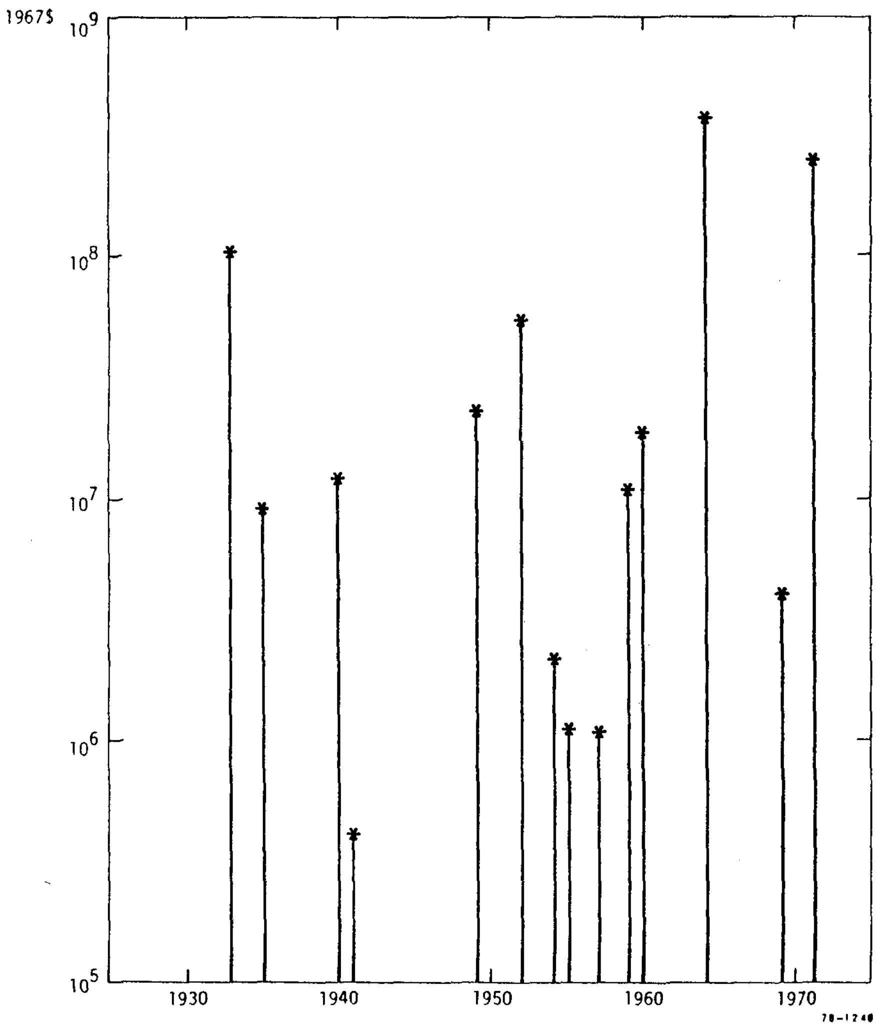

Figure 1-1. Earthquake Losses 1933 - 1971
[Disaster Preparedness, 1972]

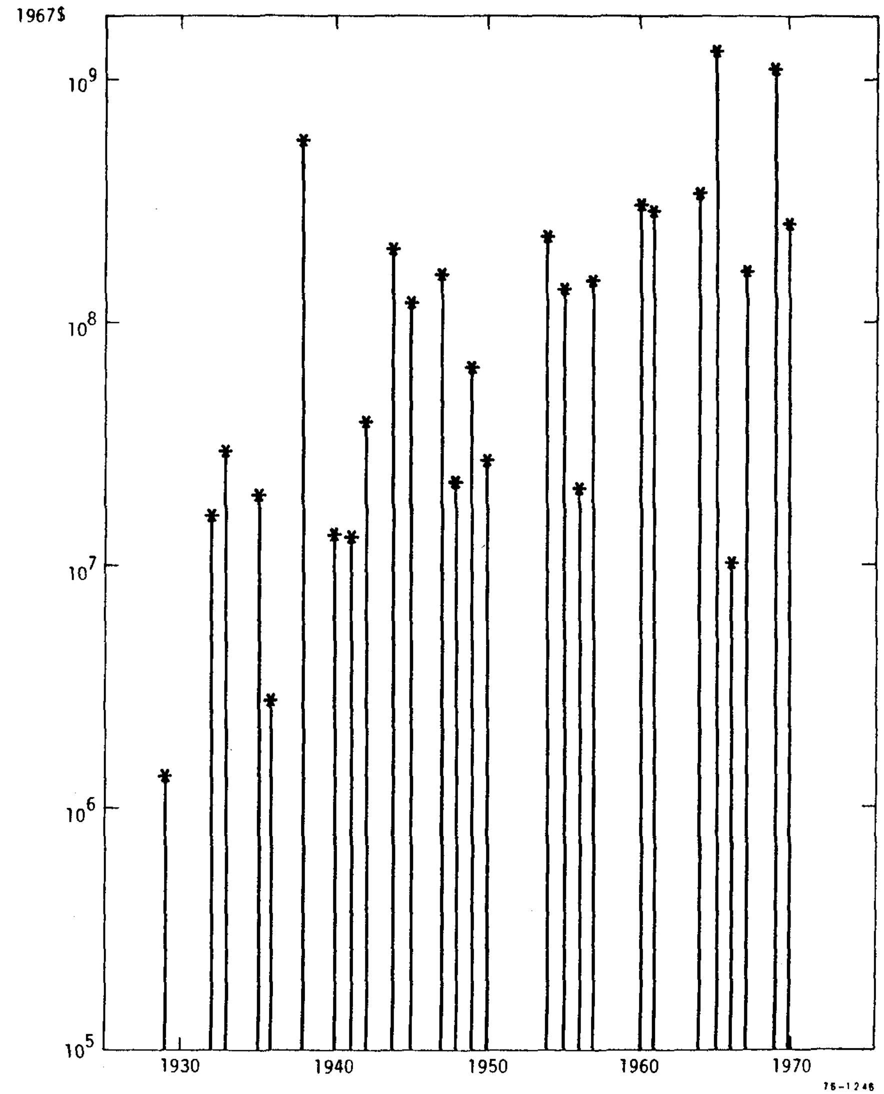

Figure 1-2. Hurricane Losses 1929 - 1970
[Sugg, et al, 1971]

quakes, while they occur relatively infrequently in the United States, cause losses subject to wide variation. The vertical axis is a logarithmic scale which tends to distort the variation in magnitude. By comparing the two figures, the differences in frequency and severity become apparent, with hurricanes being the more frequent and consistently severe hazard.

Therefore, the annual loss approach is used in this study for estimating the intensity and effects of natural events. This procedure also provides comparative measures of mitigation benefits which are borne in a steady manner over a number of years. That is, aggregated present value computations of annual losses are discounted at various rates and compared to the aggregated discounted savings resulting from the implementation of specific mitigations. The resulting net benefits are compared to expected losses occurring as a result of natural hazards, calculated on an annual basis and aggregated by region and economic sector.

This report describes a general system methodology for the design of an expected loss model (based on computer modelling) to calculate impacts of different natural events in a uniform manner for the entire United States. A description of the techniques and data used to develop the computer model is presented and finally the results from the implementations of the model are presented by hazard, target year, region, damage state, and economic sector in the appendices.

Some scenario analyses were performed with the use of some modifications to the annual loss model. These are detailed in Chapter 8.

The use of computer models to simulate hazard impacts has been well documented by Friedman [1975]. Specifically, the riverine flooding model employed in estimating losses for this project is a modification of a model originally constructed by Friedman [Lee, 1976]. Other models of the type proposed here which deal with the economic impacts of the environment, namely, climatic impacts, are discussed by Mannders [1974] in his review of Econoclimatic models.

Projecting Losses from Natural Disasters

This section is concerned with the extent of damage to building and contents and various other socio-economic impacts which may flow from various natural events. Methodologically, these expected damages are the product of the value in dollars of buildings and contents subject to risk, multiplied by the probability of various levels of loss from a given occurrence. Thus, two sets of information must be developed. The first set consists of annual probabilities of occurrence for each of the nine natural hazards studied in this project, with each occurrence further refined by assessing a probability of various intensities; the other set of data provides the dollar value of the items at risk.

This approach does not diminish uncertainty about the future, but rather it points to a long-range decision rule: in the long run, the value of what will be lost due to a natural event is the value of items at risk (exposure) multiplied by the various probabilities of levels of loss (hazard-vulnerability). This notion is not intended to define the consequences of any specific event, but to provide policy makers with a set of "expected" losses over an extended period of time.

Once the value of the items subject to a level of risk is determined, it is possible to derive the expected annual loss by multiplying the amount at risk by the probability of loss, and summing over all contingencies. This series of calculations is illustrated in the form of an event tree shown in Figure 1-3. The probabilities placed on the branches represent the likelihood of a specific natural event occurring of a particular intensity. This means that there is a set of contingencies - intensities of a hazard - each shown as a branch and each having an annual probability of occurrence. The sum of the elements of the right hand column represents the annual expected dollar loss for a specific location from all natural hazards. Again it should be noted that this expected value does not represent loss from any specific event, but is the average value of loss over an extended period based on the probabilities developed by the natural hazard models and assigned to the branches of the event tree.

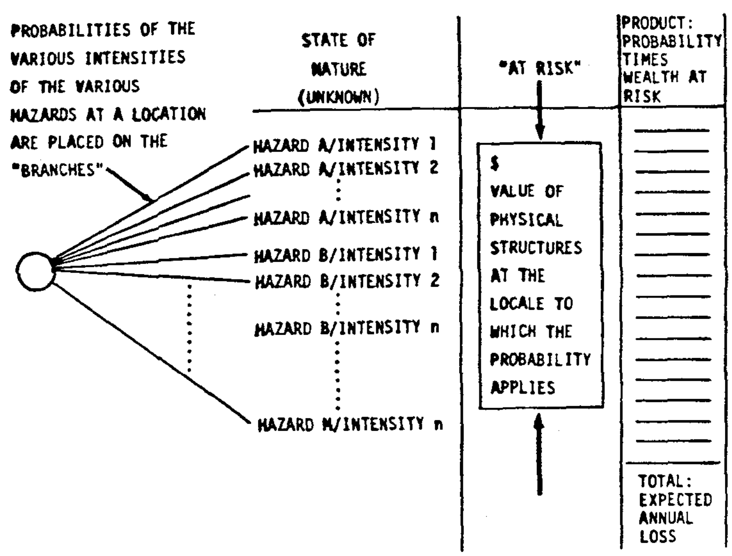

Figure 1-3. Event Tree for Deriving Expected Loss from Probabilities of Extreme Natural Events

The probabilities of "annual states of nature" (annual probabilities of intensities) are available from natural hazard models and the historical record. However, the determination of the dollar value of items at risk is a much more subtle economic problem. Care must be taken to account for all relevant dimensions of value. At the same time, double-counting must be avoided. Finally, once the dimensions of the factors at risk have been catalogued, they must be given an accurate dollar valuation. Such valuations are obvious in some instances and elusive in others. For instance, the cost of wealth destroyed can be measured in terms of the costs of replacement, however, the cost of interruption of production requires a more complex analysis.

Hazard Intensity Probabilities

The first calculation required to develop the natural hazard loss model is to generate estimates of annual probabilities of occurrence for an event of various intensities for a defined geographic area. In this study, regional areas are generally defined by county boundaries, except for tsunami, which uses coastal communities as its regions, and riverine flooding, which uses a set of community sizes defined by groups of states.

The probabilities can be defined as a set of Intensity Probability Vectors (I_{hr}) of the form:

$$I_{hr} = \begin{bmatrix} \iota_1 \\ \iota_2 \\ \iota_3 \\ \cdot \\ \cdot \\ \cdot \\ \iota_J \end{bmatrix}_{hr} \qquad (1\text{-}1)$$

where

ι_j = annual probability than an event will occur of level or intensity j

J = total number of intensity levels of the hazard (varies by hazard):

h = hazard:

r = region (definition varies by hazard - usually a county).

Table 1-1 provides a brief listing of the parameters used to establish measures of intensity for purposes of examining the consequences of the nine hazards considered in this study. Because the factors causing each hazard and the effects of occurrence may vary widely, the measures of intensity also vary widely. All, however, are designed to yield levels of damage to buildings and contents through the operation of a loss model developed for this study.

Earthquake intensity is generally based upon the use of the Modified Mercalli Intensity scale, which categorizes the earthquake's surface effects as perceived by the impacted population. It should be noted that this scale is quite different from the Richter scale which measures geophysical force.

The landslide intensity model is based on the relationship of topography, bedrock, and precipitation. Topographic relief is important because it regulates surface stream erosion and other energy sources, and because of the exponentially increasing effects of gravity with increasing slope. As bedrock strength decreases or is influenced by natural or man-made changes in energy conditions, landslides may occur more readily. Precipitation largely affects the distribution and occurrence of landslides in terrain conditioned by the other two factors.

For expansive soil, the Coefficient of Linear Extensibility (COLE) scale developed by the Soil Conservation Service was used to identify intensities. The COLE scale is basically an estimate of the vertical component of swelling in a natural soil clod due to changes in water content and mix of clay and materials. All the earth-related hazards described above are further documented in Wiggins [1976].

Intensities of the three water hazards (storm surge, riverine flood, and tsunami) are given in terms of depth-probability curves derived from combinations of environmental conditions and site modifications. Lee, et al. [1976] provides complete detail of the water hazard models.

*The results presented in this report for landslide were obtained from the landslide data prepared by Krohn and Slosson. Subsequently, a modification of this data was made through the incorporation of a later USGS study and these results appear in Wiggins [1976].

HAZARD	INTENSITY MEASURE	DESCRIPTION	REFERENCE
EARTHQUAKE	MODIFIED MERCALLI SCALE	TWELVE CATEGORIES OF EARTHQUAKE EFFECTS, BRIEFLY IDENTIFIED HERE BY THEIR STRUCTURAL EFFECTS. MORE DETAIL MAY BE FOUND IN YANEV (1974) I NOT FELT BY PEOPLE II SUSPENDED OBJECTS MAY SWING III HANGING OBJECTS SWING I VIBRATION SIMILAR TO THE PASSING OF HEAVY TRUCKS V SMALL, UNSTABLE OBJECTS SHIFTED OR UPSET. DOORS CLOSE OR OPEN VI POORLY BUILT BUILDINGS MAY BE DAMAGED, AND WEAK PLASTER WALLS MAY CRACK VII SLIGHT-TO-MODERATE DAMAGE TO WELL-BUILT ORDINARY STRUCTURES VIII CONSIDERABLE DAMAGE TO WELL-BUILT ORDINARY STRUCTURES IX INTERIOR DAMAGE IS CONSIDERABLE IN SPECIALLY-DESIGNED EARTHQUAKE-RESISTANT STRUCTURES X MOST MASONRY AND MANY FRAME STRUCTURES ARE DESTROYED XI FEW, IF ANY, MASONRY STRUCTURES REMAIN STANDING. OTHERS SEVERELY DAMAGED XII DAMAGE IS TOTAL	YANEV (1974)
EXPANSIVE SOIL	EXTENSIBILITY (COLE) SCALE	COLE ESTIMATES THE VERTICAL COMPONENT OF SWELLING IN A NATURAL SOIL CLOD. THE LEVELS OF INTENSITY ARE BASED ON THE EXTENT OF CLAY AND MINERAL CONTENT: INTENSITY — COLE VALUE HIGH — > 6% MODERATE — 3 - 6% LOW — < 3%	WIGGINS (1976)
LANDSLIDE	TOPOGRAPHY, BEDROCK AND PRECIPITATION	LANDSLIDE POTENTIAL IS A FUNCTION OF ADVERSE (LANDSLIDE-PRONE) BEDROCK FUNCTIONS AND THE DEGREE OF TOPOGRAPHIC RELIEF: POTENTIAL = FORMATION + RELIEF HIGH — ADVERSE — STEEP MODERATE — ADVERSE — MODERATE LOW (STEEP) — NOT ADVERSE — STEEP LOW — NOT ADVERSE — MODERATE LOW — NOT ADVERSE — LOW LOW — ADVERSE — LOW THESE RATINGS ARE ASSIGNED AN INTENSITY BASED ON THE AMOUNT OF ANNUAL RAINFALL: POTENTIAL — RAINFALL — INTENSITY HIGH — OVER 32" — XII HIGH — 8 - 32" — X HIGH — 0 - 8" — IV MODERATE — OVER 32" — XI MODERATE — 8 - 32" — IX MODERATE — 0 - 8" — III LOW (STEEP) — OVER 32" — VIII LOW (STEEP) — 8 - 32" — VI LOW (STEEP) — 0 - 8" — II LOW — OVER 32" — VII LOW — 8 - 32" — V LOW — 0 - 8" — I	WIGGINS (1976)

Table 1-1. Hazard Intensity Measures

<table>
<tr><th>HAZARD</th><th>INTENSITY MEASURE</th><th>DESCRIPTION</th><th>REFERENCE</th></tr>
<tr><td>STORM SURGE</td><td>DEPTH-PROBABILITY CURVE</td><td>THE DEPTH-PROBABILITY CURVE IS AN AGGREGATION OF THE FOLLOWING FACTORS:

ENVIRONMENTAL CONDITIONS: METEOROLOGICAL CONDITIONS; PRESSURE EFFECT; ONSHORE WIND EFFECT; CORIOLIS EFFECT; WAVE EFFECT; RAINFALL EFFECT

SITE MODIFICATIONS: LOCAL BATHYMETRY; COASTAL ORIENTATION; COASTAL IRREGULARITIES; LOCATION OF STRUCTURES; LOCATION OF ADJACENT BUILDINGS; ENGINEERING WORKS</td><td>LEE (1976)</td></tr>
<tr><td>RIVERINE FLOOD</td><td>DEPTH-PROBABILITY CURVE</td><td>ENVIRONMENTAL CONDITIONS: PHYSIOGRAPHY; METEROLOGICAL CONDITIONS; EXTENT OF UPSTREAM WATERSHED; CLIMATE; VEGETATION AND SURFACE CONDITIONS; RESERVOIRS, LAKES; CHANNEL LENGTHS AND DRAINAGE AREA SLOPE; DEGREE OF URBANIZATION IN WATERSHED

SITE MODIFICATIONS: LOCATION OF STRUCTURES; PRESENCE OF ENGINEERING WORKS; LOCAL SLOPE AND CHANNEL CONSTRICTIONS</td><td>LEE (1976)</td></tr>
<tr><td>TSUNAMI</td><td>DEPTH-PROBABILITY CURVE</td><td>ENVIRONMENTAL CONDITIONS: TECTONIC MOTION OF EARTH; IGNEOUS ACTIVITY OF EARTH; LANDSLIDES

SITE MODIFICATIONS: COASTAL IRREGULARITIES; LOCATION OF STRUCTURES</td><td>LEE (1976)</td></tr>
<tr><td>TORNADO</td><td>FUJITA-PEARSON TORNADO SCALE</td><td>CHARACTERISTICS OF TORNADOES ARE EXPRESSED AS A COMBINATION OF FUJITA-SCALE WIND SPEED IN MILES PER HOUR, AND THE PEARSON-SCALE OF PATH LENGTH AND WIDTH. THE FOLLOWING WIND SPEED STATES ARE IDENTIFIED:

STATE NO. / FUJITA RATING / REPRESENTATIVE WIND SPEED (MPH) / RANGE OF WIND SPEEDS
1 / F0 / 50 / 40 - 72
2 / F1 / 100 / 73 - 112
3 / F2 / 150 / 113 - 157
4 / F3 / 200 / 158 - 206
5 / F4 / 250 / 207 - 260
6 / F5 / 300 / 261 - 318</td><td>HART (1976)</td></tr>
<tr><td>HURRICANE</td><td>FRECHET EXTREME WIND MODEL</td><td>A CUMULATIVE PROBABILITY DISTRIBUTION OF COASTAL REGION HURRICANE WINDS

STATE NO. / REPRESENTATIVE WIND SPEED (MPH) / RANGE OF WIND SPEED
1 / 75 / 73 - 87.5
2 / 100 / 87.5 - 112.5
3 / 125 / 112.5 - 137.5
4 / 150 / 137.5 - 175.0
5 / 200 / 175.0 - 225.0
6 / 250 / 225.0 - 275.0
7 / 300 / 275.0 - 325.0</td><td>HART (1976)</td></tr>
<tr><td>SEVERE WIND</td><td>WIND SPEED</td><td>DAMAGE STATES WERE BASED ON EIGHT WIND STATES DERIVED FROM PROBABILITIES OF HOURLY WIND SPEEDS:

INTENSITIES: 50 75 100 125 150 200 250 300</td><td>HART (1976)</td></tr>
</table>

Table 1-1. Hazard Intensity Measures (continued)

Wind hazards are defined in terms of probabilites of different wind speed categories. The severe wind probabilities were derived from means and variances of seasonal winds by region, through the use of a particular cummulative probability distribution. Hurricane wind was modeled in a similar manner except the regions examined were along the Gulf and Atlantic coast. For tornado, the raw data was in the form of frequencies of occurrence of tornadoes distributed by region. For further details of these methods see Hart [1976].

Any event of any given intensity can lead to any number of damage states. Thus, the event tree requires an additional element or another set of branches which yields a somewhat more complex structure as is shown in Figure 1-4.

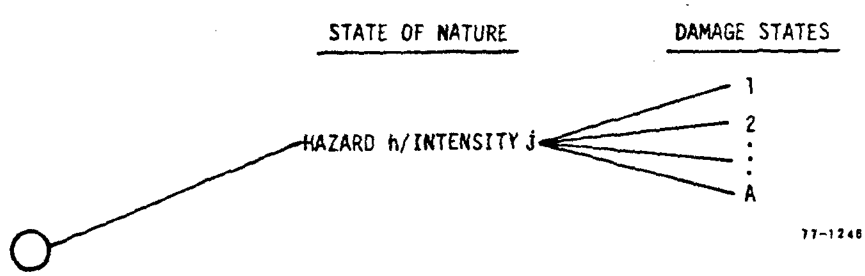

Figure 1-4. Event Tree for Deriving Expected Damage States from Given Intensity Levels for Extreme Natural Events

Since probabilities are placed on each set of branches, the hazard event intensity has a particular probability of occurrence and, thus, the various damage states have a conditional probability of occurrence for each level of intensity.

Mathematically, the Intensity Probability Vector (I_{hr}) is extended in the same manner to include levels of damage and can be presented in the form of a matrix. This "Damage Probability Matrix" (D_{hk}) has as its elements the probabilities that events of specific incremental levels of intensity will produce specific incremental levels of damage. Table 1-2 is an example of a Damage Probability Matrix derived from Whitman [1974] for earthquakes*.

RATIO OF REPAIR COST TO REPLACEMENT COST		DAMAGE STATE	DAMAGE STATE PROBABILITY BY MODIFIED MERCALLI INTENSITY						
CENTRAL VALUE	RANGE		V	VI	VII	VII.5	VIII	IX	X
0.0	0.0 - 0.05	1 - None	1.00	0.27	0.15	0.00	0.00	0.00	0.00
0.3	0.05 - 1.25	2 - Light	0.00	0.73	0.48	0.21	0.00	0.00	0.00
5.0	1.25 - 20.0	3 - Moderate	0.00	0.00	0.33	0.45	0.25	0.00	0.00
30.	20.0 - 65.0	6 - Heavy	0.00	0.00	0.04	0.29	0.41	0.00	0.00
100.	65.0 - 100.0	7 - Total	0.00	0.00	0.00	0.05	0.34	0.75	0.25
100.	100.0	8 - Collapse	0.00	0.00	0.00	0.00	0.00	0.25	0.75

Table 1-2. Damage Probability Matrix for Earthquake, Building % UBC 0.1 CODE [Whitman, et al, 1974] This is a conditional probability table.

From Table 1-2 it can be seen that each intensity of the earthquake (given in Modified Mercalli Intensity units V - X) has associated distribution of damage states, which refer to amounts of damage inflicted on buildings meeting Uniform Building Code (UBC) specifications for the different seismicity zones 0 and 1. Thus, for an earthquake of intensity VI there would be an 0.27 probability of incurring damage state 1 and an 0.73 probability of incurring damage state 2. Replacement cost (as used in this study) is the present cost of constructing a building identical to the one destroyed. For each damage state, the ratio of repair to replacement cost varies over a given range. For example, the range of building damage for damage state 3 varies from 1.25% to 20% of replacement cost, with a central or median value of 5%. The central value assumes a lognormal probability distribution of percents of losses.

Generalizing this technique to encompass other hazards and building types for a range of disaster intensities and resulting damage states, we obtain

$$D_{hk} = \begin{bmatrix} \delta_{11} & \delta_{12} \ldots & \delta_{1J} \\ \delta_{21} & \delta_{22} \ldots & \delta_{2J} \\ \cdot & & \\ \cdot & \delta_{aj} & \\ \cdot & & \\ \delta_{A1} & \delta_{A2} \ldots & \delta_{AJ} \end{bmatrix}_{hk} \qquad (1\text{-}2)$$

*Chambers and Rogers [1974] have performed damage analysis in a similar manner in which they also estimate losses by level of damage for flood losses.

where

δ_{aj} = probability that an intensity j event (of the particular disaster) will cause a damage state a;

J = number of event intensities (varies with hazard);

A = number of damage states;

D_{hk} = Damage Probability Matrix for hazard h and building type k.

In (1-4), we derive the annual probability for a given hazard, region and building type, that a particular damage state will occur. This is described as an Annual Damage State Vector (S_{hrk}). For the model developed in this study, S_{hrk} is not time dependent, since we assume the annual probabilities of each hazard intensity are constant:

$$S_{hrk} = \begin{bmatrix} \sigma_1 \\ \sigma_2 \\ \cdot \\ \cdot \\ \cdot \\ \sigma_A \end{bmatrix}_{hrk} \qquad (1\text{-}3)$$

σ_a = probability that damage state a will occur to building type k, from hazard h, in region r in any year;

S_{hrk} = annual damage state vector for hazard h, region r, and building type k.

Given the Intensity Probability Vectors for a region and hazard, and the Damage Probability Matrix for a hazard and structure type, the Annual Damage State Vector can be derived as follows:

$$S_{hrk} = D_{hk} \times I_{hr} \qquad (1\text{-}4)$$

or

$$\begin{bmatrix} \sigma_1 \\ \sigma_2 \\ \cdot \\ \cdot \\ \cdot \\ \sigma_A \end{bmatrix}_{hrk} = \begin{bmatrix} \delta_{11} & \delta_{12} & \ldots & \delta_{1J} \\ \delta_{21} & & & \\ \cdot & & & \\ \cdot & & & \\ \cdot & & & \\ \delta_{A1} & \ldots & & \delta_{AJ} \end{bmatrix}_{hk} \times \begin{bmatrix} \iota_1 \\ \iota_2 \\ \cdot \\ \cdot \\ \cdot \\ \iota_J \end{bmatrix}_{hr} \qquad (1\text{-}5)$$

thus

$$\begin{array}{llll} \sigma_1 = \delta_{11}\,\iota_1 + \delta_{12}\,\iota_2 + \ldots + \delta_{1J}\,\iota_J \\ \cdot \quad \cdot \quad \cdot \quad \cdot \\ \cdot \quad \cdot \quad \cdot \quad \cdot \\ \cdot \quad \cdot \quad \cdot \quad \cdot \\ \sigma_A \quad \delta_{A1}\,\iota_1 + \delta_{A2}\,\iota_2 + \ldots + \delta_{AJ}\,\iota_J \end{array} \qquad (1\text{-}6)$$

The above series of calculations reflect multiplication along the branches of the event tree (Figure 1-4). The probability of a specific damage state is the sum of the probabilities of the hazard intensities which result in the particular level of damage. Consequently, total annual building loss estimates can be derived with the aid of the total damage state vector. This process has converted the probabilities of intensities into corresponding probabilities of damage states, given the damage density matrix for a particular structure type. A new set of branches will reflect a summation of the damage state probabilities of types of building loss.

To determine these annual building losses, the loss increment associated with each damage state is needed. For example, in the earthquake example, the first column in table 1-2 gives the ratios of repair to replacement value for each damage state. These ratios can be used to describe physical damage to buildings given the occurrence of a particular damage state.

For example, if a hypothetical vector of earthquake intensity probabilities for a region is:

MODIFIED MERCALLI INTENSITY* (probability of occurrence/year)

V	VII	VII	VII.5	VIII	IX	X
.500	.100	.050	.025	.010	.005	.001

The computation of S = D X I using the data in Table 1-2 would be

$$S = \begin{bmatrix} .535 \\ .012 \\ .041 \\ .013 \\ .009 \\ .003 \end{bmatrix} = \begin{bmatrix} 1.00 & .27 & .15 & .00 & .00 & .00 & .00 \\ .00 & .73 & .48 & .21 & .00 & .00 & .00 \\ .00 & .00 & .33 & .45 & .20 & .00 & .00 \\ .00 & .00 & .04 & .29 & .41 & .00 & .00 \\ .00 & .00 & .00 & .05 & .34 & .75 & .25 \\ .00 & .00 & .00 & .00 & .05 & .25 & .75 \end{bmatrix} X \begin{bmatrix} .500 \\ .100 \\ .050 \\ .010 \\ .005 \\ .001 \end{bmatrix} \quad (1-7)$$

Thus, the probabilities of the *third damage state occurring to this type building*, in this region, due to this hypothetical event, would be .041/yr.

Overview of Risks

The intensity of a hazard will result in specific losses to buildings and their contents, losses in income, and an increase in transportation costs caused by supplier losses. Other "social" losses are identified as life loss, homelessness, and unemployment, and are not affixed dollar values. Both sets of losses are derived from the expected loss in building wealth. The order of computation for assessing these hazard effects or impacts is shown in Figure 1-5. Specifically, the impacts progress from the physical phenomenon alone to aggregate economic and social costs. The wealth losses and most deaths are concurrent, whereas

*These values are purely for computational expedience no implementation of actual distribution of these values is implied.

the income losses, unemployment, and homelessness occur over time.

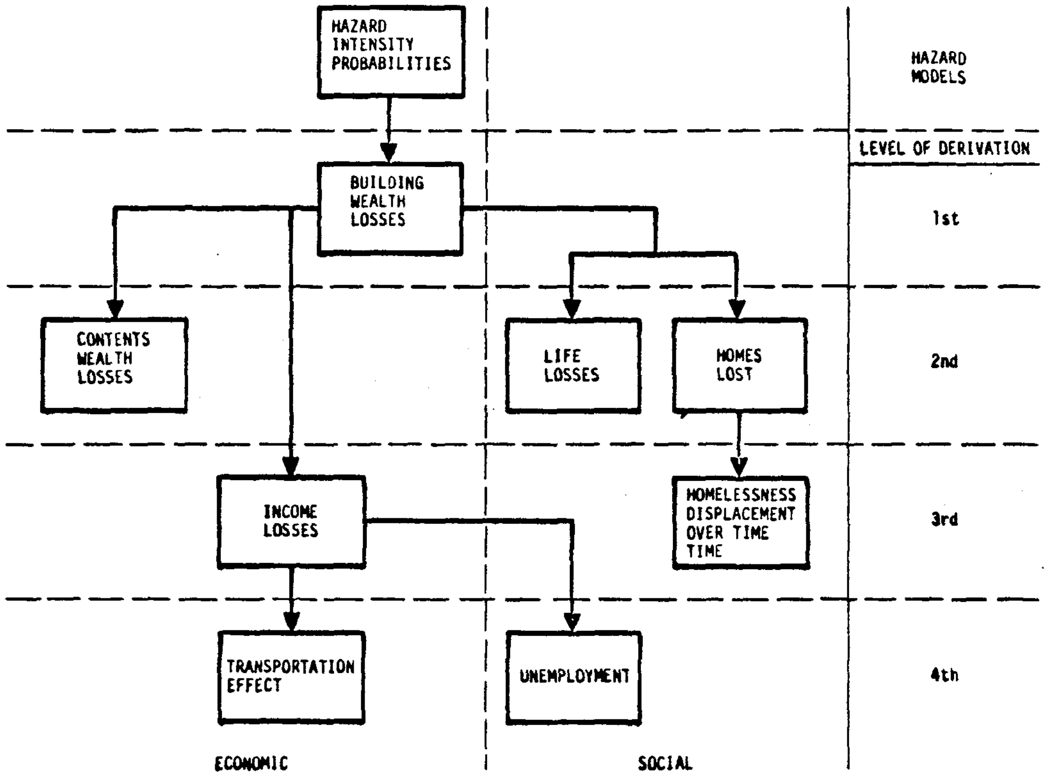

Figure 1-5. Comprehensive Risk Assessment Methodology by Order of Computation.

Building wealth losses are measured as a function of "Damage Rates," or the proportion of replacement value required for building repair. The damage rates, a function of hazard intensity, are applied to buildings of various types and to building contents within particular sections of the local economy. The repair to replacement ratios described in the previous section are a form of damage rate for building wealth.

Expected income losses are estimated through the use of a regional multi-sector model of income determination, where eleven sectors are considered (i.e., farming, construction, manufacturing, etc.), and the regions are defined as states or counties. These estimates are computed by including damage and time of inoperation relationships, which allow estimation of loss of product due to the inactivity of productive capital.

A fourth expected dollar loss (transportation effect) investigated is the loss to a purchaser (even though he did not sustain direct damage) who incurs a loss due to increased transportation costs which are required to obtain a product no longer available when the present supplier suffers direct damage from the occurrence of the natural event.

In addition to the losses in economic terms (dollars) some of the effects of natural hazards are described in the form of non-economic relationships. For example, a level of "homelessness" is estimated in terms of estimated person-days of dislocation resulting from a specific hazard. Another such aspect is the projected unemployment associated with an event. This is quantifiable in economic terms, but is not included in the economic loss calculation since product loss computations already account for this part of wealth loss. Adding expected unemployment to the loss computations would be an example of double counting, because the income loss computation already accounts for this loss. Nevertheless, this dimension of loss must be examined and it is considered in this study as a social impact of natural hazards. In addition to the social and economic losses identified, expected levels of life loss are predicted. They could also be quantified as part of the economic calculations (given a dollar value), but are simply itemized in terms of numbers of lives lost as a function of a given natural hazard. This is done because the controversy over the proper economic measure of life loss has not been adequately settled.

Components of Physical Wealth at Risk

One of the direct consequences of a natural hazard event is loss to "physical wealth" or the market value of destroyed tangible assets. Potential savings in physical wealth loss attributable to specific natural hazard mitigation measures can thus serve as a comparative guide to the effectiveness of those measures. In this study, we define physical wealth as the value of buildings, durable contents, and producer inventories.

Two types of structures and their values (residential and commercial/industrial) are identified for use in this study. Residential structures are defined as dwelling units, while commercial and industrial structures are all those structures not used as dwellings. The national totals are derived from estimates of residential building value [Goldsmith and Lipsey, 1963; Goldsmith, 1962; Bureau of Economic Research, 1971; Manual, 1968; Bureau of the Census, 1972; Young, 1971]. Commercial and industrial building values are derived from the value of fixed non-residential asset data [Bureau of the Census, 1972; Bureau of the Census, 1973; Bureau of Economic Analysis, 1974; Goldsmith and Lipsey, 1963; Goldsmith, 1962, Bureau of Economic Research, 1971; Musgrave, 1974]. In order to estimate losses in various geographical regions, it is necessary that these national totals be distributed over space National estimates of residential building values are allocated geographically by use of regional per capita personal income from the OBERS data [U.A. Water Resources Council, 1974]. The value of commercial and industrial buildings is distributed geographically using a relationship between income and building value for each economic sector under consideration, then projections of per capita income by industry in those regions included in the OBERS projections are utilized to determine future values of industrial and commercial buildings (in a manner similar to the procedure used for the distribution of residential building values).

Because this study is limited to considerations of land use planning and building code measures for the mitigation of natural hazards, we have not included the value of assets beyond the purview of these measures (agricultural goods and other raw materials are not included). Structures other than buildings, such as bridges and highways are also excluded. Therefore, the total damage to structure estimates produced in this study can be considered as only general indicators of total national losses for natural hazard events, since only those losses associated with the loss of buildings are specifically detailed.

Another specific category of wealth at risk considered here is durable contents of buildings. Durable contents of buildings are divided into three groups: producer durables, consumer durables, and inventories. The first class consists of productive capital such as industrial machinery and office equipment. National estimates of each type of capital used by economic sectors [B.E.A., 1974] are allocated to counties in a manner similar to the method used for regional allocation of non-residential buildings.

Consumer durables such as household appliances are categorized separately from the business capital accounts. National estimates of consumer durables [Shavel, 1971] and a structure value-to-contents ratio is used to distribute the value of consumer durables on a county basis. Other items owned by consumers, such as foodstuffs and clothing, are not included because no suitable values for such items were found.

The value of producer inventories, such as goods stored for shipment or on retailers' shelves, are also added to the physical wealth at risk. Inventory data are aggregated by industry, and are then distributed to counties according to the regional industry contribution to total county per capita income levels [Loftus, 1972].

To compute expected losses of physical wealth, the generated data for physical wealth at risk is combined with data for the annual probabilities of each damage state. From equation (1-3), S_{hrk} is the vector of the annual probabilities for hazard h, at some locale r, for building type k. The elements of this vector are probabilities that various damage states will occur, given h, r, k. These probabilities are then multiplied by a vector which defines the extent of the damage states for the physical wealth stock under consideration. These probabilities make up the vector of hazard effects on damage (W_f) as stated by

$$W_f = | \omega_1 \ \omega_2 \ \cdots \ \omega_A | \qquad (1\text{-}8)$$

where

W_f = vector of hazard effects on wealth type f (e.g., buildings, contents)

ω_a = the extent (percentage) of market value of wealth stock f that is damaged due to occurrence of damage state a; a = 1, ..., A.

For example, to estimate building wealth loss, the elements (ω) of the Wealth Effect Vector will be the average ratio of repair to replacement cost by damage state. Thus, in the earthquake example, using the central values in Table 1-2 these elements would be: .000, .003, .005, .300, 1.000.

Thus, the damage rate DR_{hrfk} applied to the wealth stock f, is the dot product of the vectors S_{hrk} and W_f.

$$DR_{hrkf} = S_{hrk} \cdot W_f \qquad (1\text{-}9)$$

Using elements from equations 1-3 and 1-7, this equation may be written

$$DR_{hrkf} = \sum_{a=1}^{A} \sigma_{ahrk} \cdot \omega_{af} \tag{1-10}$$

where

DR_{hrfk} = joint probability of the expected wealth damage rate due to to the occurrence of hazard h, in region r, for building type k, applied to physical wealth stock f.

In a given economic sector the physical wealth will be allocated to a variety of building types. Thus, a value of each type of wealth is given, V_{refk}, and a total annual expected loss for that sector, LW_{href}, is computed for each sector

$$LW_{href} = \sum_{k=1}^{K} DR_{hrfk} \cdot V_{refk} \tag{1-11}$$

where

V_{refk} = value of wealth in region r, for economic sector e, in structure type k, of wealth type f;

LW_{href} = the expected annual loss in wealth due to hazard h, in region r, to economic sector e, wealth type f;

Thus, total annual expected wealth loss LW_{hre} for economic sector e, in region r, due to hazard h, for F wealth types would be computed by the following summation:

$$LW_{hre} = \sum_{f=1}^{F} LW_{href} \tag{1-12}$$

Income Losses

If the interrupted productive capacity were restored immediately after a disaster, the wealth loss computations discussed above would be an appropriate estimate of the total economic loss. However, an extreme natural event can destroy or temporarily interrupt productive capacity. Factories and equipment may be destroyed, vehicles and transportation facilities may be rendered inactive for a period of time; all leading to a diminished level of economic activity. In developing this methodology, it is assumed that this productive capacity is replaced only after a period of time has elapsed. Thus, the loss of productive capacity during this period results in an economic flow loss. Economic losses due to a decrease in the productive capacity of an affected area can be determined using a standard regional income multiplier analysis for each economic sector.

The multipliers used here are applied in reverse form to those used in predicting the increase in income due to an exogenous income injection into an economy. The basic assumption is the existence of a net reduction in income instead of a depletion of savings to make up the losses. This assumption suggests stable properties to save and may prove too strong in light of further research into post-disaster economic behavior, and the effects of the injection of federal funds which may reduce the disaster's impact.

The multipliers are derived from an input-output table for each region. These tables are transformations of a national input-output table that render the coefficients amenable to regional analysis. A more complete discussion of methods for regionalizing input-output coefficients is contained in Richardson [1972].

The multi-sector income expenditures model consists of a regional matrix of the propensities for one sector (i) to spend in another sector (j). The model is derived from the transactions table of a regional input-output table [Polenski, 1970, 1974] and is illustrated in Figure 1-6.

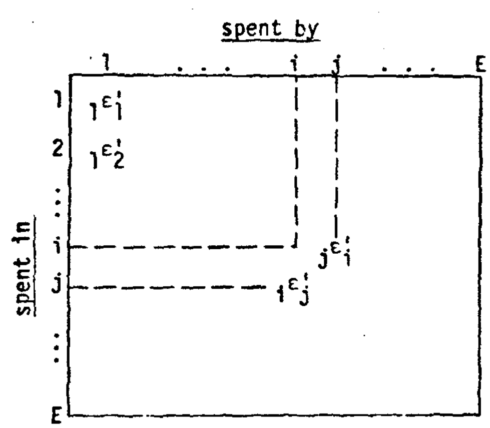

Figure 1-6. Matrix of Sector i Propensity to Spend in Sector j

As an example, consider a two-commodity case where the matrix of propensities to spend is

$$M_r = \begin{bmatrix} {}_1\varepsilon_1 & {}_2\varepsilon_1 \\ {}_1\varepsilon_2 & {}_2\varepsilon_2 \end{bmatrix} \tag{1-13}$$

where

$${}_1\varepsilon_2 = \frac{\Delta\varepsilon_2}{\Delta\psi 1} = \text{section 1's propensity to purchase the product of sector 2}$$

$\Delta\psi_1$ = net change in income for sector 1

$\Delta\varepsilon_2$ = net change in expenditure in sector 2

r = region

$\Delta\psi_1$, $\Delta\varepsilon$ will be the ultimate changes resulting from the autonomous changes in expenditure $\Delta\varepsilon_1, \Delta\psi_2$.

For sector 1, the final change in income consists of:

- the autonomous change in expenditure $\Delta\varepsilon_1$
- the internally (to the sector) induced change in expenditure ${}_1\varepsilon_1\ \Delta\psi_1$
- the externally (to the sector) induced changes in expenditure ${}_2\varepsilon_1\ \Delta\psi_2$

Thus

$$\Delta\varepsilon_1 = \Delta\varepsilon_1 + {}_1\varepsilon_1\Delta\psi_1 + {}_2\varepsilon_1\Delta\psi_2 \tag{1-14}$$

$$\Delta\varepsilon_2 = \Delta\varepsilon_2 + {}_1\varepsilon_2\Delta\psi_1 + {}_2\varepsilon_2\Delta\psi_2$$

or

$$(1 - {}_1\varepsilon_1)\ \Delta\psi_1 - {}_2\varepsilon_1\Delta\psi_2 = \Delta\varepsilon_1 \tag{1-15}$$

$$-{}_1\varepsilon_2\Delta\psi_1 + (1 - {}_2\varepsilon_2)\Delta\psi_2 = \Delta\varepsilon_2$$

or in matrix form

$$(I-M_r)\ \Delta Y_r = \Delta E_r \tag{1-16}$$

where M_r is given in (1-13) and

$$\Delta Y_r = \begin{bmatrix} \Delta\psi_1 \\ \\ \Delta\psi_1 \end{bmatrix}, \quad \Delta E_r = \begin{bmatrix} \Delta\varepsilon_1 \\ \\ \Delta\varepsilon_2 \end{bmatrix} \tag{1-17}$$

The total change in the entire regional economy's income would be

$$\Delta Y_r = (I-M_r)^{-1} \times \Delta E_r \tag{1-18}$$

The "exogenous" part of this expression, the change in expenditures, is estimated from a loss of use of productive facilities for an assumed length of time.

To determine the income effects using the multi-sector multiplier requires a change in sector expenditures. To calculate these changes, the following assumptions are made:

- Expenditure losses are directly related to a time of inoperation. All operation ceases for a length of time after which all operation is restored [Munroe, et al., 1975].

- Production in each sector is at a full employment level before the event occurs. (In the case of construction industry, even though repairs are necessary after the event, construction which is allocated to repair will be re-directed from its previous uses. Consequently, there is no corresponding increase in net expenditures and the construction industry will be treated as any other sector.) Recent research proposes that due to local inflation in construction costs the repair costs may be substantially higher [Yancy, et al., 1976].

To determine the disruption caused by damage for a specific damage state a vector of time lost at each damage state is needed. This is analogous to the vector of ratios of repair to replacement cost by damage state discussed above. From Whitman, et al, 1974, the following estimates of time lost due to repair and restoration were made by damage state for earthquake in Figure (1-6).

DAMAGE STATE	PERCENT OF YEAR'S USE LOST TO REPAIR AND RESTORATION TIME
NONE	0.000%
LIGHT	0.000%
MODERATE	.055%
HEAVY	2.600%
SEVERE	50.000%
COLLAPSE	100.000%

Figure 1-6. Proportion of Year Lost by Damage State

This vector will be called T_h, the time loss vector for hazard h.* This is for earthquake

$$T_{earthquake} = \begin{Bmatrix} .000 \\ .000 \\ .055 \\ 2.660 \\ 50.000 \\ 100.000 \end{Bmatrix} \qquad (1\text{-}19)$$

Using the damage state vector S_{hrk} and the time-loss-to-damage-state ratio vector T_h, a time loss is derived for type of building k, located in a region r, due to the occurrence of hazard h.

$$TL_{hrk} = S_{hrk} \cdot T_h \qquad (1\text{-}20)$$

*The assumption that the same vector T can be used for all structure types and economic sectors is an obvious over-simplification which can only be improved through collection of data providing recovery times by economic sector and structure types.

or

$$TL_{hrk} = \sum_{a=1}^{A} \delta_{hrka} \cdot \tau_{ha} \tag{1-21}$$

where

T_h = time loss vector for hazard h;

τ_{ha} = expected portion of year lost due to damage state a, from hazard h;

TL_{hrk} = expected total time lost due to hazard h, in region r, to sectors housed in structure type k;

A = total number of damage states.

*S = probability that hazard h, in region r, will damage structure type k, hrha at damage state a.

Because building losses are allocated (from Eq. 1-12) by economic sector, time lost can be converted to product lost by multiplying total annual product by the expected portion of the year for each sector:

$$PL_{hre} = P_{re} \sum_{k=1}^{K} (TL_{hrk} \cdot PP_{rek}) \tag{1-22}$$

where

P_{re} = annual product of sector e, in region r;

PP_{rek} = proportion of sector e, in region r, housed in structur type k;

PL_{hre} = expected annual product lost due to hazard h, in region r, to sector e;

K = total number of structure types.

Returning now to the multi-sector multiplier analysis and assuming that the elements of ΔE_r, $\Delta\varepsilon_{er}$, are equal to PL_{hre}, the following expression provides a value for ΔY_{hr}: the net change in output in region r due to hazard h.

$$\Delta Y_{hr} = (I-M_r)^{-1} \times PL_{hr} \tag{1-23}$$

where, Y and $(I-M_r)^{-1}$ are now regionalized for hazard h.

Expanding

$$\begin{bmatrix} \Delta\psi_1 \\ \Delta\psi_2 \\ \cdot \\ \cdot \\ \cdot \\ \Delta\psi_E \end{bmatrix}_{hr} = \begin{bmatrix} \\ \\ (I-M_r) \\ \\ \\ \end{bmatrix}^{-1} \times \begin{bmatrix} PL_1 \\ PL_2 \\ \cdot \\ \cdot \\ \cdot \\ PL_E \end{bmatrix}_{hr} \qquad (1\text{-}24)$$

or

$$\left(\Delta Y_{hr}\right)_{TOTAL} = \left(\sum_{e=1}^{E} \Delta\psi_e\right)_{hr} \qquad (1\text{-}25)$$

E = total number of economic sectors.

which are final expected product losses for region r due to the occurrence of hazard h.

Market Area Effects

After the occurrence of a natural event both the supply of and the distribution facilities for many commodities may be disrupted. The result is a need to acquire goods and services normally available in the affected area from sources of supply outside the area. This has the consequence of increased cost due to a variety of factors, such as higher labor cost, lack of inventory supply, and higher transport costs. In this study, the market area effects are limited to consideration of higher transport charges, because the transportation costs are the most obvious of these increased costs.

Specifically, purchasers of goods and services must travel farther in order to acquire what they had been accustomed to purchasing in the local area. Industrial purchasers, as well as households, are affected in this way. In addition, suppliers must temporarily ship their products farther to new market areas because normal customers have become inactive. Offsetting economics of scale are assumed to be negligible.

In the model developed for this analysis, purchasers will buy from, and suppliers will ship to, the adjacent "market area " and, therefore, transportation costs will double. The source for these data transportation costs is the regional input-output—specifically, the inputs of the transportation sector to all other sectors. The use of input-output data in this manner assumes that the inter-industry transport costs are paid by the shipper and are thus reported as an input in the table. This suggests that the aggregate cost to a set of customers given the loss of a supplier will be double the previous shipping cost [Census of Transportation, 1975; Faucet Associates, 1971]. This result seems severe until it is realized that the supplier generally includes shipping charges implicitly in his product price. Therefore, the cost is not usually perceived as a transport cost by the purchaser. The following analysis shows how this doubling of transport costs results.

The supplier of a product is assumed to have a near circular market area with a homogenously distributed set of customers in that area, as illustrated in Figure 1-7. This follows from the assumption of a set of homogenous competitive sellers in an area of homogeneous buyers.

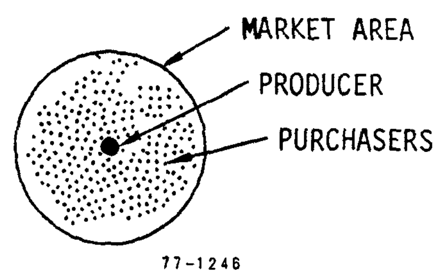

Figure 1-7. Distribution of Purchasers in Market Area

It is assumed that market area is directly adjacent to the market area of another supplier of the same product, as illustrated in Figure 1-8. Thus, if market area "1" were to lose its supplier, the purchaser in area "1" could go to market areas "2" through "7". Those located on the periphery of market area "1" will have only a slightly greater distance to travel, while those located nearest the site of the supplier in "1" (at the center) will travel, at most, twice the radius of the market areas. One further assumption that is necessary requires the market area be greater than the area suffering damage; otherwise, the damage area should be subtracted from the market area so that only the losses to those customers that are still operating are considered. Since both suppliers and buyers who are located in the damage area are affected and thus subject to inoperation and supply loss will be either less or nonexistent. This effect could be used to scale the result in the case of a specific scenario.

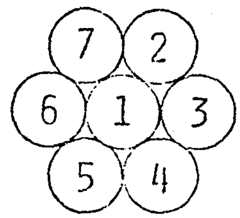

Figure 1-8. Geographical Relationship Between Market Areas

The new distance to be travelled after the event will be:

$$DN_j = R + (R - DP_j) \tag{1-26}$$

where:

R = radius of market area;
DPj = distance of customer to center of market area;
DN_j = new distance to be travelled for customer j to center of unaffected market area.

Then

$$\sum_{j=1}^{L} DN_j = \text{total new distance} = DN \tag{1-27}$$

where,

L = total number of customers

Substituting (1-26) into (1-27)

$$DN = \sum_{j=1}^{L} (2\ R - DP_j) \tag{1-28}$$

So

$$DN = 2\,LR - \sum_{j=1}^{L} DP_j \tag{1-29}$$

let

$$DO = \sum_{j=1}^{L} DP_j \tag{1-30}$$

where

DO = the total distance of all the customers of the market area before the loss.

Then,

$$DN = 2\,LR - DO \tag{1-31}$$

The average distance traveled by the customers in a market area is given by DO/L (from 1-30). Thus, if an average value for the radius $\bar{r}$ could be derived, a value for DO can be found from DO = $\bar{r}$ L. To obtain $\bar{r}$, it is necessary to integrate the radius over the area and normalize for the average (under the assumption of market area homogeneity), thus:

$$\bar{r} = \frac{\int r\,dA}{\int dA} = \frac{\int_0^R\int_0^{2\pi} r r\,d\phi\,dr}{\int_0^R\int_0^{2\pi} r\,d\phi\,dr} = \frac{\frac{2\pi}{3} R^3}{\pi R^2} = \frac{2}{3} R \tag{1-32}$$

where

R = radius of market area
A = market area

From (1-32) and the definition of (DO), it follows that:

$$DO = (\tfrac{2}{3} R) \cdot L \text{ or, } DO = \left(\frac{2}{3}\right) LR \tag{1-33}$$

and so

$$DN = 2\ LR - \frac{2}{3}\ LR \text{ or, } DN = \left(\frac{4}{3}\right) LR, \text{ and thus, } DN = 2\ DO \tag{1-34}$$

Hence, it is seen that the new total distance is twice the old total distance. Therefore, the transport costs are doubled and the average change in cost after the occurrence of the hazard is equal to the original transport cost.

To estimate the original transportation cost, it is assumed that the payments to the transportation sector by the supplier are equal to the transportation costs. This assumes that the seller pays for the transportation of his product. Thus, input/output data can provide a value for transportation cost. An example from the input/output table is illustrated below.

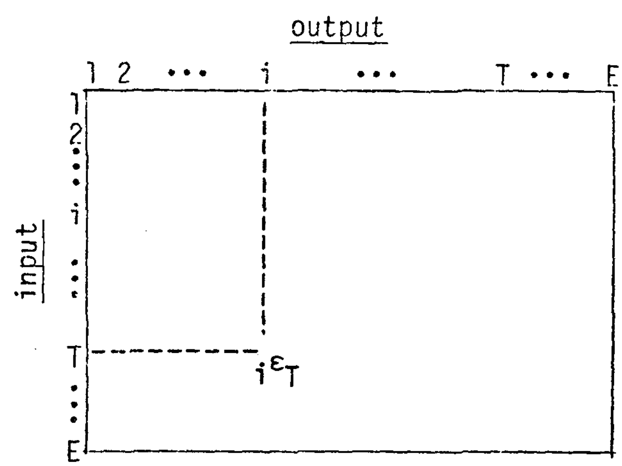

Figure 1-9. Total Input-Output Matrix for Region r

$_i\varepsilon T_r$ = the portion of the total inputs to sector i purchased from the transportation sector T, in region r.

The total cost due to the loss of a supplier to the purchasers that rely on that producer will be given by:

$$P_{re} \times {}_i\varepsilon T_r \times PL_{re} = MAF_{re} = \text{market area factor loss due to the loss of industry e, in region r} \tag{1-35}$$

where

PL_{re} = precent of a year that the total industry e, in region r is out of commission (see equation (1-20);

T_{re} = the transportation input to economic sector e, in region r;

P_{re} = annual regional gross output for industry e, in region r.

The total market area loss due to the incapacity caused by the natural event can then be summed:

$$\text{Total Market Area Effect (MAE) in region r} = \sum_{e=1}^{E} MAE_{re} \qquad (1\text{-}36)$$

The above summation does not include increased costs to the governmental and household sectors, but only includes the industrial and commercial sectors. These costs originate only from the costs of transporting goods and services. The payment of these costs is distributed amoung all sectors including government and households. This allocation is made utilizing the input-output table for the region on the basis of the proportion of the expenditures by the various sectors.

Estimation of Life Loss

The economic value of the loss of life is often measured by the total discounted lifetime income that is lost by such an occurrence. This figure measures the product expected to be produced by the person's labor, weighted by the extent to which the economy values that labor. However, to reduce the value of lives to the value of labor does not describe the severity of life loss as a criteria separate from othe economic losses, and therefore dollar values for life loss are not provided in this study. Rather, a forecast is made of the number of persons expected to die due to the occurrence of an event of given severity.

Estimates of life loss can be calculated using either of the following methods:

1. Employ historical data to predict a ratio of life loss to economic loss for each hazard and to explain the variation in this ratio by:
   a. The time of day of occurrence. The lives lost to earthquakes have especially been linked to the time of the occurrence [NOAA, 1972, Blume, 1971].

b. The date of occurrence. This implies that mitigating factors such as newer buildings, knowledge of hazard, specific warnings, etc., have reduced the ratio of lives lost to economic damage [Darcy and Kunreuther, 1967].

c. The value of wealth-at-risk per capita. This factor would influence the ratio of lives lost to economic loss and may interact with the trends explained by the date of occurrence.

2. Employ specific mortality rates based on the physical phenomena that cause death--building collapse, ceiling failure, etc. This may be termed a "death algorithm." Whitman [1974] has furnished such an analysis for earthquakes.

For this study, it was decided that, due to the lack of substantial data for the construction of specific mortality rates, the first method would be used to estimate life loss. Specifically, the ratio derived using the date of occurrence as the explanatory variable was employed. The other methods required data that was either unavailable from the annual loss models (such as the time of day), or involved complications that did not provide more efficient methods of prediction.

Impacts on Housing

The wealth items discussed previously can be summed in order to arrive at a total value of wealth at risk by regions.* However, there are other than economic ways to characterize expected losses. For example, it is possible to calculate the expected loss of home use. Actually, the value of expected housing losses is already included in the analysis under the wealth, income, and contents loss for households. People value shelter and thus assign a value to residences. If we cite values of home use loss statistics, then we should not also cite estimates of residential structure value loss, since they measure the same phenomenon.

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*Actually, the total wealth stock must be treated as an expanding amount over the planning period, utilizing an assumption of wealth growth. Only then can each period's wealth be treated as "at risk" and be multiplied by the various probabilities to determine expected losses, which must be discounted at an appropriate discount rate. Thus, three rate structures are of importance: disaster probabilities, growth rates, and discount rates.

Nevertheless, loss of home use may be a more graphic depiction of the same situation, and is thus forecast and included separately in the analysis. It should be kept in mind that a level of residence loss, as cited above, is easily convertible into a level of home use loss, if we know the extent of time that such homelessness typically persists before rebuilding or repair is accomplished.

Housing losses are examined to dramatize the social impact of the disastrous event. These losses are categorized in two ways: 1) the number of dwellings lost, and 2) the number of people made homeless over time ("level of homelessness").

To compute the number of dwellings lost, the elements of the damage state vector (S_{hrk}) for dwellings of building type k, in region r, due to hazard h is multiplied by NUM_{rk} the total number of dwellings of type k, in region r.

$$NTL_{hrk} = NUM_{rk} \; (PTL_{hk} \cdot S_{hrk}) \tag{1-37}$$

where,

$$PTL_{hk} = \pi_1 \; \pi_2 \cdots \pi_A \; {}_{hk} \tag{1-38}$$

PTL_{hk} = vector of portions of structures of type k destroyed from hazard h by damage state a

π_a = probability that damage state a will cause total destruction.

NTL_{hrk} = total number of dwellings of structure type k, in region r lost annually due to hazard h [Bureau of Census Final Report HC, 1972].

NUM_{rk} = total number of dwelling units in structure type k, in region r.

In order to compute the "level of homelessness", a time factor must be introduced. This is accomplished by taking the dot product of the time lost vector (T_h), from equation (1-20) and the damage state vector (S_{hrk}), and weighting the result by the total occupancy of residences of type k (O_{rk}) in persons per housing unit.

$$HL_{hrk} = \begin{bmatrix} \Omega_1 \\ \Omega_2 \\ \vdots \\ \Omega_A \end{bmatrix}_{hrk} = O_{rk} \;\; (S_{hrk} \cdot T_h) \tag{1-39}$$

where

O_{rk} = the number of persons who reside in structures of type k, in region r;

Ω_a = homelessness vector for hazard h, region r, and residence in structure type k.

Thus, the total homelessness for region r due to hazard h will be the summation shown below.

$$\text{Total annual homelessness in region r due to hazard h} = \sum_{K=1}^{K} \sum_{a=1}^{A} \Omega_{ahrk} \qquad (1\text{-}40)$$

Unemployment

Unemployment represents a somewhat difficult conceptual problem. The economic effects of unemployment have already been included by relying on the value of product lost, directly and indirectly, using the input-output multipliers. Nevertheless, unemployment statistics are useful because of their familiarity to policy makers.

The expected level of total unemployment is given as a percentage change from full employment.* Thus, the product lost to each sector of the local economy can be multiplied by the ratio of product to the number of employees, to account for a number of persons unemployed as a result of a disaster. Due to variations in regional unemployment, this level of analysis is not able to predict regional conditions of unemployment. However, the increased unemployment which is forecast can be later applied to a given level of employment for a particular region.

The income lost by economic sector is weighted by the ratio of number of people employed to the income of the sector, to derive the change in employment. Thus, the elements of the vector of changes in sector income (ΔY_{hr} from Equation (1-24)) are multiplied by the ratio of employment to product, by economic sector, for that particular region (E/P_{er}).

*Full employment is defined as the number of employees in each industry predicted by the ratio of employee to income provided by the input-output data.

Computationally, the form is

$$\frac{\Delta U_{hr}}{TLF_r} = \sum_{e=1}^{E} \Delta\psi_{ehr} \cdot E/P_{er} \tag{1-41}$$

where

$\Delta\psi_{ehr}$ = the change in income in sector e due to the effects of hazard h in region r;

E/P_{er} = the ratio of employees per dollar of income produced for sector e in region r;

ΔU_{hr} = total annual number of persons unemployed due to hazard h in region r;

TLF_r = total labor force in region r

$\frac{\Delta U_{hr}}{TLF_r}$ = the unemployment rate in region r, due to hazard h

Summary

This chapter has described a general model of loss valuation that could be applied to many different time frames, geographic settings, and natural hazards. From the probability of a specific natural event, a loss estimation process providing perspectives from a number of different viewpoints is achieved. There are four basic steps in this estimation procedure. In the first step, a vector of hazard intensity probabilities is estimated. For instance, for earthquake the annual probabilities of Modified Mercalli Intensities of VI, VII, VIII, IX X, and XI would provide such a vector. The second step requires the prediction of the effect of the intensities on different types of buildings. An example of the most general form of these prodictions is the damage probability matrix such as in Table 1-2. The third step combines the results of the first two steps in the multiplication of the vector of hazard intensities and the predicted losses to a specific structure type. This results in the calculation of the probability of damage, by building type, hazard and area over which the hazard intensities have been defined. In the fourth step, the resulting probabilities, provided in categories of severity of damage state, e.g., light, moderate, etc., and through the application of constants, are converted to estimates of the main types of loss: economic and social.

Economic losses are those impacts of the event with specific dollar values. These losses are subdivided into stock losses or flow losses. Stock losses (either contents or structure) are losses of physical property through outright physical destruction. Their calculation results from weighting the probabilities of occurrence of each type of damage by the expected losses of each severity level. For example, light damage might cause .3% structure and 0% contents loss thus, the probabilities by type of loss weighted accordingly.

The other economic losses are flowlosses estimated in a time frame. In these calculations, the probabilities of hazard loss at different damage severity levels is weighted by the length of time each level of severity will incapacitate a structure. These time periods then establish the loss of income caused by the inability to use the structure housing a particular productive process. Also, the flow losses are the direct losses felt by the customers of a particular supplier over the time a supplier is disabled by a natural disaster.

Social losses, unlike economic losses, share no common denominator and cannot be aggregated. These losses include: houses lost, homelessness (displacement from homes), life loss, and unemployment. Houses lost is a count of homes estimated to be destroyed. The hazard intensity vectors and the damage intensity relationships for residential structures are applied to the number of housing units at risk. The disruption of households, or homelessness, is analogous to the economic flow losses discussed above, except the value of the structure-use is in terms of the structure's use as a residence rather than a factor of production. Life loss is calculated more as a scale factor, rather than through a theoretical analysis. The aggregate level of building failure provides the key by which this estimate is scaled. Unemployment is calculated directly from the estimates of income loss by translating these productive reductions into a decrease in the number of employees employed.

Certain aspects of natural hazards are not included in this model. The degree of threat from a natural hazard, and the benefits and costs of a mitigation policy, are not distributed among various segments of the population. Do the poor or elderly, for example, suffer greater proportional risk from natural hazards, and how do land-use policies and building code measures affect them in comparison to other groups? To estimate the distributive aspects of losses from potential natural events and the savings resulting from mitigation measures would require further refinement of the present model to include such information concerning the ownership of wealth-at-risk. Some partial analysis of this type is found in Chapter Eight, in reference to income classes in the context of a scenario.

Also excluded from the model are the losses to infrastructure or lifelines, such as public utilities, telecommunications, and public services. Loss to infrastructure may outweigh the scale of building losses in magnitude.

The present analysis also does not consider the phenomenon of multiple disasters and their interrelationships. Dam burst, conflagration, and tsunami are potential attendant events of an earthquake. To facilitate the examination of particular mitigations, separate analysis is required for each hazard defined in this report. The hurricane hazard includes both a wind and a water element; however, to assess the mitigations which apply to one but not the other they were treated as separate events.

The policy proposals for mitigation to natural hazards can thus be asserted through the judicious use of this model. Comparison of mitigations can be made by simulating the future national hazard losses under various assumptions. Because annual probability has been used, aggregate losses, costs, and surveys can be compared. The remainder of this report presents the methods used in the implementation of this model and the results from investigations of specific mitigation alternatives. Also provided are detailed estimates of the annual loss estimates for a base year (1970). This alone can provide a useful tool for analysis of natural disasters.

Chapter Two

CONTENTS ASSESSMENT OF BUILDING AND VALUE AT RISK

Introduction

This chapter presents the data and methodology for estimating the wealth-at-risk (identified here as buildings and their contents) from the nine natural hazards. The first section discusses the sources used to create the county data which is used as the regional information base. These data are employed to establish the value and type of buildings by location. The second section estimates the values of buildings by economic sector on the national level, and also provides the models used to project the national estimates to the year 2000. The third section provides a similar procedure for the estimation of the contents of structures. The fourth section discusses the allocation of the wealth by type of structure of which it is a part, or in which it is housed. The chapter concludes with a discussion of how the value of wealth-at-risk is determined by economic sector (e), wealth type (f), year (y), region (r) and the structure type (k) that embodies or houses the wealth.

The County Data Base

The County Data Base provides the information necessary for the estimation of exposure and vulnerability of the buildings, differentiated regionally by county. It was constructed using the following compilations:

- The 1970 Census of Population and Housing [U.S. Bureau of Census, 1972]
- SMSA and non-SMSA portions of Water Resources Council sub-areas (NSMSA-WRCS), approximated by county, Figure 2-1.
- SMSA and non-SMSA portions of state census data (state NSMSA), Figure 2-2.
- The 1972 Census of Governments [U.S. Bureau of the Census, 1972]
- OBERS Series E Projections of Regional Economic Activity in the United States [U.S. Water Resources Council, 1974].*

*OBERS is an acronym for the united effort of OBE, the Office of Business Economics, and ERS, the Economic Research Service. Since the time of the original collaboration, however, the OBE has been renamed the Bureau of Economic Analysis, but the widespread use of OBERS has led to the continued use of the acronym.

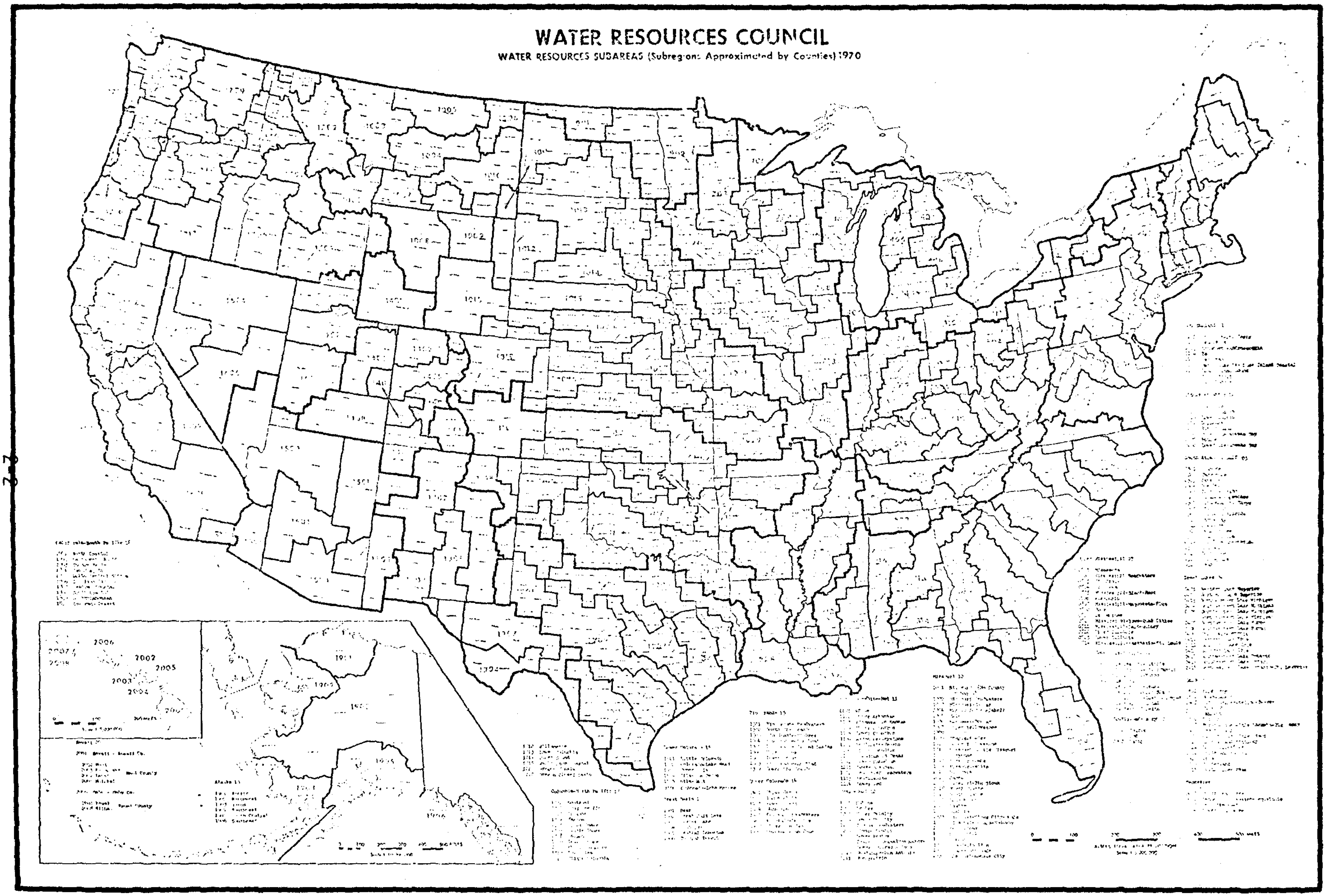
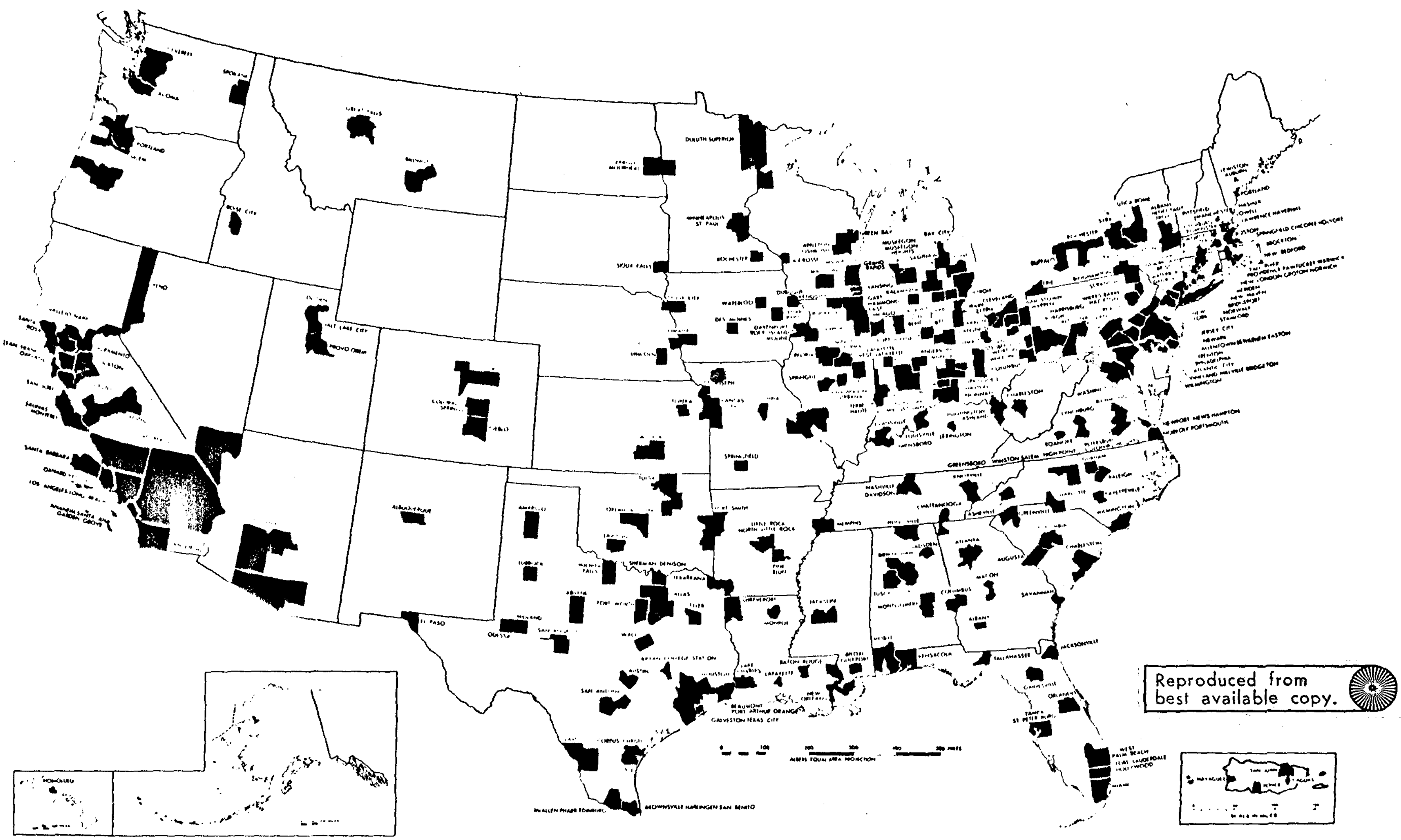


Figure 2-1. Water Resources Council Sub-areas (W.R.C.S.S.)



Areas defined by Office of Management and Budget, February 1971.

U.S. DEPARTMENT OF COMMERCE Social and Economic Statistics Administration BUREAU OF THE CENSUS

76-1248

Figure 2-2. Standard Metropolitan Statistical Areas (SMSA)

TYPE OF DATA	DATA AGGREGATED TO LEVEL OF:	DATE DATA TAKEN	NUMBER OF DATA POINTS	SOURCE
GENERAL COUNTY DATA				
County population	County	1970	3,132	[Newspaper Enterprise Assoc., 1974]
County area	County	1970	3,132	" "
County name	County	1970	3,132	[National Bureau of Standards 1974]
County latitude and longitude	County	1970	3,132	[Dept. of Interior, 1970]
County coastal flag (whether on an ocean coast or not)	County	1970	3,132	" "
Name of SMSA County is part of	County	1970	3,132	[U.S. Water Resources Council, 1971]
HOUSING CHARACTERISTICS DATA				
Percent of housing units with basements	State NSMSA SMSA	1970	298*	[U.S. Bureau of Census, 1972]
Percent of housing units with cement slab foundation	State NSMSA SMSA	1970	298	" "
Percent of housing units built before 1940	State NSMSA SMSA	1970	298	" "
Percent of housing units that are mobile homes	State NSMSA SMSA	1970	298	" "
Percent of housing units in structures with 4 or more stories	State NSMSA SMSA	1970	298	" "
Percent of housing units in structures with 5 or more stories	State NSMSA SMSA	1970	298	" "
Average number of persons per housing units	State NSMSA SMSA	1970	298	" "
ECONOMIC DATA				
Locally assessed real property values	County	1971	3,132	[U.S. Bureau of Census, 1972]
Assessment-Sales price ratios	State	1971	2,002	" "
Total personnel income percapita	NSMSA - WRCS, and SMSA	(1980)*	[illegible]52	[U.S. Water Resources Council, 1974]
Total agricultural income percapita	NSMSA - WRCS, and SMSA	(1980)	452	" "
Total mining income percapita	NSMSA - WRCS, and SMSA	(1980)	452	" "
Total construction income percapita	NSMSA - WRCS, and SMSA	(1980)	452	" "
Total manufacturing income percapita	NSMSA - WRCS, and SMSA	(1980)	452	" "
Total wholesale-retail income percapita	NSMSA - WRCS, and SMSA	(1980)	452	" "
Total financial insurance, real estate income percapita	NSMSA - WRCS, and SMSA	(1980)	452	" "
Total service industry income percapita	NSMSA - WRCS, and SMSA	(1980)	452	" "
Total federal government income percapita	NSMSA - WRCS, and SMSA	(1980)	452	" "
Total state and local government income percapita	NSMSA - WRCS, and SMSA	(1980)	452	" "
Percent of national average of total local income percapita	NSMSA - WRCS, and SMSA	(1980)	452	" "
GROWTH PROJECTIONS				
Intercept of population projection***	NSMSA - WRCS, and SMSA	(1970-2000)	452	[U.S. Water Resources Council, 1974]
Slope of population projection***	NSMSA - WRCS, and SMSA	(1970-2000)	452	" "
Intercept of income/percapita projection***	NSMSA - WRCS, and SMSA	(1970-2000)	452	" "
Slope of income/percapita projection***	NSMSA - WRCS, and SMSA	(1970-2000)	452	" "

*247 SMSA where used in the 1970 census and 51 states, District of Columbia the 51st.

**Projected data.

***Computed linear least square fit of projected data from 1970-2020.

Table 2-1. County Data Base, Sources, and Scale from Which Estimated

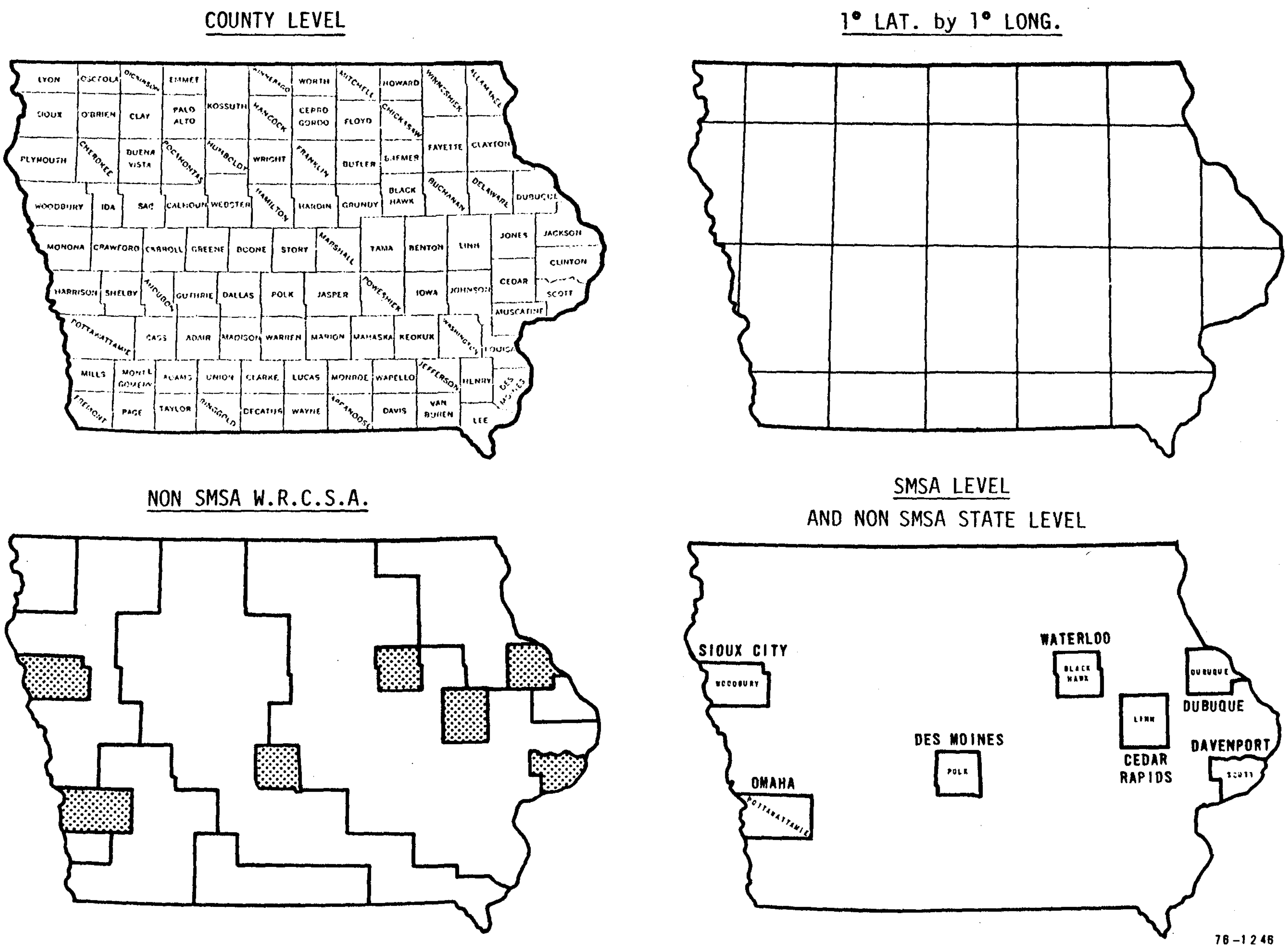


Figure 2-3. Examples of Relative Levels of Data Bases as They Describe Iowa.

The economic data are given in two forms: the first is the locally assessed real property values available by county, the second is industry level income which is available in terms of groups of counties. The locally assessed real property values are taken from the 1972 Census of Governments, and the estimates of the ratios of real property sales values to the values assessed are based on samples of sales taken from 2,002 counties over a six-month period in 1971 [U.S. Bureau of the Census, 1972]. The OBERS Projections [U.S. Water Resources Council, 1974] do not list data for 1970 in many areas for all of the income categories, due to restrictions on the disclosure of specific information which may describe individual producer's operations. Thus, the available projected data (1980) were used to estimate 1970 values. The 1970 values were derived by using the estimated growth relationship for income derived from a linear least squares fit of 1970 to 2020 data of all income in the NSMSA-WRC's and SMSA's and the estimated income by sector for 1980. The OBERS Projections are based on state totals that have been disaggregated to the county level, then reaggregated to the SMSA and WRCS levels (see Figures 2-1, 2-2, and 2-3).*

The OBERS data cited above provided growth rates for both population and total county income. The projections of population are based on historic data by county and the assumption of the Series E projected fertility rates. The Series E projections imply that an equality in deaths and births will be reached by the middle of the 21st century [McEwen, 1974]. Using the data projected by this series, linear regression provided a method for projecting each county's population and income growth. To check the ability of this procedure to duplicate the aggregate OBERS projection, a comparison was made of the totals obtained for the year 2000. The population of the United States in 2000 is estimated as 256,176,160 by the regression, compared to the OBERS projection total of 263,830,000. Thus, the sum of the separate county estimates used are less than the OBERS projections by about 3.69%. The total personal income projected by the OBERS data is $2,154,266 million (1976$), a difference of +2.24% from the county total.**

The building characteristics data are based on the 1970 Census of Population and Housing [U.S. Bureau of the Census, 1972]. The housing data was in the form of

*In one instance, the OBERS projection populations seemed to counter recent history of population growth. In non-SMSA Hawaii, the OBERS projections predict a declining population in all counties.

**Total OBERS projections were not included in the data base because of space limitations and the disclosure problems encountered with the 1970 data.

SMSA data and state-wide totals. To approximate the non-SMSA data, the totals of all those SMSA's located in each state were subtracted from the state total. In some cases the SMSA's could be defined as including the counties of more than one state and many of these SMSA's could be identified as being substantially in one state or another. However where this could not be done, they were not subtracted and the state value was used.* In these cases, the proportions computed for the non-SMSA areas will be weighted slightly by the SMSA data not removed. The data used for these calculations are available in Appendix B.

The Estimation of National Building Wealth by Economic Sector

Estimates of national building wealth were made for private and public sectors through the use of the recent series of wealth estimates published by the Bureau of Economic Analysis (BEA), [BEA, 1974; Loftus, 1972]; Musgrave, 1974; Shavell, 1971; and Young, et al., 1971].

The building values are given for only two land use categories: industrial and commercial, and miscellaneous [BEA,1974]. The values are provided in 1958 dollars. These values are the estimated gross stock values derived using Winfrey's S-3 survival curves** and the 95% of Bulletin F lifetimes. This depreciation rate is descriptive of advancing technology with a faster retirement predicted. The gross stock values provide replacement values which are appropriate for estimating damages because the rates of damage are given in terms of repair to replacement cost ratios.

The data available for non-residential buildings are for types of buildings, but are not disaggregated by industry. Thus, it was necessary to estimate the building wealth held by the following eight private sectors of the economy:

1 Agriculture
2 Mining
3 Construction
4 Manufacturing
5 Transportation, utilities
6 Wholesale, retail trade
7 Finance, insurance, real estate
8 Service Industries

*In California, an apparent error in the Census calculations was discovered when it was found that the number of dwelling units with basements in all the California SMSAs was greater than the number in the state total. In this case, the state total was used to calculate the proportions for non-SMSA areas.

**Details of the survival curves are given in Appendix E.

The data available under these categories were allocated among the eight sectors listed above in proportion to their corporate capital consumption allowances by year [BEA, 1967]. This was done by year from 1940 to 1972. The distribution of private commercial building wealth by economic sector is shown in Table 2-3 (columns 3-10). These estimated data were then fitted to a polynomial trend to provide a model for projection of building wealth. The following equations were used for forecasting (when capital consumption data was unavailable, an average of other years was used.):

	a	B_1	B_2	R^2	SSR	N
Farming	-491,368.0	20,986.2	-46.17	0.998	4864.56	33
Mining	28,724.5	-408.8	4.14	0.093	1397.15	33
Construction	-20,324.0	554.9	-0.49	0.976	847.62	33
Manufacturing	64,246.5	-2,173.2	34.99	0.991	1880.69	33
Trans-Utility	467,416.0	-14,806.4	151.19	0.906	7845.10	33
W-R Trade	-9,519.6	818.98	2.89	0.868	4439.08	33
Finan., Insur.,	201,170.0	-6,934.1	71.32	0.938	3120.43	33
Real Estate Services	94,476.9	-4029.3	49.57	0.988	1725.06	33

The wealth estimates used for estimating public building values were taken from the Institutional Investor Study Report of the Securities and Exchange Commission. These values are provided in constant 1958 dollars. They are estimates of replacement values for all non-residential publicly-owned buildings from 1952 to 1968 [National Bureau of Economic Research, 1971]. As in the case of private wealth estimates for the value for public structures need to be extrapolated into the future.

Using the same relationship applied above, we found the following estimates for the public secter equation parameters:

	a	B_1	B_2	R^2	SSR	N
State and Local Government	47,943.1	-2,792.2	50.101	0.936	476.75	17
Federal Government*	-131,719.1	3,219.92	------	0.990	560.41	17

The data used in this analysis are listed in Table 2-3

*A linear model was used for the projection of Federal Government Status at risk.

YEAR	RESIDENTIAL	FARMING	MINING	CONSTRUCT	MANUFACTOR	TRANS-UTILY	W-R TRADE	FINANCE	SERVICES	FED GOV	ST-LOC GOV
1925	0.*	2151.3	8613.5	9709.7	32017.	65698.	32673.	34663.	27755.	0.	0.
1926	0.	2195.8	8791.6	9991.6	33095.	68392.	33622.	33411.	28766.	0.	0.
1927	0.	2241.5	8974.3	10282.	34121.	90564.	34666.	34559.	29603.	0.	0.
1928	0.	2260.8	9131.6	10551.	35474.	93338.	35503.	35492.	30376.	0.	0.
1929	0.	2503.8	21356.	7066.3	37251.	.10540E+06	32545.	39412.	14232.	0.	0.
1930	0.	2647.9	18315.	7360.2	37942.	.10921E+06	33320.	42669.	13925.	0.	0.
1931	0.	2397.3	17980.	6399.6	37714.	.11510E+06	32093.	42314.	12799.	0.	0.
1932	0.	2479.0	16677.	5697.2	36956.	.11598E+06	30622.	43441.	13226.	0.	0.
1933	0.	2307.7	17666.	4759.0	36589.	.11454E+06	29635.	44545.	12222.	0.	0.
1934	0.	2352.2	19880.	4150.4	36191.	.10926E+06	29883.	45655.	11952.	0.	0.
1935	0.	2239.1	18584.	4082.1	35610.	.11032E+06	29167.	44699.	11438.	0.	0.
1936	0.	2571.6	18662.	4356.1	35289.	.10424E+06	30596.	46776.	12342.	0.	0.
1937	0.	2540.2	19321.	4762.6	35623.	.10160E+06	32068.	45403.	13547.	0.	0.
1938	0.	2198.3	16875.	3958.5	35151.	.10042E+06	31772.	46044.	14896.	0.	0.
1939	0.	2116.2	18139.	4358.0	34684.	.10200E+06	31648.	44307.	14631.	0.	0.
1940	0.	2183.0	18518.	4140.7	34723.	98445.	31967.	46376.	14803.	0.	0.
1941	0.	1927.4	18448.	4261.9	35599.	.10351E+06	31254.	42429.	13527.	0.	0.
1942	0.	1776.9	15563.	4188.8	35146.	.11667E+06	27981.	33678.	12401.	0.	0.
1943	0.	1926.9	13799.	3894.1	33998.	.11665E+06	26920.	33553.	12444.	0.	0.
1944	0.	1695.8	13114.	3144.6	33064.	.12325E+06	23395.	30142.	10814.	0.	0.
1945	0.	1523.8	11936.	2678.5	33336.	.12987E+06	20260.	26253.	9663.6	0.	0.
1946	0.	1578.6	13007.	4812.9	37364.	.10056E+06	32917.	36011.	14697.	0.	0.
1947	0.	1596.1	12520.	6499.8	40336.	99597.	38796.	30874.	14895.	0.	0.
1948	0.	1623.4	13695.	7925.3	42590.	94678.	42457.	29777.	17153.	0.	0.
1949	0.	1694.0	14362.	8645.2	43550.	90256.	44975.	32032.	16690.	0.	0.
1950	0.	1734.6	15845.	9222.3	44291.	92176.	46519.	30922.	16063.	0.	0.
1951	0.	1833.6	15425.	9547.0	45524.	96609.	45417.	31352.	18151.	0.	0.
1952	0.	1871.0	15202.	9472.6	46768.	95680.	43298.	30538.	17531.	33788.	43193.
1953	.53690E+06	1881.5	15303.	9557.6	47815.	.10443E+06	43462.	32664.	18948.	35411.	46066.
1954	.55520E+06	1820.2	14147.	10044.	48639.	.10843E+06	43186.	34157.	19782.	36661.	49176.
1955	.57400E+06	1981.3	15070.	10711.	51041.	.11032E+06	45012.	34221.	20431.	36597.	52515.
1956	.59100E+06	1822.8	15033.	11091.	53004.	.11159E+06	46431.	35642.	23795.	36841.	55716.
1957	.60730E+06	1859.8	15265.	12227.	55128.	.11185E+06	47729.	38306.	25678.	36973.	59171.
1958	.62320E+06	2228.5	14656.	12951.	56194.	.11646E+06	46502.	41087.	25270.	37200.	62992.
1959	.65140E+06	2278.8	15406.	13904.	57084.	.11825E+06	46693.	41993.	29194.	37678.	66253.
1960	.66610E+06	2449.5	14922.	13915.	58655.	.11903E+06	48171.	45489.	31927.	38014.	69491.
1961	.67660E+06	2872.1	14974.	14384.	60740.	.12232E+06	48428.	48082.	33331.	38407.	73013.
1962	.69470E+06	2874.2	14493.	14477.	62707.	.12926E+06	48815.	48406.	35043.	36754.	76514.
1963	.71450E+06	3072.4	13754.	15519.	64678.	.13266E+06	49399.	49345.	38376.	39155.	80056.
1964	.73360E+06	3136.3	13364.	15639.	66355.	.13537E+06	52264.	51811.	40055.	39679.	83693.
1965	.75340E+06	3218.5	12886.	15804.	69301.	.13981E+06	53180.	52163.	45599.	40193.	88052.
1966	.76970E+06	3249.2	13169.	16311.	73540.	.14430E+06	54867.	54869.	45960.	40040.	92757.
1967	.78490E+06	3404.2	13630.	16973.	77095.	.15015E+06	57114.	57096.	48866.	39772.	97598.
1968	.80530E+06	3501.5	14019.	17617.	79858.	.15585E+06	59260.	59261.	50719.	39547.	.10293E+06
1969	.82760E+06	3597.0	14402.	18286.	83177.	.16177E+06	61533.	61513.	52647.	0.	0.
1970	.84920E+06	3694.8	14793.	18939.	85736.	.16755E+06	63731.	63711.	54528.	0.	0.
1971	.87840E+06	3787.5	15164.	19608.	86516.	.17347E+06	65962.	55960.	56453.	0.	0.
1972	.91450E+06	3889.9	15575.	20349.	86421.	.18002E+06	68476.	66454.	58587.	0.	0.
1973	.94880E+06	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1974	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1975	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

*ZERO VALUES DENOTE ABSENCES OF DATA

Table 2-3. Historic Structure Values Allocated by Economic Sector in Million 1958$

The parameters for forecasting residential stock were estimated for total residential wealth, as well as for residential wealth disaggregated into the following building classes: Those with 5 units or more; mobile homes; and the residential units not in either category. The data employed are the gross values computed with a declining balance pattern of depreciation, in 1958 dollars [Young, et al., 1971]. These data employ different service lives depending on the building types for the years 1953-1973. The estimated parameters and their associated statistics for the forecast equations are listed below.

	a	B_1	B_2	R^2	SSR	N
All residential	525,924	-13,391.1	259.49	0.996	7,935.3	21
5 units or more	291,107	-10,209.9	104.91	0.957	4,106.6	21
Mobile homes	294,274	-10,274.8	90.15	0.976	1,219.8	21
All other residential	1,533,220	-47,768.8	565.16	0.995	11,196.4	21

Table 2-3 presents all the historic building values, as allocated by economic sector, except that the residential data are for total residential stock only.

The estimates of wealth described above are national totals-however, in the case of tsunami a value-per-square-mile of port facility was needed to estimate losses. To arrive at this value, an analysis was conducted of average values per square mile of industrial properties in cities in the United States for which data were available. Using the areas cited in a survey of land use [Manvel, 1968] in major U.S. cities and the selected industrial, commercial, and residential property values that are provided in the 1972 Census of Governments [U.S. Bureau of the Census, 1972], ratios of industrial acreage to total land area were computed. Total values of real industrial property were derived by factoring the locally assessed real value of each type property to account for the difference between the sales value of real property and the assessed value, This ratio varies from jurisdiction to jurisdiction, and estimates are available in the 1972 Census of Government [U.S. Bureau of the Census, 1972].

The Census of Government data also allocated the land area of certain major cities among the following categories: all residential, one-family residential, vacant lots, and commercial and industrial (Table 2-4). The areas are in acres and the

CITIES	ALL RESIDENTIAL: VAL ALL RS	AREA OF RS	1 FAMILY RESIDENTIAL: VAL 1 FM RS	AREA OF 1 F	VACANT LOTS: VAL VC LOT	AREA VC LT	COMMERCIAL: VAL COMM.	AREA COMM.	INDUSTRIAL: VAL INDUS.	AREA INDUS	1970 POP.	POP DENSTY	% RESIDENCES BUILT PRE 1939: PC PRE 39	AREA DATA STUDY DATE: 1960 POP.	DATA TAKEN
BERKELEY	913338.	3067.	585087.	-0.	18795.	-0.	196692.	267.	125288.	318.	116716.	17.94	57.09	111000.	61.
OAKLAND C	2564201.	11050.	1739328.	9230.	52253.	3850.	720367.	1450.	391908.	1850.	361561.	10.57	53.42	368000.	-0.
GLENDALE	1163712.	5727.	788015.	4490.	27063.	5317.	273815.	605.	125766.	761.	132752.	7.07	38.75	119000.	65.
L BEACH	3132626.	10112.	1914135.	7795.	110773.	-0.	713369.	1076.	451949.	-0.	358633.	11.83	31.60	344000.	66.
L A	21614106.	185600.	14159734.	102400.	1070005.	29408.	6738378.	13037.	3994686.	13773.	2816061.	9.56	32.17	2479000.	65.
PASADENA	1041544.	6819.	678815.	6003.	39728.	1129.	340272.	567.	298821.	282.	113327.	7.84	42.50	116000.	61.
TORRANCE	1103975.	4365.	766924.	3894.	76964.	2186.	370049.	567.	470784.	1867.	134584.	10.19	4.44	101000.	66.
SACRAMEN	1472132.	14469.	1262712.	12135.	116976.	21170.	419349.	2800.	180981.	2800.	254413.	4.28	39.69	192000.	66.
S DIEGO	4516679.	24758.	3361846.	21633.	384946.	105746.	1090675.	2712.	237383.	4430.	696769.	3.53	21.66	573000.	66.
S FRAN	6061417.	8665.	2984396.	-0.	164658.	1371.	3303417.	1884.	699791.	1552.	715674.	24.41	65.77	740000.	64.
SAN JOSE	3744423.	13251.	3096242.	11586.	267840.	37414.	787454.	1475.	374979.	2445.	445779.	15.20	13.23	204000.	65.
HONOLULU	5423665.	22007.	4360559.	21345.	342357.	281592.	2171269.	1523.	792828.	3539.	631880.	1.67	20.00	500000.	64.
CHICAGO	12591017.	45440.	4993781.	-0.	866353.	8960.	8259245.	10560.	7075228.	7040.	3366957.	23.64	66.56	3550000.	66.
MINNEAPOL	2291819.	13767.	1774309.	12521.	44862.	46782.	1207074.	1527.	530138.	821.	434400.	12.32	67.66	483000.	67.
ST PAUL	1589292.	10861.	1340371.	8865.	16326.	5031.	628640.	1063.	487135.	4339.	309828.	8.48	62.61	313000.	62.
NEW YORK	42293209.	-0.	7007160.	23644.	917604.	25656.	-0.	-0.	3503579.	6786.	7894862.	38.57	62.12	7782000.	60.
CLEVELAND	2226382.	17249.	1313236.	11296.	127087.	6376.	941388.	4750.	1412084.	3871.	750879.	15.35	73.35	876000.	63.
PITTSBURG	1736179.	10335.	1067429.	-0.	41797.	8230.	1179959.	1104.	260426.	1909.	520117.	14.72	74.60	604000.	60.
PHILADELP	6500718.	-0.	5016631.	-0.	156771.	-0.	3072686.	6898.	710690.	6263.	1948609.	22.40	69.39	200300.	60.
MEMPHIS	2296618.	31533.	2264041.	25542.	183241.	31556.	1136092.	8826.	447921.	3897.	623530.	5.77	22.84	498000.	68.
MILWAULK	3267273.	17111.	2734623.	11879.	27457.	14092.	1251997.	2037.	938997.	3385.	717099.	11.86	55.10	741000.	62.

CALIFORNIA: BERKELEY through SAN JOSE

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NOTE: -0. = NO DATA AVAILABLE

Table 2-4. Data Used for Estimating Wealth per Area
(area in acres, value in thousands of 1971 dollars)

values are in thousands of 1971 dollars. The survey estimating land use acreages was conducted from 1960 to 1968, while the values were assessed in 1971. To compare the ratio of these values for different cities, it was necessary to account for the differences in the acquisition dates of these data. The change in occupied area was assumed proportional to the change in population. Thus, the weighting factor was the proportion of the 1970 population* present in the year the survey was taken. If the population declined from 1960 to 1970, the weighting factor remained 1.0. Table 2-5 lists the values and the acreages of each type of land use for the cities for which both assessed values and land use data are available.

The averages and standard deviations of the value/acre ratios listed in Table 2-5 are computed for the set of value-per-acre ratios. From these data, the average value of all real property per acre is $322,310. If each ratio is not equally weighted and the ratio of the totals of the columns in Table 2-5 are taken, the value per acre would be $311,310. This yields a good estimate only if the sample of cities for which data are available is representative of different city sizes in the U.S., which is not true for these data. To derive a value of structures per square mile, the inclusion of the value of the land in the $322,310 figure must be accounted for. The average proportion of the real wealth that is land is estimated at 24.7% for all non-financial corporations in 1968 [National Bureau of Economic Research, 1971].

The allocation of private business capital types by economic sector is as shown in Table 2-6. The right side of the table consists of the economic sectors associated with the business capital type on the left. The allocation of the national estimate of each business capital type among the economic sectors was made on the basis of a five-year moving average estimate of the capital consumption allowances for each economic sector. Where the moving average could not be estimated, the yearly average was used. Thus, in the case of electrical machinery it was assumed that transportation-utilities, manufacturing, and mining were the economic sectors with the majority of this type of business capital, and the total was distributed among them in relation to their relative capital consumption average for five years.

*Because the year of the Census of Government data was so close to 1970, it is assumed that growth for the one year was negligible.

CITIES	ALL RESIDENTIAL A-R VAL/A	1 FAMILY RESIDENTIAL 1FM VAL/A	VACANT LOT VLOT VAL/A	COMMERCIAL COMM VAL/A	INDUSTRIAL IND VAL/A	WEIGHTING
BERKELEY	296,34	0,00	0,00	733,09	392,06	1,00
OAKLAND C	232,05	188,44	13,57	496,80	211,84	1,00
GLENDALE	192,67	166,41	5,08	429,14	156,70	,95
L BEACH	302,21	239,55	0,00	646,75	0,00	,98
L A	109,49	130,00	36,25	630,16	272,66	,94
PASADENA	152,74	113,08	35,19	600,13	1059,65	1,00
TORRANCE	215,05	167,44	34,02	554,93	214,41	,85
SACRAMEN	86,77	88,74	5,41	127,72	55,12	,85
S DIEGO	162,99	138,84	3,60	359,30	47,87	,89
S FRAN	699,53	0,00	120,10	1753,41	450,90	1,00
SAN JOSE	205,95	194,77	6,63	389,09	111,77	,73
HONOLULU	225,88	187,23	1,21	1306,63	205,32	,92
CHICAGO	277,09	0,00	96,69	782,13	1005,00	1,00
MINNEAPOL	166,47	143,30	,96	790,49	645,72	1,00
ST PAUL	146,33	151,65	3,25	591,38	112,27	1,00
NEW YORK	0,00	296,36	35,77	0,00	516,30	1,00
CLEVELAND	129,07	116,26	19,93	198,19	364,79	1,00
PITTSBURG	167,99	0,00	5,08	1068,80	136,42	1,00
PHILADELP	0,00	0,00	0,00	445,45	113,47	1,00
MEMPHIS	61,10	74,36	5,66	107,99	96,43	,84
MILWAULK	190,95	230,21	1,95	614,63	277,40	1,00
TOTAL	4020,66	2626,65	430,33	12626,21	6446,13	19,94
AVERAGE	211,61	164,17	23,91	631,31	322,31	,95
SD DEV	135,13	58,11	33,64	391,70	291,00	,08
NUMBER	19,00	16,00	18,00	20,00	20,00	21,00

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Table 2-5. Wealth per Acre

(value in thousands of 1971 dollars)

Private Business Capital Types	Economic Sector Assigned to
Office Furniture and Fixtures	5, 6, 7, 8, 9
Engines and Turbines	2, 3, 4, 5, 6
Construction Machinery	4
Metal Working Machinery	5
Special Industrial Machinery	5
Office, Computing and Accounting Machinery	7, 8, 9
General Industry Machinery	5
Service Industry Machinery	9
Electrical Machinery	3, 5, 6
Instruments	5
Miscellaneous Equipment	2, 3, 4, 5, 6, 7, 8, 9

Private Economic Sectors	
1. Residential, Individuals	7. Retail - Wholesale trade
2. Agriculture	8. Financial, Insurance
3. Mining	9. Services
4. Construction	
5. Manufacturing	
6. Transportation - Utilities	

Table 2-6. The Allocation of Private Business Capital Types by Economic Sector

In addition to the equipment and other fixed non-residential contents, the stock of inventories for each sector was estimated from national estimates made by Loftus [1972]. These estimates were made for the following categories: farm, manufacturing, wholesale trade, and retail trade. The estimates were allocated to the specific economic sectors to which they best correspond. The remaining inventories categorized as "all other non-farm" were allocated in the same manner as the allocation of the business capital, by the five-year moving average proportion of the capital consumption for the remaining sectors. Table 2-7 (columns 3-10) lists the combined business capital and inventories by sector for the years in which both types of data are available.

The estimates of consumer durables are from Shavell [1970]. These items include:

> "Furniture, including mattresses and bedsprings, kitchen and other household appliances, china, glassware, tableware,

YEAR	RESIDENTIAL	FARMING	MINING	CONSTRUCT	MANUFACTOR	TRAN-UTILY	W-R TRADE	FINANCE	SERVICES	FED GOV	ST-LOC GOV
1925	0.*	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1926	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1927	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1928	0.	18066.	1782.2	2243.6	71675.	9619.8	23064.	3156.2	4241.5	0.	0.
1929	0.	19064.	1951.8	2406.6	74869.	10635.	23705.	3548.1	4364.5	0.	0.
1930	0.	17863.	1830.1	2409.3	76614.	10416.	22711.	3473.3	4244.5	0.	0.
1931	0.	19360.	1829.6	2319.4	74236.	10500.	20782.	3457.9	4130.2	0.	0.
1932	0.	20159.	1696.7	2089.5	70260.	9665.6	18426.	3208.8	3904.5	0.	0.
1933	0.	19656.	1655.5	1866.2	66177.	9026.3	17089.	3031.7	3715.4	0.	0.
1934	0.	16654.	1677.4	1677.2	65369.	8803.6	17065.	2998.8	3618.5	0.	0.
1935	0.	18050.	1583.5	1525.2	65563.	8135.6	17642.	2861.0	3540.4	0.	0.
1936	0.	16348.	1598.3	1454.2	68566.	8285.4	19835.	2892.0	3594.2	0.	0.
1937	0.	16144.	1625.4	1430.0	72150.	8401.5	20342.	2887.4	3680.6	0.	0.
1938	0.	18336.	1483.8	1369.0	70417.	8363.5	19395.	2661.3	3618.8	0.	0.
1939	0.	18839.	1342.2	1350.7	71111.	6322.0	19550.	2477.6	3577.7	0.	0.
1940	0.	19531.	1236.7	1406.4	65000.	8515.5	21213.	2345.7	3581.4	0.	0.
1941	0.	20628.	1219.2	1506.6	81662.	9547.3	23312.	2378.3	3677.9	0.	0.
1942	0.	22526.	1158.3	1560.3	85703.	9664.6	21643.	2348.4	3711.8	0.	0.
1943	0.	22726.	1096.9	1593.2	86864.	9251.5	20532.	2224.1	3743.3	0.	0.
1944	0.	22227.	1204.1	1588.1	86606.	9497.0	20998.	2217.1	3999.3	0.	0.
1945	0.	21331.	1389.4	2147.8	84963.	9863.4	22540.	2319.8	4432.8	0.	0.
1946	89300.	21134.	1722.8	3299.7	94113.	10470.	27576.	2690.7	5161.0	0.	0.
1947	0.	19539.	1970.0	4081.0	.10205E+06	11527.	28499.	2917.4	6157.7	0.	0.
1948	0.	20544.	2163.0	4856.2	.10722E+06	12227.	31078.	3126.5	7517.1	0.	0.
1949	0.	19748.	2198.4	5150.1	.11112E+06	12615.	31318.	3221.5	8319.2	0.	0.
1950	.11570E+06	20582.	2332.1	5651.0	.11489E+06	13934.	35763.	3574.9	9308.6	0.	0.
1951	0.	21555.	2463.5	6172.9	.13375E+06	15331.	36620.	3945.9	10140.	0.	0.
1952	0.	22258.	2562.5	6781.6	.14199E+06	16419.	37146.	4168.1	10965.	14890.	8016.0
1953	0.	21860.	2599.9	7277.0	.14996E+06	17104.	37960.	4297.5	11854.	22520.	8726.0
1954	0.	22357.	2714.7	7466.2	.15321E+06	18303.	38530.	4586.2	12656.	25873.	9601.0
1955	.15080E+06	22775.	2875.1	7720.8	.16194E+06	19389.	42112.	4792.5	13520.	27874.	10474.
1956	0.	22233.	3090.4	7996.2	.17265E+06	21054.	43108.	5268.0	14555.	25644.	11375.
1957	0.	22797.	3296.3	8082.2	.17837E+06	22695.	43951.	5826.4	15535.	25314.	12297.
1958	0.	23610.	3357.6	8044.6	.18011E+06	23958.	43945.	6211.7	16184.	28038.	13194.
1959	0.	23723.	3412.8	8247.7	.18566E+06	25257.	46778.	6574.1	16970.	28625.	14072.
1960	.18420E+06	23934.	3425.2	8300.3	.19159E+06	26633.	48706.	7059.5	17837.	29929.	15061.
1961	0.	24113.	3428.1	8387.2	.19669E+06	28072.	49047.	7471.5	18747.	30047.	16064.
1962	0.	24849.	3460.0	8415.7	.20318E+06	29267.	51052.	7869.9	19757.	31264.	17073.
1963	0.	25658.	3505.5	8786.1	.20937E+06	30587.	51956.	8477.5	20915.	31086.	18376.
1964	0.	25065.	3587.2	9226.0	.21825E+06	32063.	58359.	9316.2	22439.	30130.	19730.
1965	0.	26072.	3608.4	9782.4	.22942E+06	33745.	62344.	10094.	24344.	29238.	21230.
1966	0.	25861.	3886.4	10372.	.24657E+06	35766.	58474.	11460.	26526.	26017.	23079.
1967	0.	26593.	4155.5	11047.	.25557E+06	38194.	71844.	13142.	29122.	26163.	25382.
1968	0.	26837.	4349.7	11674.	.26949E+06	39995.	74257.	14502.	31453.	27010.	28155.
1969	.29350E+06	26823.	4614.3	12426.	.28049E+06	42392.	78615.	16164.	34251.	0.	0.
1970	0.	26838.	4456.3	13054.	.29089E+06	44584.	80976.	17642.	36841.	0.	0.
1971	0.	27956.	5091.1	13638.	.29506E+06	46685.	85151.	18792.	39143.	0.	0.
1972	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1973	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1974	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1975	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

* ZERO DENOTES ABSENCES OF DATA

Table 2-7. Historic Contents Values by Economic Sector; Consisting of Inventories and Durable Capital in Mill 1958$

utensils, and other durable house furnishings, ... radio and television receivers, records and musical instruments, opthalmic products and orthopedic appliances, books and maps, jewelry and watches"

The gross stock estimates with average service lives and L-2 survival patterns were used (see Appendix E for details). These contents values were aggregated so that a single value could be computed for the contents of residential structures. The contents for residential buildings are also listed in Table 2-7.

The estimates of public building contents are from the Institutional Investor Study Report of the Securities and Exchange Commission [National Bureau of Economic and Research, NBER, 1971]. They are categorized as "Federal Equipment (Civilian)" and "State and Local Equipment" and are made for 1952 through 1968. Also estimated is a value for "Federal Inventories." Unfortunately, estimates of state and local inventories made in the NBER study were not available due to the assumption of their small values. The sum of inventories and equipment values for both levels of government, are presented in Table 2-7.

To project the contents value-at-risk in future years, relationships of the following form were used:

$$V_y = ae^{B(y-1900)} \qquad (2\text{-}3)$$

V_y = value of contents in year y

a = constant

B = coefficient of exponent (rate of growth)

Estimation was by ordinary least squares techniques. The data were aggregated by the economic sectors listed in Table 2-7. Starting with 1940, it was possible to estimate the unknown parameters (Table 2-8). These parameters were used to forecast contents values in millions of 1958 dollars.

Sector	a	B	R^2	SSR	Number of Years's Data
Residential	9015.4	.0505	.99	.0329	5
Farming	13373.6	.0099	.81	.0452	32
Mining	197.0	.0467	.92	.1276	32
Construction	128.4	.0688	.84	.2825	32
Manufacturers	11946.4	.0460	.98	.0469	32
Transportation and Utilities	793.5	.0579	.99	.0469	32
Wholesale and Retail Trade	3356.7	.0450	.98	.0647	32
Finance	106.2	.0709	.98	.0961	32
Services	149.5	.0795	.98	.1148	32
Federal Gov.	8714.6	.0186	.29	.1509	17
State and Local Government	172.0	.0744	.99	.0209	17

Table 2-8. Results of Regression Analysis

The Distribution of Wealth by Structure Type

To further specify the wealth-at-risk it was necessary to establish the type of structure that houses (contents wealth) or embodies (structure wealth) the wealth-at-risk. The discussion of this procedure is in two parts. The first part describes the method used to determine the value of wealth by structure type. Note that the structure types are different for different hazards. The second part of this discussion provides the methods used for the projection of the housing characteristics used to determine the structure types.

The 1970 Census of Housing provided the only comprehensive source for building type distinctions. The data which define building characteristics are available by SMSA areas and portions of states outside of SMSAs (except for Washington, D.C., which was distinguished with statistics of its own). Other information utilized was non-SMSA state data which pertain to those counties of a state that are not included in an SMSA.

The data used are listed below for 1970.

- Population per housing unit
- Percent of housing units per building with 5 or more units
- Percent of housing units that are mobile homes
- Percent of housing units per buildings built in 1939 or earlier
- Percent of housing units per buildings with a basement
- Percent of housing units per buildings with concrete slab foundation
- Percent of housing units per buildings with other foundations
- Percent of housing units per buildings with 4 flooors or more.

Appendix B lists the SMSA and the non-SMSA state data used. To derive the non-SMSA state data, it was necessary to subtract the SMSA data from the state totals.

For each type of hazard, different building characteristics were used to define vulnerability. In the case of wind, the height of the building is an important characteristic; for water hazard, the presence of a basement is a factor affecting vulnerability; for earthquakes, the age of the building gives an indication of the building code used in designing for lateral strength. The following discussion provides the different categories in detail and the methods used to estimate the values by structure type.

Hurricane, tornado, and severe wind were found to have common damage-versus-intensity relationships. The set of building and window categories used for damage estimation [Hart, 1976] are given in Table 2-9 and 2-10.

	Window Categories
A.	Windows in structures less than 4 stories
B.	Window damage for 4 or more story structures

Table 2-9. Window Categories for Wind Hazard Vulnerability

Type	Building Categories for Wind Hazard
1	1-3 story wood frame residential
2	1-3 story wood frame commercial, financial, and service
3	1-3 story concrete and masonry wall residential
4	1-3 story metal commercial, financial, and service
5	1-3 story concrete and metal commercial and industrial
6	4 or more story steel ductile frame
7	Mobile home with engineered tie downs
8	Mobile homes without tie downs

Table 2-10. Building Categories for Wind Hazard Vulnerability

Type 1

The value of the first category was precisely defined as the percent of total residential wealth that is not mobile homes or is not greater than 3 stories, and is wood frame. The value of residential buildings that are less than 4 stories and not mobile homes was estimated by first using the value of those buildings that are either less than five units or single family dwellings (assuming these are always less than 4 stories). Adding to this value the percent of housing in buildings with five units or more that are in structures with less than 4 stories, the value for residential buildings under four stories was,

$$\begin{array}{l}\text{Total}\\ \text{residential}\\ \text{building value}\\ \le 4\text{ stories}\end{array} = \left[\begin{array}{l}\text{Buildings}\\ \text{value of single}\\ \text{family 4}\\ \text{units or less}\end{array}\right] + \left\{\left[\begin{array}{l}\text{Residential}\\ \text{building}\\ \text{value of units}\\ \text{with 5 or more}\\ \text{in structure}\end{array}\right] \bullet \left[1 - \frac{\begin{array}{l}\text{\% of all units in}\\ \text{building with 5 +}\end{array}}{\begin{array}{l}\text{\% of all units in}\\ \text{buildings} > 3\\ \text{floors}\end{array}}\right]\right\} \quad (2\text{-}4)$$

Wood frame dwellings are distinguished from other construction by the following data [Hart, 1976]:

	Northeast	Northcentral	South	West
%Masonry	11	16	25	16
%Wood Frame	89	84	75	84

This value was then multiplied by the proportion of the building that was not glass. The estimated proportion value of glass in a building is:

Residential [Evans, 1969]	Non-Residential*
1.0%	2.5%

Thus, the first building category value is computed as:

$$\begin{bmatrix}\text{Residential buildings}\\ \text{wood frame} < 4\\ \text{stories less window}\\ \text{value}\end{bmatrix} = \begin{bmatrix}\text{Total residential}\\ \text{buildings} < 4\\ \text{stories}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residential}\\ \text{buildings \% wood}\\ \text{construction}\end{bmatrix} \bullet .99 \qquad (2\text{-}5)$$

Type 2

The value of wood frame commercial buildings was only estimated in non-SMSA areas where the structure types for residential buildings are assumed to be approximately the same as for those containing wholesale and retail trade, financial, insurance, and real estate offices, and service industries. This assumption was based on the small size of those towns in non-SMSA counties having undifferentiated structure types for commercial and industrial uses. The building values for these three economic sectors were aggregated for structure type 2. The proportion of building value in windows was assumed to be the same as that used for residential construction:

$$\begin{bmatrix}\text{Value of commercial,}\\ \text{financial, and}\\ \text{service, 1-3 story}\end{bmatrix} = \begin{bmatrix}\text{Value of all com-}\\ \text{mercial, financial,}\\ \text{and service}\\ \text{structures}\end{bmatrix} \bullet \left\{1 - \begin{bmatrix}\text{\% of residential}\\ \text{units in structures}\\ \text{with 4 floors or}\\ \text{more}\end{bmatrix}\right\} \qquad (2\text{-}6)$$

Using the percentage of residential wood frame structures, the type 2 building value was computed as:

$$\begin{bmatrix}\text{Value of commercial,}\\ \text{financial, and}\\ \text{service, W-F, 1-3}\\ \text{story structures}\\ \text{less window value}\end{bmatrix} = \begin{bmatrix}\text{Value of commercial,}\\ \text{financial, and}\\ \text{service, 1-3 story}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residential}\\ \text{structures of wood}\\ \text{frame construction}\end{bmatrix} \bullet .99 \qquad (2\text{-}7)$$

*The values for non-residential windows was obtained by comparing the total demand for glass products (SIC Code 35.01) by the residential and non-residential construction industry SIC Code 11.01 and 11.02, respectively, in the 1967 National Input-Output tables, the ratio between their demands is approximately 2.5 to 1, [U.S.Dept. of Commerce, 1974], thus, the residential factor was scaled by 2.5.

Type 3

This is the same value as type 1 except the percentage of residential buildings with masonry construction was used as a predictor:

$$\begin{bmatrix}\text{Total residential} \\ \text{structures} \leq 4 \\ \text{stories, less wind} \\ \text{window value}\end{bmatrix} = \begin{bmatrix}\text{Total residential} \\ \text{structures} < 4 \\ \text{stories}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residential} \\ \text{structures \&} \\ \text{masonry construc-} \\ \text{tion}\end{bmatrix} \bullet .99 \quad (2\text{-}8)$$

Type 4

This is the same value as type 2 except that as in computing type 3, the percentage of masonry residential structures was used as a predictor.

$$\begin{bmatrix}\text{Value of commercial,} \\ \text{financial, and} \\ \text{service, 1-3 story} \\ \text{masonry construction} \\ \text{less window value}\end{bmatrix} = \begin{bmatrix}\text{Value of commercial,} \\ \text{financial, and} \\ \text{service, 1-3 story}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residential} \\ \text{structuresof masonry} \\ \text{construction}\end{bmatrix} \bullet .99 \quad (2\text{-}9)$$

Type 5

Type 5 building value was estimated from the forecast building value in all non-industrial sectors of the economy, except those that comprise types 2 and 4 when the county is non-SMSA. Again, this was done because of the similarity between commercial structures and housing in rural areas. This value of all non-residential structures was multiplied by the percent of residential structures that are less than four stories high, less the value of the windows. This calculation assumes that non-residential structure heights and residential structure heights are the same.

$$\begin{bmatrix}\text{Value of non-} \\ \text{residential} \\ \text{structures 1-3} \\ \text{stories less} \\ \text{window value}\end{bmatrix} = \left\{ \begin{bmatrix}\text{Value of all} \\ \text{non-residential} \\ \text{structures}\end{bmatrix} - \begin{bmatrix}\text{Value of finanical,} \\ \text{commercial, and} \\ \text{services struc-} \\ \text{tures (if non-} \\ \text{SMSA)}\end{bmatrix} \right\} \bullet \begin{bmatrix}\text{\% of resi-} \\ \text{dential units} \\ \text{1-3 stories}\end{bmatrix} \bullet .99 \quad (2\text{-}10)$$

Type 6

Building value of type 6 is the same as 5, except that the percent of residential structures greater than or equal to 4 floors with the addition of those residences above 3 stories are used as predictors

$$\begin{bmatrix}\text{All structures}\\ \text{with 4 stories or}\\ \text{more, less windows}\end{bmatrix} = \left\{ \begin{bmatrix}\text{Value of all non-}\\ \text{residential}\\ \text{structures}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residential}\\ \text{units in structures}\\ \text{greater than 3}\\ \text{stories}\end{bmatrix} + \begin{bmatrix}\text{Value of residential}\\ \text{structure or units}\\ \text{with 5 or more}\end{bmatrix} \bullet \begin{bmatrix}\dfrac{\text{\% of all units on structures with 5 or more units}}{\text{\% of all units in structures greater than 3 floors}}\end{bmatrix} \right\} \bullet .99 \qquad (2\text{-}11)$$

Types 7 and 8

The value of mobile homes was retained intact, except for the value of the windows which was assumed to be the same percentage of the total volume as that of residential buildings. Tie-downs were assumed present only in these states which have tie-down laws, (Texas, Florida, California, and New Mexico) [Hart, 1976].

For window values A and B, the amount of window value removed from the building type values was summed for buildings under and over four stories.

The probabilities of occurrence for all the wind hazards were at the county level of detail, and the county values for each building and window category were also county totals. For hurricane and severe wind, the building values used were county totals. For tornado the value used was the value per square mile using the county area to define building and window type value density. Damages are calculated for each of the above building and window categories. Damage values were then disaggregated to the economic sectors when reported.

The structure characteristics needed for the tsunami and storm surge damage forecasts are derived from the same census data as the wind-related hazards, with the exception that tsunami has an additional parameter for port facilities. Listed below are the categories of wealth used in estimating water damage:

Type	Building Categories for Water Hazards
1	1 story residential with basement
2	1 story residential without basement
3	2 or more story residential with basement
4	2 or more story residential without basement
5	Commercial, financial, service building with basement, 1-2 story
6	Commercial, financial, service building without basement, 1-2 story
7	Commercial, financial, service building with basement, >2 story
8	Commercial, financial, service building without basement, >2 story
9	Mobile homes
10	Value of all non-residential
11	Value of port facilities/sq. mile (tsunami only)

Table 2-11.

Types 1 to 4

All residential units that are not mobile homes or in structures with five or more units were multiplied by 0.44 on the Gulf and Atlantic coasts, and by 0.87 on the Pacific coast to obtain the number of one story structures [Lee, 1976]. It was assumed that all the structures with five or more units are greater than one story.

This value was then multiplied by the percent of units with basements to provide the values in types 1 through 4.*

$$\begin{bmatrix}\text{Value}\\ \text{Type 1}\end{bmatrix} = \begin{bmatrix}\text{All residential}\\ \text{value (mobile}\\ \text{homes and 5}\\ \text{units)}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residences}\\ \text{that are 1}\\ \text{story}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of units with}\\ \text{basements}\end{bmatrix} \qquad (2\text{-}12)$$

*A basic assumption made was that the value of a structure with a basement and one story is the same as a 2-story structure without a basement.

$$\begin{bmatrix}\text{Value}\\ \text{Type 2}\end{bmatrix} = \begin{bmatrix}\text{All residential}\\ \text{value (mobile}\\ \text{home and 5}\\ \text{units)}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residences}\\ \text{that are 1 story}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of units with}\\ \text{no basement}\end{bmatrix} \qquad (2\text{-}13)$$

$$\begin{bmatrix}\text{Value}\\ \text{Type 3}\end{bmatrix} = \left\{\begin{bmatrix}\text{All residential}\\ \text{value (mobile}\\ \text{home and 5}\\ \text{units)}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residences}\\ \text{that are greater}\\ \text{than 1 story}\end{bmatrix} \bullet \begin{bmatrix}\text{All residences}\\ \text{in 5 units}\end{bmatrix}\right\} \bullet \begin{bmatrix}\text{\% of units with}\\ \text{basements}\end{bmatrix} \qquad (2\text{-}14)$$

$$\begin{bmatrix}\text{Value}\\ \text{Type 4}\end{bmatrix} = \left\{\begin{bmatrix}\text{All residential}\\ \text{value (mobile}\\ \text{home and 5}\\ \text{units)}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residences}\\ \text{that are greater}\\ \text{than 1 story}\end{bmatrix} \bullet \begin{bmatrix}\text{All residences}\\ \text{in 5 units}\end{bmatrix}\right\} \bullet \begin{bmatrix}\text{\% of units with-}\\ \text{out basements}\end{bmatrix} \qquad (2\text{-}15)$$

Types 5 to 8

The commercial, financial, and service activities in non-SMSA counties were assumed to be housed in structures similar to the residential structures of an area.* Accordingly, the procedure for estimating the building values for categories 5 through 8 was similar to the method for categories 1 through 4. These categories are only provided for non-SMSA counties.

$$\begin{bmatrix}\text{Value}\\ \text{Type 5}\end{bmatrix} = \begin{bmatrix}\text{All structures}\\ \text{financial, com-}\\ \text{mercial, and}\\ \text{service}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residences}\\ \text{1 story}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residences}\\ \text{with basement}\end{bmatrix} \qquad (2\text{-}16)$$

$$\begin{bmatrix}\text{Value}\\ \text{Type 6}\end{bmatrix} = \begin{bmatrix}\text{All structures}\\ \text{financial, com-}\\ \text{mercial, and}\\ \text{service}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residences}\\ \text{of 1 story}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residences}\\ \text{without basement}\end{bmatrix} \qquad (2\text{-}17)$$

$$\begin{bmatrix}\text{Value}\\ \text{Type 7}\end{bmatrix} = \begin{bmatrix}\text{All structures}\\ \text{financial, com-}\\ \text{mercial, and}\\ \text{service}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residences}\\ \text{of 2 story}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residences}\\ \text{with basement}\end{bmatrix} \qquad (2\text{-}18)$$

*The same assumption was used in the calculations of wind-related value categories.

$$\begin{bmatrix}\text{Value}\\ \text{Type 8}\end{bmatrix} = \begin{bmatrix}\text{All structures}\\ \text{financial, com-}\\ \text{mercial, and}\\ \text{service}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residences}\\ \text{of 2-story}\end{bmatrix} \bullet \begin{bmatrix}\text{\% of residences}\\ \text{without basement}\end{bmatrix} \quad (2\text{-}19)$$

Type 9

The value for mobile homes was estimated by county and used directly.

Type 10

The value of non-residential buildings was the total value of all buildings for the other sectors of the economy, except in non-SMSA counties. In those cases, the building value of financial, commercial, and service sectors were listed in categories 5 to 8 alone because of the similarity in construction of commercial structures to residential dwellings in rural areas.

Type 11

The value of port facilities/sq. mile was used as detailed above. It was scaled by the per capita income in the county.* This value was only used in the tsunami model.

The values used in the calculation of both storm surge and tsunami damage were values per capita in each category, by county. The hazard probabilities for tsunami and storm surge were provided in terms of the number of people exposed to the hazard. Due to the coastal nature of these hazards, only a portion of each county's building value was exposed. This portion was estimated by multiplying the "exposed population"* by the per capita value of buildings in each category of structure type. The damage calculations were made by multiplying the damage probability for each category by the value in each category exposed.

Because of the detailed data requirements for modeling the water related hazards (i.e., tsunami, storm surge, and riverine flooding) only tsunami and storm surge could be modeled in a manner that allowed county level analysis of the present model (for details see [Lee, et al., 1976]). For both storm surge and tsunami the probabilities of occurrence could be estimated by reliance on documented regional variances in the incidence. Furthermore, establishment of the exposures for both coastal hazards was facilitated by the nature of the hazard zones and the availa-

*The estimates for the "exposed populations" are discussed in the "Natural Hazards: An Expected Building Loss Assessment due to Storm Surge, Riverine Flooding and Tsunami" report.

bility of topographical maps for these areas. However, in the case of riverine flooding neither of these data was so readily available. The frequency of occurrence is established by a much more complex mechanism involving mixes of meterological phenomenon. The determination of exposed populations requires the detail of the tsunami and storm surge studies for every river bank instead of only coastal regions.

The development of a riverine flood model with a county level of detail would have required an order of magnitude effort above that for any other hazard model. Thus, it was decided that an existing national model developed for HUD by Don Friedman be modified for use in this study.

The model used to predict national flood losses considers a distribution of cities located in a region of the county - a collection of states such as New England - that have flood problems. The cities with flood problems are further identified according to the type of floods they may receive. The cities for each region are then subjected to flooding using a Monte Carlo method for establishing the incidence for one year. More detail and results from this model are given in Lee, et al., [1976]. Some results by state were generated using the regional totals and distributing losses by exposed value in the consistent states. These appear in Appendix H.

Earth related hazards examined in this study are earthquake, landslide, and expansive soil. The earthquake damage-versus-intensity relationships were available for two types of structures, with four quality classifications in each. The two types of construction are: residential and industrial, and commercial. To use this categorization with the regional data base, each economic sector was associated with a type of construction [Wiggins, et al., 1977]. However, due to data limitations, damage caused by landslide and expansive soil was computed on a per capita basis only. Thus, there are no specific building values associated with these forecasts.

The residential building value used was the total value of housing. The type of residential construction was estimated from the age of the housing units in the county. In every state but California, housing units built in or prior to 1939 were assumed to be built to one specification, and those structures built after

1939 were classified as another. In California, the age distinction used was for structures built in 1933 and earlier, and those built after 1933. [See Wiggins, et at., 1977, for details]

The proportion of buildings built in 1939 or earlier was estimated from the Census of Housing Detailed Housing Statistics, [U.S. Bureau of Census, 1972]. Appendix B lists the state and SMSA values of the proportion of housing units in 1970 that were built in 1939 or earlier. These proportions were used for estimating the age of both residential and industrial-commercial buildings.

In the case of California, a method for estimating the proportion of buildings built after 1933 was necessary because the available Census data contain no references to age distributions of structures built before 1939. A relationship was estimated from national housing age data taken in earlier census of housing. The percent of national housing stock built pre-1934 are listed for the following years.

Census Year	% of Pre-1934 Housing Units
1940	100.0
1950	79.2
1960	59.2
1970	40.6

Figure 2-4. Comparison of Estimated and Actual Building Vintage Distribution

The relationship estimated from these data is:

$$\begin{bmatrix} \text{\% Pre 1940} \\ \text{in Year } Yr_2 \end{bmatrix} = \begin{bmatrix} \text{\% Pre 1940} \\ \text{in Year } Yr_1 \end{bmatrix} \bullet \text{Exp}\left[-.02994 \bullet (Yr_2 - Yr_1)\right] \qquad (2\text{-}20)$$

Yr_1 - the year in which the % of residential structures built pre 1940 are known.

Applying this relationship to the California data, the proportion of structures estimated to be pre-1933 will be 7 years different from the pre-1940 structures.

Thus, in 1970, the pre-1933 structures will be equivalent to pre-1940 structures in 1977, thus $(Yr_2 - Yr_1) = 7$ to estimate the 1933 structures from pre-1940 structures for any year and consequently:

$$[\% \text{ pre } 1933] = [\% \text{ pre } 1940] \bullet .811 \qquad (2\text{-}21)$$

The estimated values-at-risk and types of structures were not used in the expansive soil and landslide loss estimates. These estimates relied solely on the populations of each county by applying a constant loss factor per capita dependent on the hazard conditions. [see Wiggins, et al., 1976 for details].

To forecast the composition of the stock of buildings in future years, a model was used to project changes in the importance of structure types to the year 2000. Historical census data were found for only a few large SMSAs: Atlanta, Baltimore, Boston, Buffalo, Chicago, Cleveland, Dallas, Detroit, Los Angeles-Long Beach, Minneapolis-St. Paul, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco-Oakland, Seattle and Washington, D.C. [U.S. Bureau of Census, 1961]. The temporal changes in four characteristics for which data was collected before 1970 were:

- Population per housing unit
- Percent of housing units in buildings with five units or more
- Percent of housing units in structures built in 1939 or earlier
- Percent of housing units that are mobile homes

Other relationships (not shown here) were calculated to estimate the ten-year changes in these factors. However, in using these estimates it was found that they dominate the values that are available on SMSA and non-SMSA state level. For instance, a predicted change in the number of mobile homes in an area may be as great as 50% in 10 years. This may be due, in part, to the fact that these relationships were estimated for data from large metropolitan centers. Thus, it was decided to keep the residential structure characteristics constant for the thirty-year period considered. The only characteristic listed above that is definitely time dependent is the percent of housing units of structures built in 1939 or earlier. Also, the average population per housing unit was changed for years after 1970, by applying the national rate of change to each county rate. The national rate of change was found to be -.00428 persons per housing unit per year. [U.S. Bureau of Census, 1961, 1972].

The other characteristics listed in the previous part of this section (structure characteristics used) were not tabulated in the earlier census; thus, a time series method could not be used to predict changes in these factors. To compensate for this, a crossection analysis was applied to determine the relationship of the parameters for which time series data are available on those that do not have historical statistics. From 1970 SMSA data, relationships between characteristics with historical data and those characteristics for which no historical data was available were found.

The parameters for which data are available are population, population density, and 1970 values of housing characteristics. Consequently, if a relationship between the population density and the percentage of housing units in structures with four or more floors can be made, a prediction of this percentage can be made given a forecast change in population density. This relationship was only used in the prediction of the change in the percentage of housing units in structures with four floors or more, and was found to be dependent on the ten-year change in population density as well as the percentage of housing units in structures of five units or more in 1970.

$$\begin{bmatrix}\text{\% of Housing Units}\\ \text{in buildings with}\\ \geq 4 \text{ floors}\end{bmatrix} = .0322 + .0000320 * \begin{bmatrix}\text{Population per}\\ \text{square mile}\end{bmatrix} + .279 * \begin{bmatrix}\text{\% of Housing Units}\\ \text{in buildings with}\\ \text{5 + units}\end{bmatrix} \qquad (2\text{-}22)$$

$N = 94$
$R^2 = 0.73$

This estimated relationship was not used directly, however. By taking the first derivative and keeping the percent of housing units in buildings with five units or more constant, the following result is obtained as a way to estimate the change in the percentage of units in buildings of four or more floors, depending on the change in population density:

$$\begin{bmatrix}\Delta \text{ \% of Housing Units}\\ \text{in buildings with}\\ \geq 4 \text{ floors to year t}\end{bmatrix} = (.0000320) * \begin{bmatrix}\Delta \text{ Population per}\\ \text{square mile to year t}\end{bmatrix} \qquad (2\text{-}23)$$

To forecast the value of new buildings, a method for estimating the rate of new construction was needed. This was derived by dividing the percent of housing structures built since 1940 by the percent of change in the population from 1940, and applying this to the projected change in population for each location being investigated. B.G. Jones, et al., 1976 have developed statistical models similar to those described here to estimate the building characteristics of an urban area based on the population. Their work was based on more detailed information available for selected cities in the U.S. and abroad and they concluded that a consistent pattern was present. It was designed to give insights into the development of exposi models for the determination of natural hazards risk.

The Regional Distribution of National Wealth Estimates

This section summarizes the chapter by referring to the methodology of loss estimation presented in Chapter One. The first and second sections of this chapter provide the estimates of TV_{efy}, the total replacement value of wealth type f (buildin or contents), for economic sector e, in year y. To regionalize this value, we used the proportion of national income earned in the county from the economic sector. For example, if per capita income for the construction industry is estimated as $283 in 1970 dollars in San Diego County, California, and the national ratio of contents-to-income for the construction sector is 1.17 in 1970, the per capita construction sector contents in the county is estimated at $331, or the total value of constructio industry contents is $2,960,000 × 331, or 980 million dollars in construction sector contents [in 1970 dollars valued at replacement cost].

Thus, using the above procedure, a value of TV_{refy} can be estimated based on the ratios of building and contents values to earnings. These ratios were computed for each year by economic sector as shown below.

$$J_{efy} = \frac{TV_{refy}}{EN_{rey}}, \qquad TV_{refy} = J_{efy} \cdot EN_{rey} \tag{2-24}$$

where

TV = total wealth value

EN = total earnings

J = national ratio of wealth value to earnings

e = economic sector

y = year

r = region (nation)

f - wealth type (building value, contents value)

TV was provided by Equation (2-24). EN was taken from the OBERS national projections of total personal earnings or personal income paid by all sectors. For intermediate years not projected, a linear interpolation method was used. The earnings in each sector were used for all but the calculation of the ratio of residential structure values to earnings. The residential structure values for each type of residential structure and for total residential contents were divided by the total earnings. Figure 2-5 provides a graphical representation of the values of J for each structure type, and Figure 2-6 provides the values used for the ratio of contents value to earnings by economic sector.

The national wealth estimates resulted in a 1970 value in replacement cost, of 2.1×10^{12} dollars in building wealth. A value of 1.2×10^{12} dollars in contents was also estimated (in 1970 dollars). The value of contents is projected to increase at a faster rate so that by 2000, contents value will be 6.3×10^{12} dollars, and structure value will be 4.9×10^{12} dollars. These national totals were calculated by summation of the regional and sector TV for a particular year. Thus

$$2.1 \times 10^{12} = \sum_r \sum_e TV_{r,e,\text{ buildings, } 1970}$$

$$1.2 \times 10^{12} = \sum_r \sum_e TV_{r,e,\text{ contents, } 1970}$$

and

$$4.9 \times 10^{12} = \sum_r \sum_e TV_{r,e,\text{ buildings, } 2000}$$

$$6.3 \times 10^{12} = \sum_r \sum_e TV_{r,e,\text{ contents, } 2000}$$

Summary

This chapter has described the development of the wealth exposure model. This model was designed to furnish a uniform wealth stock for each hazard. The wealth estimates were made on a national basis and distributed by region, type of wealth,

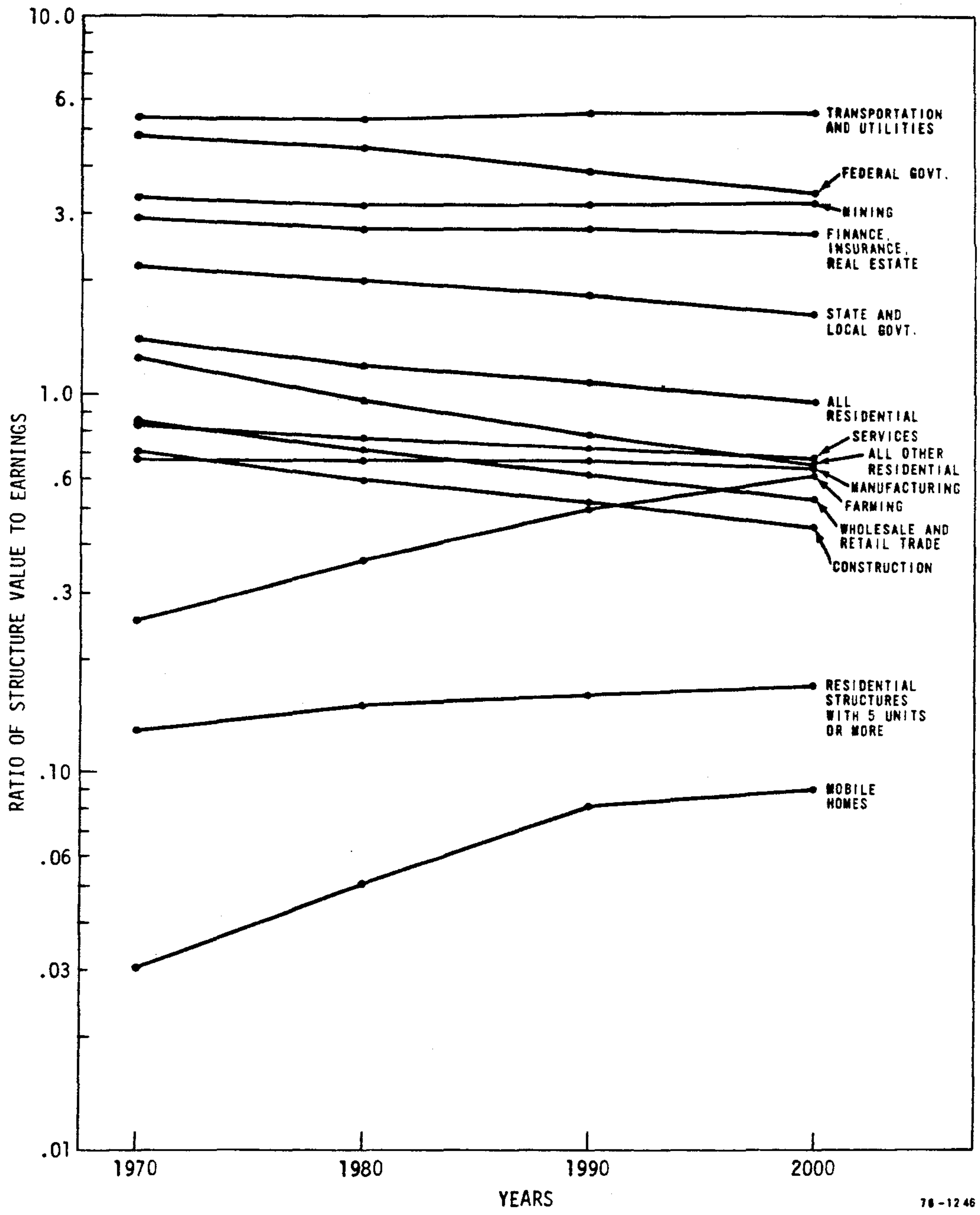


Figure 2-5. Ratio of Structure Value to Earnings by Economic Sector and Residential Structure Type

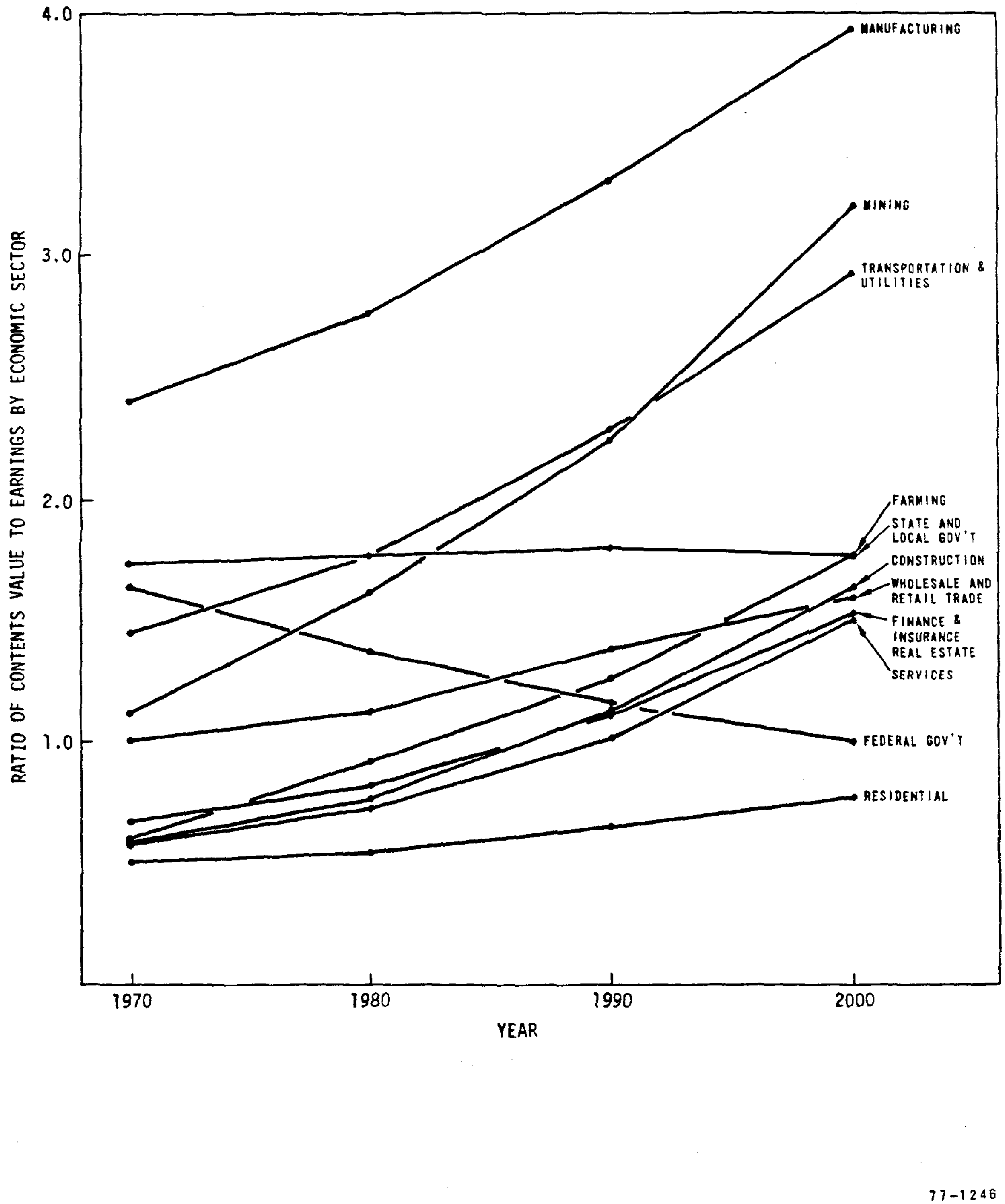


Figure 2-6. Ratio of Contents Value to Earnings by Economic Sector

economic sector, and vulnerability to hazards. The regional distribution was accomplished by county. Two types of wealth were estimated, structure wealth and contents wealth. The ownership of the wealth was established by sector of the economy, both public and private, and the vulnerability of the wealth was determined by the ability of the structure comprising or enclosing the wealth to resist damage to wind-related, water-related, and earth-related hazards. Also included in this chapter was a discussion of the projections used to estimate the distribution of wealth in the future.

Chapter Three

BUILDING LOSS ESTIMATION; TOTAL AND DISTRIBUTION BY SEVERITY

The first two chapters of this report discussed a general methodology for computing the multiple impacts resulting from building losses due to natural hazards. Included was the methodology for establishing a county-level data base of wealth-at-risk to natural hazards. This chapter describes the techniques employed in combining the wealth-at-risk (exposure), the vulnerability of the wealth-at-risk (damageability), and the probability of a hazard occurring with a defined intensity for purposes of computing building loss estimates on which these other impacts are based. The chapter presents the general method used to estimate building losses, describes the procedure for establishing the building damage distribution among damage states, and introduces the use of the damage distribution in the estimation of socioeconomic flow losses.

Estimation of Building Losses

One of the most obvious consequences of a natural disaster is the physical destruction to buildings. Life loss is another consequence; however, far more data are available for the prediction of building damage in relation to a specific physical event than are available for the prediction of loss of life. Consequently, the key element established for purposes of an overall assessment of the consequences of natural hazards is the development of an accurate forecast of potential building losses. This was necessary for at least two reasons: (1) building losses are the most predominant dimension of damage from natural events, and (2) they provide the basis for estimating other damages or losses through the use of an overall socioeconomic assessment model. Thus, the work described in this section is a preliminary step in the development of a more complete risk assessment.

Figure 3-1 provides an overall illustration of the system for estimating the impact of the natural hazard event. The system consists of integrating

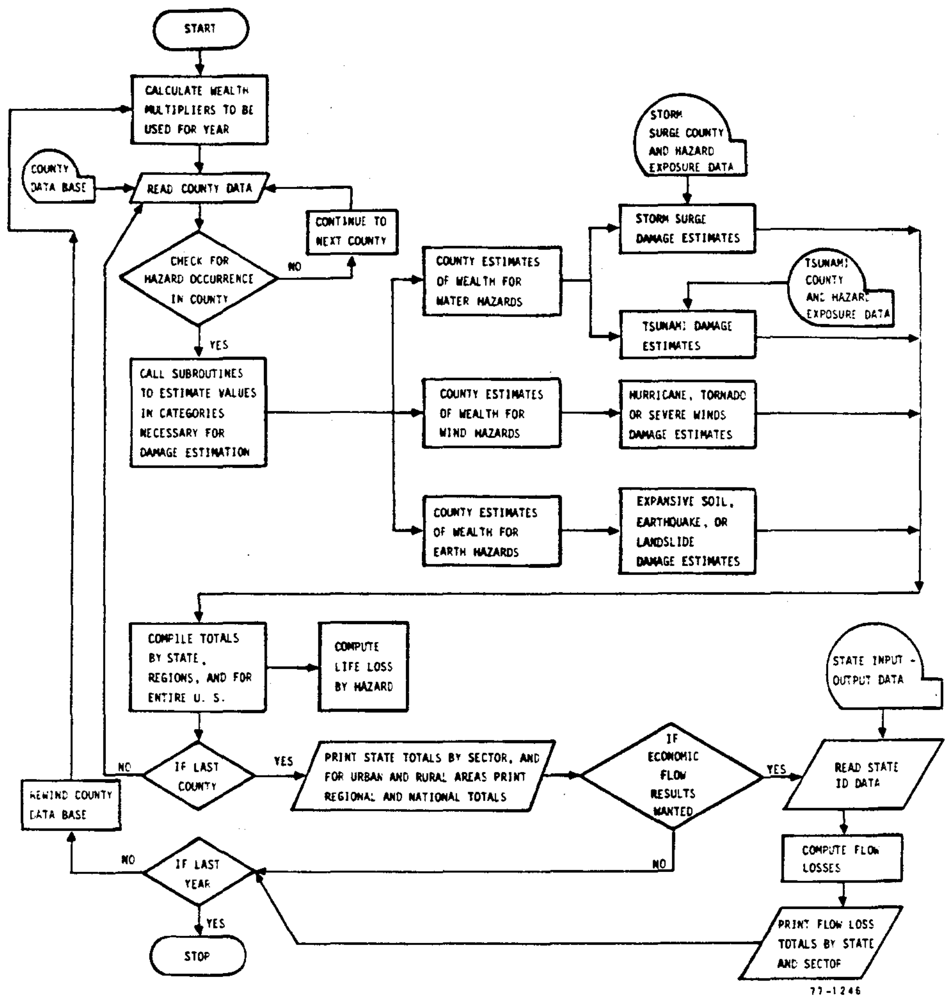


Figure 3-1. System for Estimation of Hazard Impact

a series of computer program subroutines for the purpose of incorporating building damage estimates into one procedure. Briefly, it is first necessary to establish the year or years under consideration, the hazard of concern, and the details of the desired output. The data set containing the wealth-at-risk information for each county of the United States is then scanned for purposes of assessing those counties which have a loss potential associated with the specific hazard in question. For those counties in which the probability of a hazard occurrence is greater than zero, the expected building damages are calculated. Loss forecasts are made based upon the damage assessment methodology developed for each hazard. These damage estimates are specific to each hazard and are directly related to the intensity measures identified in Table 1-1. The county level losses assessed for each specific hazard are then cumulatively totaled as each county is processed. It should be noted at this point that this methodology applies to all of the natural hazards considered in this paper with the exception of riverine flooding. Specifically, riverine flooding loss assessments were estimated using a national model developed by Friedman [1975] and later modified by Lee [1976].

As stated earlier, the values of the buildings present in any county are allocated from national data, based on the income earned in the county. Income earned is the only available factor estimated and projected by county and by industry. (In Chapter Seven, which deals with the sensitivity of the results, a comparison is made with the only other data which could be used to estimate property value, the locally-assessed value.) Thus, residential structures are valued according to total income; structures for manufacturing are based on manufacturing income; farming structures are allocated to local areas on the basis of farming income, etc. Consequently, each county's value of manufacturing structures is computed by multiplying the income earned from manufacturing in that county by the ratio of total national manufacturing structure wealth to total national income earned in manufacturing.

In some instances, the characteristics of a building determine its susceptibility to damage, given the presence of a particular hazard. In those cases, the value of structures by class is also estimated. For example, in the case of wind, a value is estimated for one-to-three story wood frame dwellings by county (one of the structure categories for which a damage-to-wind-velocity relationship has to be estimated). Once the values for a specific type of structure have been estimated, the damage calculations are made using the probabilities of the occurrence of specific events in the county. These damage estimates are summed by economic sector to yield state, regional, and national totals.

Degree of Building Damage

The determination of the value of building damage due to a natural event allows for the estimation of some of the higher order or secondary effects of natural hazards. To make these estimates, the building damage relationship from a natural event is given in terms of the degree or type of damage inflicted. By establishing an estimate of the geographic distribution of the damage types, the resulting time-related and other indirect consequences can be estimated. Distribution of damage types have been discussed by both Cochrane [1975] and Whitman [1974].

The average annual structure damages due to hurricane wind, severe wind, tornado, storm surge, tsunami and earthquake have been categorized by levels referred to as "damage states."* These are defined quantitatively by the percent of the replacement cost of the structure required for complete repair, and qualitatively by description of the structure condition.

DAMAGE STATE	STRUCTURE CONDITION
None (0 - 0.5%)*	No damage
Light (0.5 - 1.25%)	Minor ceiling tile or partition cracking; possible damage due to missiles.
Moderate (1.25 - 7.5%)	Many partitions cracked or ceiling tiles fallen down; a few structural members appear to be stressed beyond yield level.
Heavy (7.5 - 65%)	Significant number of structural members with structural damage, or damage to a structural system, roof having major damage.
Very Severe (65 - 100%)	Major damage; structure standing but will probably be taken down.
Collapse (100%)	Structure does not remain standing.

Figure 3-2. Damage State Description

*The damage caused by expansive soil was assumed to be in the "none" category due to the slow nature of the hazard. No damage state analysis was available for landslide due to the incomplete nature of the data. The riverine analysis also excluded reference to damage states.

The losses discussed here are based on annual rates of occurrence, and consequently the estimates of damage and damage state distributions may be modified by the consideration of major specific events through the use of a scenario analysis. Cochrane [1975] discusses the use of computer simulations of flood and earthquake as a means of assessing the consequences of a natural event.

Because each hazard is different in its action or levels of intensity, it was necessary to develop specific hazard damage programs. Thus, a variety of methods were needed to derive the distribution among damage states for the various hazards. For wind (hurricane, tornado, and severe winds) the damage relationships were given in the form of a damage matrix [Hart, 1976]. The distribution among damage states is a direct output of the damage estimation program. Figure 3-3 gives an example damage matrix for hurricane wind. Specifically, for various wind speeds (intensity) and for a given structure type a probability of a specific damage state is established. This provides an estimate of the distribution of the degree of damage among the buildings exposed [Hart, 1976].

HURRICANE DAMAGE MATRIX FOR ONE-TO-THREE STORY WOOD FRAME RESIDENTIAL STRUCTURE

DAMAGE STATE	PERCENT DAMAGE*	HURRICANE INTENSITY (Wind Speed - mph)						
		75	100	125	150	200	250	300
None	0 - 0.05%	.668	.356	.197	.113	.089	.064	.000
Light	.05 - 1.25%	.269	.266	.148	.063	.028	.039	.000
Moderate	1.25 - 7.5%	.049	.224	.239	.106	.049	.014	.013
Heavy	7.5 - 65%	.010	.130	.239	.314	.086	.021	.013
Very Severe	65 - 100%	.003	.016	.155	.255	.407	.119	.078
Collapse	100%	.001	.008	.021	.150	.340	.744	.898

*Ratio of repair cost to total structure replacement cost x 100.

Note: columns do not necessarily add to 1.000 due to round-off error.

SOURCE: G. Hart [1976]

Figure 3-3. Example Damage Matrix Used in Hurricane Wind Hazard Estimations

In the case of tsunami and storm surge, five damage categories were developed with different damage levels related to water depth [Lee, et al., 1976]. Figures 3-4 and 3-5 are illustrations of the depth-damage relationships.

These types of damage relationships are integrated with the categories of building exposed in the specific coastal community for tsunami or coastal county for storm surge. This integration provides the basis for assessment of the building wealth losses.

The earthquake building wealth loss assessment procedure was developed utilizing the Modified Mercalli Intensity [MMI] scale as the basis for the damage-intensity relationship. Figure 3-6 is an illustration of the earthquake-damage-versus-intensity relationship for commercial and industrial buildings built to Uniform Building Code quality 1 [UBCQ = 1], or a standard equal to that required under UBC.

To estimate damage, the integral of the following relationship is computed from MMI = 6 to the maximum MMI possible in an area [Wiggins, et al.,1976].

$$DR_{6rkl} = \int_{6}^{I_{max_r}} P(I)_i * D(I)_j dI \qquad (3\text{-}1)$$

$P(I)_i$ = annual probability of the intensity I occurring in area i

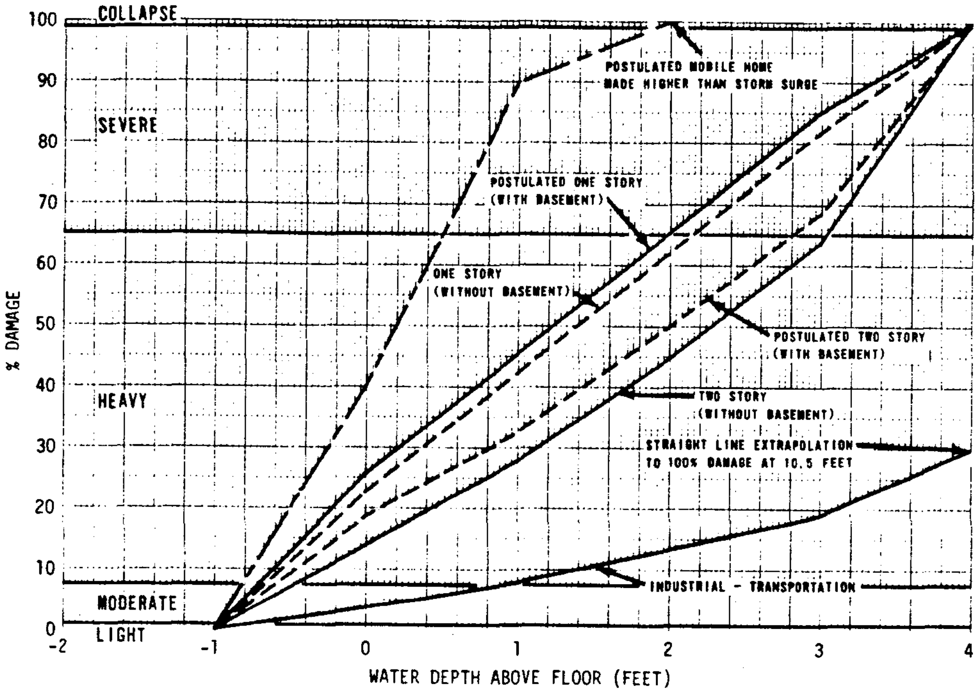
$D(I)_j$ = the damage to replacement value ratio caused by the occurrence of intensity I to building type j

DR_{6rkl} = the annual damage ratio in region r to structure type k, due to hazard 6 (earthquake) to wealth type l (buildings)

I_{max_r} = the maximum intensity in region r

In order to estimate the proportions of damage by damage state, ranges for the damage states in terms of MMI are determined. The ranges for the damage algorithm in Figure 3-5 are described below.

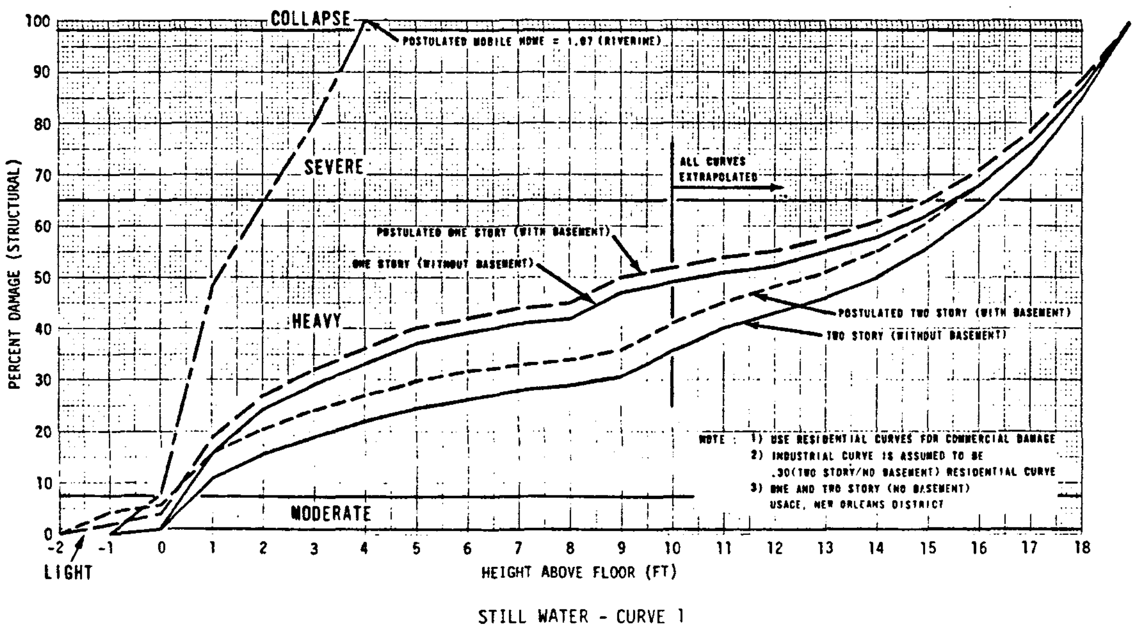
DAMAGE STATE	MMI
Light	6.0 → 6.5
Moderate	6.5 → 7.5
Heavy	7.5 → 9.5
Severe	9.5 → 9.8
Collapse	9.8 → 12.0



SOURCE: L. Lee, et al., [1976]

78-1246

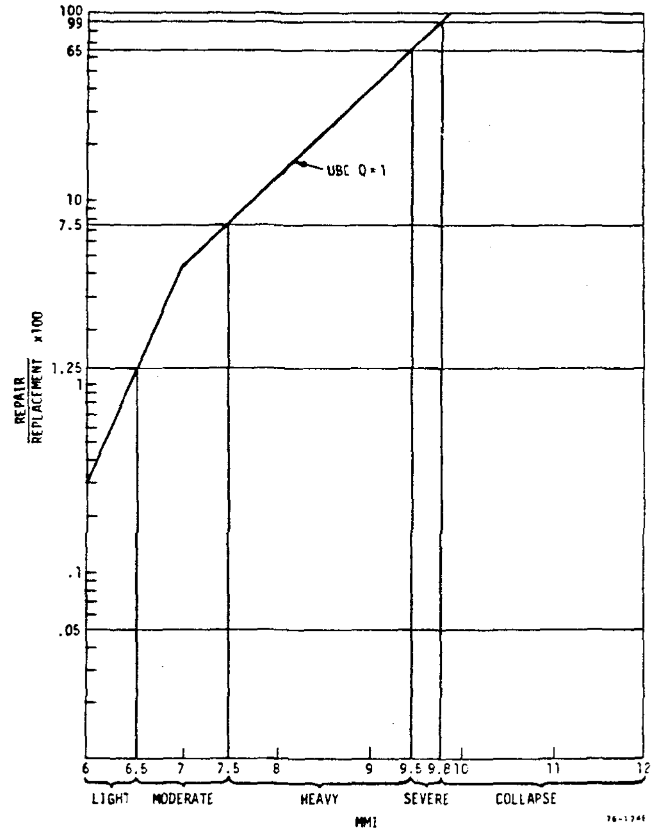
Figure 3-4. Tsunami Depth versus Damage Curves



SOURCE: L. Lee, et al., [1976]

78-1248

Figure 3-5. Storm Surge Depth versus Damage Curves



SOURCE: Wiggins, et al., [1976]

Figure 3-6. Earthquake Damage Algorithm for Commercial and Industrial Buildings

So if the I_{max} in a county is 9, then three integrals are solved with a series of different values for I_{max}, and the following computations are made:

$$DR1 = \int_{6}^{6.5} P(I) * D(I)\, dI \qquad (3\text{-}2)$$

$$DR2 = \int_{6.5}^{7.5} P(I) * D(I)\, dI \qquad (3\text{-}3)$$

$$DR3 = \int_{7.5}^{9} P(I) * D(I)\, dI \qquad (3\text{-}4)$$

DR4 = 0 DRi = Damage ratio for damage state i.

DR5 = 0

Implications of Damage State Distribution

Once the proportions of the estimated annual building structure damage in each damage state have been established, the following direct and indirect effects can be estimated:

1) Contents loss
2) Income loss
3) Unemployment
4) Homes lost and resultant homelessness

Contents loss is estimated from the severity of building structure damage that occurs by damage state and for each type hazard. For example, in the case of wind hazards, the contents of the structure are found to be only slightly damaged in buildings experiencing damage in the light and moderate category, whereas, in the case of storm surge, even light structural damage will affect the contents due to the vulnerability to water damage of objects resting on the floor. In the case of landslide and expansive soil, contents losses were not considered. Contents damage from riverine flooding was determined using the building damage estimates developed by Lee [1976].

Table 3-1 provides a general contents damage-building damage state relationship.

Damage State	WATERBORNE		EARTHQUAKE	AIRBORNE		
	Storm Surge	Tsunami	Earthquake	Severe Wind	Tornado	Hurricane
Light	1.0	1.0	0.0	0.0	0.0	0.0
Moderate	1.0	1.0	0.0	0.0	0.0	0.0
Heavy	1.0	1.0	1.0	1.0	1.0	1.0
Severe	1.0	1.0	1.0	1.0	1.0	1.0
Collapse	1.0	1.0	1.0	1.0	1.0	1.0

Table 3-1. Contents Damage by Hazard Type

Thus, if contents damage due to tsunami was being determined, damage in every damage state to buildings would be applied to the contents-at-risk estimates for those buildings. In the case of contents damage due to tornado, only that damage estimated as occurring in the Heavy, Severe, or Collapse damage states was applied to the contents-at-risk. The value of contents was distributed in the same manner used for building value because no method to estimate contents vulnerability (by contents type) was available.

Income losses were estimated from the time of inoperation which results from the occurrence of a damage state. R.V.Whitman has proposed that the occurrence of earthquakes results in some specific consequences. Table 3-2 gives the type of indirect consequences which he predicts.*

DAMAGE STATE	CORRESPONDING DAMAGE RATIOS	TIME TO RESTORE ORDER TO BUILDING CONTENTS (CLEANUP TIME) IN MAN-HOURS/ (100 sq.ft.)	LENGTH OF TIME BUILDING IS OUT OF FUNCTION	FRACTION OF PEOPLE — INJURED WITH (WITHOUT) CONVENTIONAL SUSPENDED CEILINGS AND LIGHT FIXTURES	FRACTION OF PEOPLE — KILLED WITH (WITHOUT) CONVENTIONAL SUSPENDED CEILINGS AND LIGHT FIXTURES
L	0.0005 to 0.0125	≤3.5	0	0 (0)	0 (0)
M	0.0125 to 0.20	4.5	0 to 1 day	$\frac{1}{100}$ $\left(\frac{1}{500}\right)$	0 (0)
H	0.20 to 0.65	4.5 - 6.5	up to 3 months	$\frac{1}{50}$ $\left(\frac{1}{75}\right)$	$\frac{1}{400}$ $\left(\frac{1}{500}\right)$
T	0.65 to 1.0	>6.5	>3 months	$\frac{1}{10}$ $\left(\frac{1}{20}\right)$	$\frac{1}{100}$ $\left(\frac{1}{150}\right)$
C	1.0	---	---	most	$\frac{1}{4}$ $\left(\frac{1}{4}\right)$

Source: R.V. Whitman, 1974

Table 3-2. Some Expected Consequences of Earthquakes

The average of the log of the ranges Whitman proposed are used for estimation of time of inoperation. These values are presented in Table 3-3. These portions of a year were then used to scale the proportions of the structures lost in each damage state in each industry to arrive at an estimate of the production time

*It may be noted that the damage states defined by Whitman are different from those defined above. Due to the insensitivity of the damage algorithms, this difference results in a negligible problem.

lost. The method of computation is given in detail in Chapter Five.

DAMAGE STATE	TIME OF INOPERATION IN YEARS
Light	0.0000
Moderate	0.00055
Heavy	0.0260
Severe	0.5000
Collapse	1.0000

Table 3-3. Time of Inoperation by Damage State

If the employment in each economic sector can be assumed to be linearly related to the income paid, then the level of unemployment can be estimated from the estimate of income lost. Chapter Six gives a detailed discussion of these calculations.

The amount of dislocation as a result of the occurrence of a natural disaster can be estimated from the number of damaged housing units and their time of inoperation. This loss is called loss of home use or homelessness, and is measured in person-years without a home. To calculate homelessness, the number of housing units damaged was used instead of the dollar value of housing structures. Thus, in a county with a population of 10,000 and a ratio of persons per housing unit of 3.00 the number of housing units would be estimated as 3,333. This is used as the "value-at-risk" instead of the 1970 dollars residential building replacement value of 53.3 million used when computing building loss. The time of inoperation is used to estimate the number of housing units affected over time. Results of these analyses are given in Chapter Six.

The estimated losses presented throughout this study are aggregated at national and state levels. The distribution of losses among the damage states is not necessarily meaningful at the county level because of the assumptions of homogeneity in the county data, even though such data exist for state and national aggregations.

Also, if a disaster strikes, the resulting building damage may not be proportioned among the damage states as the annual loss data would indicate. The annual loss data only gives the probability that a damage state will occur in a year. Thus, if a major earthquake occurs in the center of an isolated town, the majority of the damage due to that event will be in the heavy, severe, and collapse damage states. However the annual damage distribution among damage states would differ by consideration of the annual probabilities of many earthquakes, most with relatively low intensity.

Summary

This chapter has provided detail on the means for estimating building damages and how these estimates are used in the calculation of the related economic and social impacts that result. Two different methods of hazard modelling have been discussed. One is the damage probability matrix which is only available for the wind hazard models, and the other is the continuous function or damage curve type relationship that gives a specific damage level at each intensity level which is available for the other hazards. Also discussed were the methods used to compute the damage state distributions from these two types of damage intensity relationships in order to compute the time and contents losses.

Chapter Four

WEALTH IMPACTS

Wealth impacts from natural hazards are the losses incurred to the building and contents stocks subject to the risk of each hazard. This chapter presents computation of these losses from four different perspectives. First, a regional distribution of wealth impacts provides a logical extension of our basic model, defined by the spatial relationships of natural hazards and the building stock exposed to them. The county level of exposure and the growth models employed establish both the time stream of estimated wealth losses, and the distribution of losses among economic sectors. A time perspective influenced by a regional growth model provides a second perspective for examining wealth impacts. Thus, the discounting of aggregate wealth losses from 1970 to 2000 results in a present value for future losses. Consideration of the distribution of impacts, on different elements of the economy, provides a third view - one which demonstrates the incidence differences among the various economic sectors. A fourth perspective provides the distribution of total aggregated losses among damage states or types of damage. The distribution among damage states determines the degree of other losses that are attributed to each hazard. The classes of loss are therefore defined by the severity of the damage to specific buildings. Due to the dependence of contents loss calculations on building losses, the distribution of contents losses is not viewed from all perspectives, but is rather examined only through one perspective, by economic sector. Because the other impacts are monotonic functions of the building loss, their distributions can be inferred from the building losses.

Regional Distribution of Wealth Impacts

Tables 4-1 and 4-2 list the building losses by state for the eight hazards, as estimated by the model discussed in this report. The losses estimated for riverine flood follow the procedure in Lee, et al., [1976] in which losses are also predicted to occur by state. The baseline percent damage column identifies the percent of the total replacement value of all buildings in each state estimated to be lost in the years 1970 and 2000. The "all hazards" column displays estimated total losses by state due to the nine natural hazards studied.

1970 BASELINE % DAMAGE	STATE	TOTAL STRUCTURE VALUE ($BILL.)	POPULATION (MILLIONS)	EARTH HAZARDS			WATER HAZARDS			WIND HAZARDS			ALL HAZARDS
				EQ	ES**	LS	FL*	SS	TS	TO	HU	SW	
.309	AL	26.7	3.44	.0	14.45	4.6	28.9	4.3	0	18.4	11.9	0	82.6
.164	AK	3.9	0.27	3.6	0	0	2.4	0	0.4	.0	0	0	6.4
.130	AZ	16.9	1.77	0.7	2.3	2.29	14.7	0	0	1.9	0	0	21.9
.299	AR	13.6	1.92	3.3	7.01	2.98	20.0	0	0	7.3	0	0	40.6
.375	CA	228.0	19.96	439.6	182.59	36.83	178.5	0	3.5	13.8	0	0.8	855.6
.319	CO	22.7	2.21	20.2	17.77	6.27	18.4	0	0	9.4	0	0.4	72.3
.284	CT	35.0	3.03	0.8	7.08	10.30	21.8	9.7	0	5.7	43.6	0.4	99.4
.184	DE	5.7	0.55	0.1	.64	1.59	4.5	0.5	0	1.4	1.8	0	10.5
.087	DC	12.6	0.76	0.1	.79	.82	6.3	0	0	1.1	1.9	0	11.0
.825	FL	61.1	6.79	1.0	14.60	3.91	56.9	195.0	0	41.8	190.4	0.2	503.8
.223	GA	41.5	4.59	0.5	17.17	5.12	38.5	4.4	0	18.6	8.4	0	92.7
.114	HI	10.0	0.77	0.3	0	0	6.9	0	4.1	.0	0	0.1	11.4
.179	ID	6.3	0.71	1.5	2.42	1.01	5.9	0	0	0.4	0	0.1	11.3
.274	IL	126.8	11.12	1.0	28.69	33.16	132.2	0	0	152.2	0	0.8	348.0
.252	IN	48.8	5.20	0.1	6.31	6.80	61.8	0	0	47.7	0	0.4	123.1
.291	IA	25.8	2.83	.0	14.69	5.21	36.4	0	0	18.6	0	0.3	75.2
.423	KS	21.5	2.25	0.2	25.88	3.41	28.9	0	0	32.3	0	0.2	90.9
.192	KY	25.6	3.22	1.3	8.58	5.96	25.4	0	0	8.0	0	0	49.2
.721	LA	30.3	3.64	1.9	26.29	5.95	37.8	84.5	0	13.3	48.6	0.1	218.4
.233	ME	8.3	0.99	.0	2.30	2.12	7.1	0.5	0	1.0	6.3	0	19.3
.155	MD	49.2	3.92	0.1	6.66	11.97	32.2	4.0	0	8.6	12.8	0.1	76.4
.272	MA	63.4	5.69	1.7	4.83	13.21	40.8	12.5	0	35.3	63.6	0.8	172.7
.230	MI	90.8	8.88	0.9	42.31	19.47	105.6	0	0	40.1	0	0.1	208.5
.215	MN	37.7	3.80	.0	5.87	5.52	48.8	0	0	20.3	0	0.4	80.9
.477	MS	14.6	2.22	0.4	13.19	2.76	23.1	13.2	0	8.4	8.7	0	69.7
.396	MO	45.1	4.68	15.3	37.22	10.75	60.1	0	0	55.2	0	0.2	178.8
.202	MT	6.4	0.69	1.4	4.02	1.18	5.8	0	0	0.4	0	0.1	12.9
.391	NE	14.3	1.49	0.2	21.33	2.64	19.2	0	0	12.3	0	0.2	55.9
.153	NV	5.8	0.49	2.7	1.12	.64	4.1	0	0	0.2	0	0.1	8.9
.220	NH	7.4	0.74	0.2	.70	1.47	5.3	0	0	2.8	5.8	0	16.3
.159	NJ	83.7	7.17	3.4	7.47	10.70	49.7	11.5	0	26.2	23.1	0.8	132.9
.182	NM	9.1	1.02	1.2	3.81	.82	8.5	0	0	2.2	0	0.1	16.6
.166	NY	229.6	18.24	20.2	14.76	29.36	126.5	50.0	0	10.7	129.4	1.0	381.9
.310	NC	40.0	5.08	0.1	18.92	9.76	41.8	7.7	0	12.7	32.	0.2	124.1
.277	ND	4.8	0.62	.0	1.88	1.13	8.0	0	0	2.2	0	0.1	13.3
.194	OH	106.3	10.66	1.0	14.57	21.87	126.8	0	0	41.9	0	0.3	206.4
.338	OK	23.1	2.56	0.5	4.86	2.16	26.6	0	0	43.5	0	0.4	78.0
.151	OR	19.9	2.09	1.7	4.97	4.19	18.7	0	0.1	0.4	0	0	30.1
.136	PA	116.1	11.80	0.4	14.84	24.91	81.8	0	0	20.1	15.7	0.4	158.2
.284	RI	9.3	0.95	0.1	.74	.60	6.8	7.1	0	0.5	10.4	0.2	26.4
.311	SC	19.6	2.59	1.9	8.66	3.21	21.7	7.0	0	7.9	10.5	0	60.9
.311	SD	5.3	0.67	0.1	3.49	1.31	8.6	0	0	2.9	0	0.1	16.5
.210	TN	30.8	3.92	15.1	6.67	2.00	30.9	0	0	10.0	0	0	64.7
.398	TX	103.7	11.20	0.8	143.69	11.36	116.5	15.7	0	92.6	30.6	1.0	412.3
.286	UT	10.6	1.06	12.2	5.53	3.13	8.8	0	0	0.5	0	0.1	30.3
.137	VT	3.8	0.44	.0	.44	.54	3.2	0	0	.8	0.2	0	5.2
.220	VA	48.8	4.65	0.4	8.87	8.94	38.2	13.5	0	8.5	28.8	0.3	107.5
.404	WA	35.6	3.41	96.9	4.71	10.41	30.5	0	0.7	.4	0	0.2	143.8
.166	WV	14.2	1.74	0.1	3.87	4.88	13.7	0	0	1.0	0	0	23.6
.213	WI	41.2	4.42	.0	6.28	10.43	52.6	0	0	18.2	0	0.2	87.7
.200	WY	3.2	0.33	.0	2.27	.71	2.8	0	0	0.5	0	0.1	6.4
.279	U.S.	2064.5	203.24	655.2	798.1	370.3	1901.0	441.1	8.8	880.2	685.4	11.3	5751.4

*Flood is estimated with a different model

**Only residential expansive soil losses

Table 4-1. Summary of Annual Building Losses due to Natural Hazards in 1970 (millions of 1970$)

2000 BASELINE DAMAGE	STATE	TOTAL STRUCTURE VALUE ($ BILL.)	POPULATION (MILLIONS)	EARTH HAZARDS			WATER HAZARDS			WIND HAZARDS			ALL HAZARDS
				EQ	ES**	LS	FL*	SS	TS	TO	HU	SW	
.213	AL	65.0	4.17	.0	17.51	10.8	30.2	9.6	0	43.9	26.8	.0	138.81
.124	AK	8.6	0.34	7.1	-	-	2.2	0	1.4	0	0	.0	10.7
.063	AZ	47.8	2.78	1.6	3.61	6.2	13.3	0	0	5.5	0	.1	30.31
.163	AR	32.4	2.18	6.3	7.96	7.4	14.5	0	0	16.8	0	.0	52.96
.232	CA	539.8	26.03	748.8	238.10	88.7	135.5	0	8.8	31.8	0	1.9	1253.6
.219	CO	56.1	2.86	44.5	22.99	15.7	15.7	0	0	23.2	0	.9	122.99
.227	CT	82.6	4.05	1.6	9.47	24.4	16.9	22.0	0	13.2	98.6	1.0	187.17
.121	DE	14.4	0.75	.1	.87	4.0	4.2	1.3	0	3.3	4.6	.1	18.47
.062	DC	42.4	1.49	.1	1.55	2.7	12.1	0	0	3.5	6.3	.0	26.25
.781	FL	198.8	11.61	2.2	24.97	12.7	91.9	647.4	0	132.8	639.1	.6	1551.67
.147	GA	116.0	6.32	.9	23.64	14.2	53.8	9.8	0	49.9	18.7	.0	170.94
.056	HI	26.2	1.11	.3	-	-	6.6	0	7.5	0	0	.2	14.6
.093	ID	13.5	0.79	3.0	2.69	2.1	3.6	0	0	1.0	0	.1	12.49
.197	IL	286.8	13.60	1.7	35.09	74.9	119.1	0	0	333.3	0	1.7	565.79
.157	IN	118.2	6.56	.3	7.96	16.6	49.0	0	0	110.9	0	1.0	185.76
.157	IA	53.4	3.03	.1	15.73	11.0	19.3	0	0	37.2	0	.5	83.83
.264	KS	47.0	2.51	.3	28.88	7.8	17.0	0	0	69.7	0	.4	124.08
.099	KY	65.8	4.04	2.6	10.77	15.4	15.7	0	0	20.4	0	.0	64.87
.569	LA	66.4	3.91	3.9	28.24	13.1	29.6	171.0	0	28.3	101.2	.2	377.54
.156	ME	17.0	1.05	.1	2.44	4.5	3.6	1.1	0	2.0	12.7	.0	26.44
.105	MD	133.3	5.71	.3	9.70	31.0	38.1	9.4	0	22.4	29.6	.1	140.6
.220	MA	151.3	7.48	3.3	6.35	31.3	30.8	31.1	0	81.5	146.1	1.9	332.35
.131	MI	206.6	10.89	1.7	51.87	43.3	85.8	0	0	88.4	0	.2	271.27
.113	MN	91.8	4.80	.0	7.41	13.1	33.2	0	0	48.8	0	.8	103.31
.307	MS	33.0	2.36	.8	14.02	6.4	14.5	28.5	0	18.8	18.4	.0	101.42
.252	MO	101.2	5.40	28.2	42.95	24.5	36.6	0	0	122.4	0	.3	254.95
.106	MT	12.3	0.68	2.2	3.96	2.2	3.6	0	0	.8	0	.3	13.06
.217	NE	31.2	1.67	.3	23.91	6.0	11.3	0	0	25.8	0	.4	67.71
.094	NV	17.7	0.84	7.1	1.92	2.2	4.8	0	0	.5	0	.2	16.72
.142	NH	18.1	0.97	.4	.92	3.6	3.6	.1	0	6.9	13.6	.1	25.62
.114	NJ	199.2	9.53	6.5	9.93	25.8	46.5	25.0	0	61.0	50.7	1.8	227.23
.092	NM	20.2	1.15	2.3	4.29	1.8	5.4	0	0	4.6	0	.2	18.59
.125	NY	511.3	22.55	36.1	18.24	66.2	119.1	106.2	0	23.2	267.0	2.0	638.04
.199	NC	103.0	6.53	.2	24.31	25.6	29.6	17.1	0	32.0	75.7	.3	204.81
.126	ND	8.9	0.57	.0	1.73	2.1	3.2	0	0	4.0	0	.2	11.23
.108	OH	242.5	12.82	2.0	17.53	48.4	100.9	0	0	92.3	.0	.6	261.73
.255	OK	55.8	3.08	1.2	5.85	5.2	24.8	0	0	104.1	0	1.0	142.15
.069	OR	45.1	2.49	3.2	5.92	9.6	11.4	0	.1	.8	0	.1	31.12
.082	PA	252.0	13.49	.7	16.96	53.2	58.6	0	0	42.8	32.9	.9	206.06
.218	RI	20.4	1.14	.1	.89	1.3	4.2	14.8	0	1.0	21.9	.3	44.49
.213	SC	48.0	3.20	3.8	10.70	7.8	22.4	15.1	0	18.6	23.6	.1	102.1
.150	SD	10.4	0.65	.1	3.39	2.6	3.7	0	0	5.5	0	.3	15.59
.115	TN	80.0	5.04	33.6	8.58	5.2	19.0	0	0	25.9	0	.0	92.28
.261	TX	261.0	14.37	1.4	184.35	28.5	115.5	38.4	0	229.0	80.8	2.1	680.05
.191	UT	27.2	1.39	27.3	7.25	8.1	7.9	0	0	1.1	0	.2	51.85
.066	VT	8.6	0.51	.0	.51	1.2	1.6	0	0	1.8	.4	.0	5.71
.150	VA	133.0	6.46	.8	12.32	25.3	38.1	29.9	0	21.5	71.1	.6	199.62
.305	WA	78.5	3.99	187.7	5.51	23.1	19.7	0	1.9	.8	0	.5	239.21
.078	WV	29.5	1.73	.1	3.85	10.1	7.0	0	0	2.1	0	.0	23.15
.119	WI	89.5	5.10	.0	7.25	22.8	36.9	0	0	39.6	0	.4	106.95
.106	WY	6.4	0.33	.1	2.29	1.4	1.8	0	0	1.0	0	.2	6.79
.196	US	4925.2	256.10	1177.0	997.13	871.28	1594.0	1177.8	19.7	2055.7	1739.8	24.8	9657.2

*Flood is estimated with a different model
**Only residential expansive soil losses

Table 4-2. Summary of Annual Building Losses Due to Natural Hazards in 2000 (millions of 1970$)

It is interesting to note the change in rank order when annual losses are examined in relation to the individual state's wealth-at-risk. Appendix H contains tables of each state's total losses for 1970 and 2000, including contents wealth loss, supplier costs, and income losses. These state values comprise totals of the estimated impacts for each of the state's counties.

A casual look at Table 4-1 reveals that hurricane wind, storm surge, tsunami, and earthquake risks are concentrated in certain states. Hurricane wind, storm surge, and tsunami events are hazards which occur only in coastal zones while earthquake hazards are predominantly in the western United States. Appendix H also contains a state level distribution of loss reductions resulting from selected mitigations for several hazards (riverine flooding, expansive soil, and landslide mitigations are not considered in Appendix H).

Estimated Structure Losses Over Time

Table 4-3 provides estimated damages to buildings, forecast to the year 2000 by hazard type. The change in wealth-at-risk to the year 2000 was modeled using OBERS regional growth projections. The change in estimated damage to buildings was modeled using alternative mitigation policies, such as changes in building code design strength. This provided the ability to estimate the benefits through changes in the vulnerability of building wealth exposed to individual hazards. Population growth and land use mitigations were also simulated. Loss reductions due to these mitigations were discounted over a range of rates to provide the present value for the expected aggregate losses under alternative mitigation policies for the thirty-year period.

Discounted future losses due to tsunami, storm surge, hurricane, severe wind, earthquake, and tornado are given in Table 4-3. For example, the estimated aggregate losses to buildings due to tornado over the thirty-year period between year 1970 and year 2000 total $43,570,000,000, if we use a discount rate of 0% and no change in mitigation policies from 1970. However, if the "best"* mitigation policy selected from those compared in this study is adopted and becomes effective by 1980, there will be an estimated aggregated reduction in those damages by $4,501,900,000 or 10.3% of the expected loss under existing conditions. Similarly, for the tornado hazard (given a discount rate of 15%) there would be a total

*That mitigaion which leads to the most significant loss reductions.

	DISCOUNT RATE, %	ESTIMATED AGGREGATE BUILDING LOSSES	ESTIMATED AGGREGATE LOSS REDUCTIONS OF BUILDINGS DUE TO SELECTED MITIGATIONS	% LOSS REDUCTION
Tsunami	0.0	267.1	3.5	1.3
	2.9	163.1	1.8	1.1
	6.1	104.3	0.9	0.9
	10.0	69.6	0.4	0.6
	15.0	48.8	0.1	0.2
Storm Surge	0.0	23,971.0	6,960.0	29.0
	2.9	14,865.0	3,505.9	23.6
	6.1	9,449.1	1,677.3	17.8
	10.0	6,073.2	715.2	11.8
	15.0	3,955.9	253.3	6.4
Severe Wind	0.0	540.1	53.6	9.9
	2.9	340.1	26.9	7.9
	6.1	220.0	12.8	5.8
	10.0	144.2	5.4	3.7
	15.0	95.9	1.9	2.0
Tornado	0.0	43,570.0	4,501.9	10.3
	2.9	27,287.4	2,263.0	8.3
	6.1	17,546.7	1,080.0	6.2
	10.0	11,426.8	459.2	4.0
	15.0	7,546.5	162.0	2.1
Hurricane (Wind)	0.0	35,857.5	4,286.9	12.0
	2.9	22,330.6	2,144.1	9.6
	6.1	14,265.3	1,017.2	7.1
	10.0	9,220.3	429.3	4.2
	15.0	6,040.7	150.1	2.5
Earthquake	0.0	15,264.1	955.5	6.3
	2.9	9,532.0	485.9	5.0
	6.1	6,304.4	235.0	3.7
	10.0	4,395.7	101.5	2.3
	15.0	3,237.6	36.6	1.1

Table 4-3. Aggregated Estimated Building Losses for the United States and Loss Reductions Discounted from 1970 to 2000 (in 10^6 1970$)*

*Appendix D contains graphs of the present values of the cumulative losses and the loss reduction possible due to the most effective mitigation alternatives for each hazard from 1970 to 2000. The specific mitigations are described in the reports dealing with the individual hazards. (Lee, et al, 1976; Hart, 1976; and Wiggins, et al.,1976) and in chapter nine of this report.

of $7,546.5 million in building damage over the thirty-year period if no mitigation policy is adopted. Under the "best" mitigation, however, there would be a savings of $162.0 million, which is 2.1% over the unmitigated loss.

In Table 4-3, the 2.9% discount rate represents the national growth rate of the structure value used in the OBERS model predictions. The 6.1% discount rate has been estimated as the appropriate rate for use by the Water Resources Council in fiscal year 1976 [Grigg, et al., 1975]. The 10% rate approximates the level of the higher prime rates charged by banks in the past few years and is a rate recommended for use by the Office of Management and Budget [Lloyd, 1974]. Therefore, 15% is used as an approximate corporate opportunity cost.

The higher the discount rate, the less value or utility placed on the future savings or losses. In addition, higher discount rates translate into less consideration given to future generations.

Distribution of Wealth Losses Among Economic Sectors

The geographical incidence of each hazard, in conjunction with the geographic distribution of the elements of the various economic sectors, results in a different distribution of wealth losses for each hazard.

Table 4-4 summarizes the building impacts computed for 1970 for all hazards except riverine flooding and expansive soil. Table 4-5 provides a summary table of the contents wealth impacts by economic sector.

Contents loss estimates were only calculated for hurricane, severe wind, tornado, earthquake, storm surge, and tsunami. Landslides and expansive soils are assumed not to cause contents losses and the riverine flood model did not include these factors due to the different nature of the riverine flood model. It should be noted that the distribution of total contents loss by hazard differs from the distribution of building values listed in Table 4-4. The exposure values in Tables 4-4 and 4-5* provide the percent of the total structure and contents values

*More detailed tables for these hazards are given in Appendix F. Riverine flooding losses were estimated using a separate model, and thus are not included in this distribution analysis and the expansive soil losses are residential structures.

	HOUSING STRUCTURES	FARMING AND MINING STRUCTURES	CONSTRUCTION STRUCTURES	MANUFACTURING STRUCTURES	TRANSPORTATION & UTILITIES STRUCTURES	RETAIL AND WHOLESALE TRACE STRUCTURES	FINANCE STRUCTURES	SERVICES STRUCTURES	FEDERAL GOVERNMENT STRUCTURES	STATE AND LOCAL STRUCTURES	TOTAL VALUE OF STRUCTURES
Total Estimated Value Exposed in 10^6 1970$	1,106,073	21,026	27,058.1	109,897.4	235,109.4	85,075.9	104,911.4	93,039.0	128,561.01	153,753.8	2,064,507.5
Percent of Total	53.7	1.0	1.3	5.3	11.4	4.1	5.1	4.5	6.2	7.4	100.0
SEVERE WIND											
Exposure Total = 100	100.	100.	100.	100.	100.	100.	100.	100.	100.	100.	100.
Est. Loss 10^6 1970$	7.55	.07	.07	.26	.64	.60	.69	.64	.38	.42	11.32
Percent of Total	66.6	0.6	0.6	2.3	5.17	5.3	6.1	5.7	3.4	3.7	100.0
HURRICANE (Wind)											
Exposure Total = 100	32.6	19.2	33.3	28.9	33.5	32.6	39.5	36.5	36.2	31.2	33.1
Est. Loss 10^6 1970$	451.0	3.4	5.3	16.0	45.9	33.6	45.7	37.9	20.9	25.6	685.3
Percent of Total	65.9	0.5	0.8	2.3	6.7	4.9	6.7	5.5	3.0	3.7	100.0
STORM SURGE											
Exposure Total = 100	20.8	13.7	21.1	17.2	24.0	21.5	28.5	24.4	18.0	19.8	21.3
Est. Loss 10^6 1970$	333.	3.1	2.9	7.2	28.9	12.9	15.4	13.2	11.6	13.6	441.8
Percent of Total	75.4	0.7	0.7	1.6	6.5	2.9	3.5	3.0	2.6	3.1	100.0
TORNADO											
Exposure Total = 100	87.2	92.2	88.5	91.2	84.5	87.1	81.1	85.0	87.9	84.9	86.7
Est. Loss 10^6 1970$	502.	7.2	8.8	36.8	75.0	53.9	59.5	53.8	37.6	44.9	879.5
Percent of Total	57.1	0.8	1.0	4.2	8.5	6.1	6.8	6.1	4.3	5.1	100.0
TSUNAMI											
Exposure Total = 100	10.3	3.9	9.7	8.5	11.5	10.6	11.6	11.6	11.1	11.5	10.5
Est. Loss 10^6 1970$	4.52	.004	.02	.04	3.3	.17	.18	.24	.14	.11	8.72
Percent of Total	51.8	0.0	.2	.5		1.9	2.1	2.8	1.6	1.3	100.0
EARTHQUAKE											
Exposure Total = 100	71.9	72.8	71.3	68.5	72.7	71.8	75.1	74.6	75.9	72.7	72.4
Est. Loss 10^6 1970$	354.2	5.7	7.2	24.8	77.9	26.0	34.1	29.1	46.5	49.7	655.2
Percent of Total	54.0	0.9	1.1	3.8	11.9	4.0	5.2	4.4	7.1	7.6	100.0

Table 4-4. Distribution of Exposed Building Value and Losses in 1970

	HOUSEHOLD CONTENTS	FARMING AND MINING CONTENTS	CONSTRUCTION CONTENTS	MANUFACTURING CONTENTS	TRANSPORTATION & UTILITIES CONTENTS	RETAIL AND WHOLESALE TRADE CONTENTS	FINANCIAL CONTENTS	SERVICE CONTENTS	FEDERAL GOVERNMENT CONTENTS	STATE AND LOCAL CONTENTS	TOTAL CONTENTS
Total Contents Value At Risk 10^6 1970$	399,973.0	35,384.0	22,675.0	394,141.0	63,947.0	106,145.0	24,362.0	65,468.0	43,925.0	49,476.0	1,207,499.0
Percent of Exposure	33.1	2.9	1.9	32.6	5.3	9.5	2.0	5.9	3.6	4.1	100.0
SEVERE WIND											
Exposure Total = 100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Est. Loss 10^3 1970$	2,258.7	131.4	54.0	814.1	150.5	460.9	100.2	274.6	113.7	118.6	4,476.6
Percent of Total Loss	50.5	2.9	1.2	18.2	3.4	10.3	2.2	6.1	2.5	7.6	100.0
HURRICANE											
Exposure Total = 100	32.6	19.2	33.2	28.9	33.5	32.6	39.5	36.5	36.2	31.2	31.5
Est. Loss 10^3 1970$	138,455.0	4,324.1	3,763.0	47,909.0	10,493.3	26,166.9	6,675.6	16,518.8	6,004.2	6,901.5	307,332.0
Percent of Total Loss	45.1	1.4	1.2	15.6	3.4	8.5	2.2	5.4	2.0	2.2	100.0
STORM SURGE											
Exposure Total = 100	20.8	13.7	21.1	17.2	24.0	21.5	28.5	24.4	18.0	19.8	19.7
Est. Loss 10^3 1970$	120,400.0	3,104.0	2,432.0	25,900.0	7,849.0	16,360.0	3,584.0	9,292.0	3,969.0	4,381.0	197,200.0
Percent of Total Loss	61.1	1.6	1.2	13.1	4.0	8.3	1.8	4.3	7.0	2.2	100.0
TORNADO											
Exposure Total = 100	87.0	92.2	88.5	91.2	84.5	87.1	81.1	85.0	87.9	84.9	88.2
Est. Loss 10^3 1970$	180,971.3	13,232.6	7,341.8	130,788.3	20,243.4	41,422.7	10,547.0	28,597.6	12,738.9	14,339.0	470,194.0
Percent of Total Loss	38.5	2.8	1.6	27.8	4.3	10.9	2.2	6.1	7.7	3.0	100.0
TSUNAMI											
Exposure Total = 100	10.3	3.9	9.7	8.5	11.5	10.6	11.5	11.6	11.1	11.5	9.8
Est. Loss 10^3 1970$	1,635.0	7.8	15.1	136.1	3,226.0	216.4	41.3	170.8	46.7	35.0	5,530.2
Percent of Total Loss	29.6	.1	.3	2.5	58.4	3.9	.7	3.1	.8	.6	100.0
EARTHQUAKE											
Exposure Total = 100	71.9	72.8	71.3	68.5	72.7	71.6	75.1	74.6	75.9	72.7	71.1
Est. Loss 10^3 1970$	59,990.0	3,819.0	1,204.0	44,910.0	6,090.0	9,365.0	2,222.0	5,671.0	4,752.0	4,520.0	122,600.0
Percent of Total Loss	48.9	3.1	1.4	36.6	5.0	7.6	1.8	4.6	3.9	3.7	100.0

Table 4-5. Estimated Annual Contents Loss in 1970

exposed to a particular hazard. Because of hazard definition on a county basis, the exposure values are also estimated at the county level. In the case of storm surge and tsunami, which only affect the coastal properties, the exposure of the entire coastal county represents the exposed value. In the case of earthquake, only counties with a maximum possible Modified Mercalli Intensity above VI are included at-risk.

Distribution of Building Loss by Damage State

The type of damage incurred in each damage state contributes to the estimation of economic flow impacts discussed in Chapter 5. Figure 4-2 gives a perspective of the distribution of building damages by damage state for related hazards. Damage states refer to the scale of damage for a particular set of buildings. Portions of these buildings at-risk, either specific units or parts of buildings, suffer different degrees of damage. In the present model, these damage states provide an indication of the potential losses associated with the activities housed in the building.

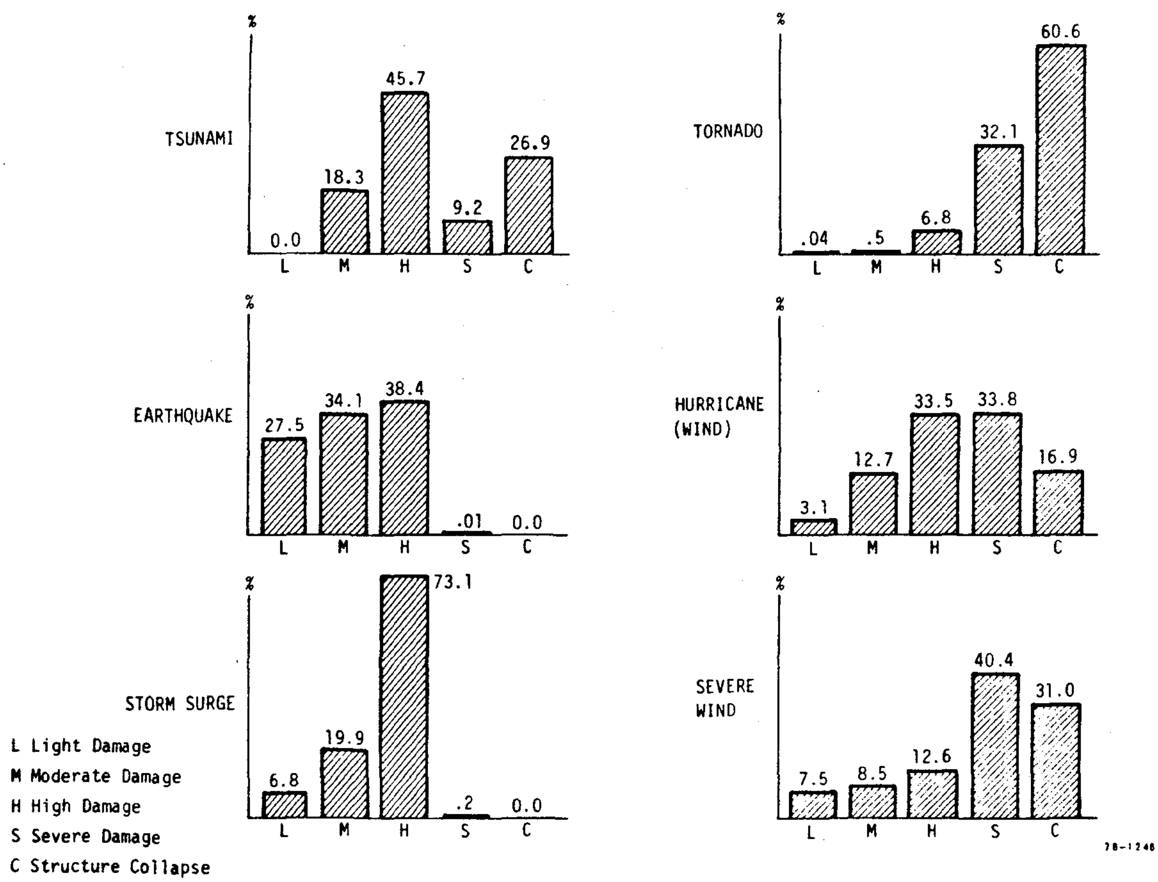


Figure 4-1. Average Proportionate Distribution of Building Damage by Selected Hazard Type in the United States and by Level of Severity of Hazard Effects

Estimates of contents loss rely on the distribution of building losses by damage state (Table 4-1 provides the distribution of contents loss by damage type). The building losses for tornado and tsunami are highly skewed in the direction of the highest damage state: collapse. Also skewed in a similar direction are severe wind losses; however, the lower rate of damage for severe wind implies relatively low damage in the collapse damage state.

Summary

This chapter has given four different views from which the national annual wealth losses can be examined. One of the difficulties in performing a study of this kind is the definition of an appropriate "point of view" for use in the evaluation of alternative mitigations. In Chapter Nine, a cost-benefit analysis is applied to some mitigations. This methodology relies on the time frame of the losses, the regional distribution of building damage rates, and the total economic impacts which includes income, contents, building, and supplier losses. The use of the multi-sector multiplier to calculate income losses requires the distribution of building losses by economic sector and data on the relationship between the time of inoperation and damage type. Thus, the cost-benefit analysis indirectly uses all the alternative loss distributions presented in this chapter. However, the present chapter presents these separate distributions as alternative policy parameters by themselves without the weights translation these distributions into "the economic effects" implies. The aim of this chapter is, therefore, to inform the reader of the alternative views of this complex phenomenon so that he or she may judge whether some of these criteria are more applicable than others for the evaluation of mitigations.

Chapter Five

ECONOMIC FLOW IMPACT ESTIMATES

Economic flow losses are those indirect losses resulting from the loss of use of a building and its contents. They are the impacts related to the economic transactions associated with buildings and their functions. Chapter One described the general procedure involved in the estimation of income losses using standard input-output data. These estimated losses, when integrated with the distribution of building damages among damage states, provide the basis for estimating the overall economic flow impacts.

The first part of this chapter describes the input-output data used to estimate the multisector multiplier $(I-M_r)^{-1}$ (see Equation 1-17). The second section describes the derivation of the economic product by economic sector and the direct product losses augmented with the use of the corresponding multiplier, to derive lost income. The third portion of this chapter describes the method and data used to compute what is called the market area or transportation effect.

State Input-Output Tables

In order to construct the regional input-output tables for this analysis, the state input-output tables developed by the Harvard Research Project, the Multi-Regional Input-Output Model (MRIO) [Polenske, 1970a, 1970b, 1974], were modified to provide eleven-sector tables for each state in the union. Table 5-1 lists the sectors contained in the original tables which were substantially aggregated into the eleven-sector tables used for this analysis. Both the direct flows and the secondary flows were summed for each sector. The economic sector tables available contained estimates for 1963; more recent data were not available at this level of detail. Thus, when using the input-output technique, it was assumed that the technology of production does not change, and that relative prices remain constant over the forecast period. These assumptions are consistent with previous input-output analyses.

The input-output tables were available by state, and for the District of Columbia. Thus, the income losses are calculated on a state-by-state basis.

AGGREGATED SECTORS	ORIGINAL SECTORS
1. AGRICULTURE AND MINING	Agriculture, Forestry and Fisheries: 1. Livestock and livestock products 2. Other agricultural products 3. Forestry and fishery products 4. Agricultural, forestry, and fishery services Mining: 5. Iron and ferroalloy ores mining 6. Nonferrous metal ores mining 7. Coal mining 8. Crude petroleum and natural gas 9. Stone and clay mining and quarrying 10. Chemicals and fertilizer mineral mining
2. CONSTRUCTION	Construction: 11. New construction 12. Maintenance and repair construction
3. MANUFACTURING	Manufacturing: 13. Ordinance and accessories 14. Food and kindred products 15. Tobacco manufactures 16. Broad and narrow fabrics, yarn and thread mills 17. Miscellaneous textile goods and floor coverings 18. Apparel 19. Miscellaneous fabricated textile products 20. Lumber and wood products, except containers 21. Wooden containers 22. Household furniture 23. Other furniture and fixtures 24. Paper and allied products except containers and boxes. 25. Paperboard containers and boxes 26. Printing and publishing 27. Chemicals and selected chemical products 28. Plastics and synthetic materials 29. Drugs, cleaning and toilet preparations 30. Paints and allied products 31. Petroleum refining and related industries 32. Rubber and miscellaneous, plastics products 33. Leather tanning and industrial leather products 34. Footwear and other leather products 35. Glass and glass products 36. Stone and clay products 37. Primary iron and steel manufacturing 38. Primary nonferrous metals manufacturing 39. Metal containers 40. Heating, plumbing, and fabricated structural metal products 41. Screw machine procucts, bolts, nuts, etc., and metal stampings 42. Other fabricated metal products 43. Engines and turbines 44. Farm machinery 45. Construction, mining, oil field machinery and equipment 46. Materials handling machinery and equipment 47. Metalworking machinery and equipment 48. Special industry machinery and equipment 49. General industrial machinery and equipment 50. Machine shop products 51. Office, computing, and accounting machines 52. Service industry machines 53. Electric transmission and distribution equipment and electrical industrial apparatus 54. Household appliances 55. Electric lighting and wiring equipment 56. Radio, television, and communication equipment 57. Electronic components and accessories 58. Miscellaneous electrical machinery, equipment and supplies 59. Motor vehicles and equipment 60. Aircraft and parts 61. Other transportation equipment 62. Professional, scientific, and controlling instruments and supplies 63. Optical, ophthalmic, and photographic equipment and supplies 64. Miscellaneous manufacturing

Table 5-1. The Aggregation of the MRIO Sectors Used in the Study

AGGREGATED SECTORS	ORIGINAL SECTORS
4. TRANSPORTATION AND UTILITIES	Transportation, Communication, Electric, Gas and Sanitary Services: 65. Transportation and warehousing* 66. Communications, except radio and television broadcasting 67. Radio and television broadcasting 68. Electric, gas, water and sanitary services
5. WHOLESALE AND RETAIL TRADE	Wholesale and Retail Trade: 69. Wholesale and retail trade
6. FINANCE INSURANCE AND REAL ESTATE	Finance, Insurance and Real Estate: 70. Finance and insurance 71. Real estate and rental
7. SERVICES	Services: 72. Hotels and lodging places, personal and repair services, except automobile repair 73. Business services 74. Research and development Eliminated as a separate industry in the 1963 study. Research and development performed for sale is distributed to the purchaser by each of the industries performing the research and development 75. Automobile repair and services 76. Amusements 77. Medical, educational
8. FEDERAL GOVERNMENT	Federal Government: 78. Federal Government Enterprises, Federal Government expenditures added to column
9. STATE AND LOCAL GOVERNMENT	State and Local Government: 79. State and Local Government Enterprises, State and Local Government expenditures added to column
10. OTHER SECTORS	Other Sectors: 80. Direct allocated imports 81. Transferred imports 82. Transfers in (row) 83. Tranfers out (column) 84. Inventory depletion 85. Scrap production 86. Scrap purchases
11. HOUSEHOLD	Household: Personal consumption (column) Payroll (row)
12. TOTAL REGIONAL PRODUCT	Total Regional Product: Total Regional Product (row only)

*Sector used in calculation of the market area effect.

Table 5-1. The Aggregation of the MRIO Sectors Used in the Study (Continued)

FROM \ TO	1 FARMING & MINING	2 CONSTRUCTION	3 MANUFACTURING	4 TRANSPORTATION COMMUNICATIONS AND UTILITIES	5 WHOLESALE RETAIL TRADE	6 FINANCE INSURANCE & REAL ESTATE	7 SERVICES	8 FEDERAL GOVERNMENT	9 STATE & LOCAL GOVERNMENT	10 OTHER SECTORS	11 HOUSEHOLDS
FARMING & MINING — 1	.2411	.1258E-01*	.8489E-01	.3014E-01	.1663E-02	.2137E-01	.9973E-03	.1630E-02	.3033E-02	.2588E-01	.1225E-01
CONSTRUCTION — 2	.1241E-01	.2894E-03	.2672E-02	.2700E-01	.3178E-02	.5816E-01	.8394E-02	.7823E-01	.3042	.1123	0.
MANUFACTURING — 3	.1185	.3722	.3833	.4729E-01	.5826E-01	.2514E-01	.1432	.3603	.6343E-01	.3806	.2974
TRANSPORTATION COMMUNICATIONS AND UTILITIES — 4	.3082E-01	.3980E-01	.3722E-01	.1170	.3790E-01	.1885E-01	.5902E-01	.3802E-01	.4104E-01	.6034E-01	.6034E-01
WHOLESALE RETAIL TRADE — 5	.2705E-01	.6422E-01	.2880E-01	.1539E-01	.1784E-01	.1331E-01	.2846E-01	.1103E-01	.2320E-02	.1429	.1886
FINANCE INSURANCE & REAL ESTATE — 6	.7003E-01	.1176E-01	.1385E-01	.2626E-01	.6659E-01	.1037	.6038E-01	.4984E-02	.1356E-01	.1186	.1652
SERVICES — 7	.2194E-01	.4381E-01	.2644E-01	.3364E-01	.5856E-01	.4184E-01	.5736E-01	.5755E-01	.3267E-01	.1013	.1302
FEDERAL GOVERNMENT — 8	.2607E-03	.3045E-03	.1413E-02	.7526E-02	.9501E-02	.7786E-02	.8780E-02	.1669E-02	.2852E-02	.3878E-02	.2073E-02
STATE & LOCAL GOVERNMENT — 9	.1251E-03	.4481E-03	.2077E-03	.5370E-01	.3596E-02	.5784E-02	.1794E-02	.2871E-02	.3597E-03	.1095E-01	.1490E-02
OTHER SECTORS — 10	.5148E-01	.6424E-03	.7077E-01	.8232E-01	.3444E-01	.6795E-01	.9506E-01	.3834	.4725	-.4095E-01	.1913E-01
HOUSEHOLDS — 11	.8198E-01	.2182	.1914	.2726	.3663	.1150	.2610	.5530E-01	.3011E-01	.9380E-01	.8927E-02

* Scientific notation E-01, etc., in the matrix is read as $X\,10^{-1}$

Table 5-2. The Direct Input Coefficient Matrix of the U.S. Economy (1963)

FROM \ TO	1 FARMING & MINING	2 CONSTRUCTION	3 MANUFACTURING	4 TRANSPORTATION COMMUNICATIONS AND UTILITIES	5 WHOLESALE RETAIL TRADE	6 FINANCE INSURANCE & REAL ESTATE	7 SERVICES	8 FEDERAL GOVERNMENT	9 STATE & LOCAL GOVERNMENT	10 OTHER SECTORS	11 HOUSEHOLDS
FARMING & MINING — 1	1.435	.2042	.3145	.1828	.1304	.1169	.1557	.2574	.2259	.2505	.1937
CONSTRUCTION — 2	.7018E-01	1.062	.7693E-01	.1159	.6361E-01	.1088	.8066E-01	.2007	.4309	.1923	.7662E-01
MANUFACTURING — 3	.7762	1.330	2.429	.8748	.8017	.5415	.9977	1.731	1.389	1.500	1.200
TRANSPORTATION COMMUNICATIONS AND UTILITIES — 4	.1619	.2204	.2307	1.293	.1907	.1218	.2300	.2861	.2833	.2755	.2431
WHOLESALE RETAIL TRADE — 5	.2057	.3370	.3007	.2656	1.252	.1642	.2775	.3645	.3631	.4274	.4206
FINANCE INSURANCE & REAL ESTATE — 6	.2767	.2775	.2988	.2884	.3174	1.268	.3244	.3585	.3604	.4267	.4345
SERVICES — 7	.1813	.2685	.2644	.2532	.2636	.1760	1.277	.3633	.3369	.3620	.3525
FEDERAL GOVERNMENT — 8	.1028E-01*	.1419E-01	.1566E-01	.2103E-01	.2186E-01	.1642E-01	.2238E-01	1.020	.2082E-01	.2147E-01	.1852E-01
STATE & LOCAL GOVERNMENT — 9	.1469E-01	.1938E-01	.2062E-01	.7711E-01	.2069E-01	.1763E-01	.2203E-01	.3099E-01	1.029	.3448E-01	.2311E-01
OTHER SECTORS — 10	.1978	.2015	.2828	.2789	.1948	.1788	.2735	.6276	.6843	1.211	.2328
HOUSEHOLDS — 11	.5042	.8161	.8192	.7935	.8214	.4442	.7909	.8677	.8216	.8482	1.663
SUMS OF THE COLUMNS —	3.834	4.751	5.053	4.444	4.078	3.154	4.452	6.108	5.945	5.549	4.859

*Scientific notation E-01, etc., in the matrix is read as X 10^{-1}

Table 5-3. The Leontief Inverse Matrix of the U.S. Economy (1963)

Table 5-2 is the input coefficient table for the national economy in the eleven-sector form used in this analysis. Because the total value added is not included in these tables, the sum of the elements in a column do not add to unity. Table 5-3 is the inverse of the input coefficient matrix subtracted from the identity matrix, and is referred to as the Leontief inverse matrix. From equation (1-12), the matrix M_r is the matrix shown in Table 5-2 when the region examined is the national economy. The Matrix $(I-M_r)^{-1}$ that appears in equation (1-15) is the matrix shown in Table 5-3 and is used to construct the multisector multiplier.

The multisector multiplier is traditionally used to compute the effect of changes in output of the economic sectors due to changes in expenditures for the products of each sector [Chipman, 1950; Richardson, 1972]. Thus, the multiplier demonstrates the interdependence of each economic sector's output and expenditures on the output of all sectors.

In case of natural disaster, the time of inoperation of an industry is translated directly to output that is not purchased by that industry. Thus, if a manufacturing facility is inoperative, no expenditure on the items it requires can be made during that time. This assumption ignores any time lag between the sale of an item and its production. Thus, cases where sales and production are geographically disassociated are ignored (e.g., if purchases in New York are for items produced in California). Unfortunately, the model's accuracy does not allow for such distinctions and it is assumed that if the shop is closed, no purchases are made, and that these lost purchases are not made up by increased purchases when the shop reopens. This may be a bit restrictive.

Discussion of the theory of the input-output direct coefficient matrix and the Leontief Inverse Matrix is available in Chapter One. Numerous sources are available for further discussion of this model [Landcaster, 1969; Chipman, 1950; and Richardson, 1972]. The required assumption of relative price stabilty may also be restrictive in the light of short term inflation that may be fostered by the loss of productive facilities and the increased demand for specific items needed for rebuilding.

However, this method has been used successfully in similar applications. For example, Cochrane [1974] uses input-output coefficients to analyze the effects of a natural disaster on an economy. Instead of the multi-sector multiplier approach used here, he used a linear programming solution to predict change from pre-disaster to post-disaster conditions of production. The use of constant relative price differences is also noted by Cochrane as one of the major assumptions in using input-output data for the analysis of disaster consequences. However, no other tool is available that provides such a detailed set of information.

The multi-sector multipliers in $(I-m)^{-1}$ provide a vector of losses felt by different sectors of the economy. Taking the total of these impacts would result in double-counting, therefore only the household sector multipliers are used. These are the total impacts on the household sector.

Income Losses

The estimated proportion of the national building wealth lost annually from natural disasters supplied the means for establishing the yearly loss in income. The income losses were estimated by economic sector, hazard, and year.

The loss of building use was calculated from the estimated building damage in each damage state. From Chapter One, the proportion of annual losses due to the damage sustained are estimated as follows:

DAMAGE STATE	PERCENT OF YEAR'S USE LOST	NUMBER OF DAYS USE LOST
Light	0.000%	0
Moderate	0.055%	.2
Heavy	2.600%	9.5
Severe	50.000%	182.5
Collapse	100.000%	365.0

Table 5-4. Proportion of Year's Use Lost by Damage State

Therefore, in the case of a specific economic sector and a particular hazard, the annual damage estimates provide a proportion of the total structure value that is lost to damage in each damage state. By assuming that the production depends upon the operation of the buildings that contain the process, a ratio of product-to-building value for each economic sector was obtained. This ratio is analogous to a capital-output ratio under the assumptions of a linear production function. The relationship assumed is:

$$\alpha = P/S \qquad (5\text{-}1)$$

where α = Annual output per structure year.

P = Annual Production*

S = Structure value available for the year, structure year

It is assumed that this relationship does not depend on the size of the specific facility: there are no economies or diseconomies of scale. This limitation is part of the price of using input-output techniques, which imply linear production functions. Note that the value of S is not simply the value of the structure housing the process, but it is the structure value available for the year and it is measured in dollar-years. Because light damage will have a relatively small impact on the use of the structure and severe damage is much more debilitating to the use of the structure, the amount of structure value available actually depends on the distribution of damage by damage state. To estimate the annual portion of output of an industry lost the following formula is used.

$$\sum_{a=1}^{A} \Delta P_{ea} = \alpha_e \cdot \Delta S_a \qquad (5\text{-}2)$$

where ΔP_{ea} = loss in annual output, due to damage state a, to sector e

α_e = annual output per structure year, for sector e

ΔS_a = portion of structure value lost for the year, due to damage state a

A = total number of damage states

*Annual production is defined as the annual value of all production by the sector of economy.

Thus, the summation of ΔP_{ea}'s will provide the direct loss in production due to the inability to use the structure as a factor of production. The relationship assumes that the annual product cannot be recouped and denies the possibility that excess capacity exists. This assumption may have some validity in the services and trade sectors, but may be unrealistic for manufacturers and raw materials producers. These industry differences require further examination for a better description of variations in the ability to recover.

The building value of ΔS_a is computed by adding a time aspect to the building damage. If the different times to recovery by severity of damage are ignored, the proportional loss in output would be directly related to the proportional loss in structure value.

Cochrane [1974] uses this method to compute direct product losses due to a potential San Francisco earthquake. Under scenario conditions where most structure damage will be severe, this may be an accurate description. However, in the case of annual loss estimates, the proportion of building damage that occurs in the lower damage states (see Figure 4-3) is significant in several hazards.

As an example of the computation of the value of S_a, assume an annual instantaneous building loss to manufacturers of 10 million 1970 dollars due to hurricane wind and that the value of structures lost for a year is wanted. Referring to Figure 4-3, the national average distribution of hurricane wind is given as: 3.1% - light, 12.7% - moderate, 33.5% heavy, 33.8% - severe, and 16.9% - collapse. Using this as the distribution of manufacturing structure losses for hurricane (in actuality, it will not be this distribution because this distribution does not account for the regional and building type distribution of the manufacturing sector) the sum of the S_a's over all damage states is: (see Table 5-5 for the breakdown of this calculation by damage state)

$$\sum_{a=1}^{A} S_a = 3.4678 \text{ million 1970 dollars}$$

or approximately 34% of the 10 million dollars of manufacturing building value loss for a year. To complete the computation of product loss, the value of α_{ey} (the annual output per structure year, for sector e in year 7) is needed. This is given by:

$$\alpha_{ey} = \frac{P_{ey}}{SVN_{ey}} \tag{5-3}$$

where P_{ey} = annual output for economic sector e in year y

SVN_{ey} = national strutural value for economic sector e in year y

α_{ey} = ratio of annual output to structure value which pertains to economic sector e, in year y

SVN, the national structure value as described in Chapter Two, is distributed by county through the use of the earnings in the sector in the county under consideration. From Equation 2-24,

$$J_{ey} = \frac{SVN_{ey}}{EN_{ey}} \tag{5-4}$$

where J_{ey} = national ratio of structure value to earnings in sector e, year y

EN_{ey} = national earnings in sector e, year y.

DAMAGE STATE	S_a's IN MILLIONS		TOTAL STRUCTURE VALUE LOST IN MILLIONS		PROPORTION OF LOSS IN DAMAGE STATE		PROPORTION OF YEAR LOST DUE TO STRUCTURE LOSS BY DAMAGE STATE
1	$S_1 = 0_1$	=	10.0	x	.031	x	.00000
2	S_2 = .00070	=	10.0	x	.127	x	.00055
3	S_3 = .08710	=	10.0	x	.335	x	.02600
4	S_4 = 1.69000	=	10.0	x	.338	x	.50000
5	S_5 = 1.69000	=	10.0	x	.169	x	1.00000

Table 5-5. Computation of S_a's, or the structure loss over time.

The amounts of product for each sector that was used are the sector products given for 1970 [U.S. Bureau of Census, 1972]*. They were divided by the structure values estimated for each sector in 1970 listed in Table 5-6 for values of α. Table 5-6 also gives the values of J by sector in 1970.

	STRUCTURE VALUE IN BILLION 1970$	PRODUCT / STRUCTURE VALUE α	STRUCTURE VALUE / EARNINGS J
1. RESIDENTIAL (total personal income)	1,106.1	.075	1.398
2. FARMING AND MINING	21.0	2.270	1.203
3. CONSTRUCTION	27.1	1.680	.702
4. MANUFACTURING	109.9	2.304	.671
5. TRANSPORTATION AND UTILITIES	235.1	0.350	5.365
6. WHOLESALE RETAIL TRADE	85.1	1.970	.850
7. FINANCIAL, INSURANCE AND REAL ESTATE	104.9	1.274	2.889
8. SERVICE INDUSTRIES	93.0	1.228	.831
9. FEDERAL GOVERNMENT	128.6	.413	4.809
10. STATE AND LOCAL GOVERNMENT	153.8	.477	2.149

Table 5-6. The Product, Structure Value, and Earnings Ratios for 1970 by Economic Sector

The discussion above has described the process for estimating direct product loss. To estimate indirect losses due to the interrelation of each sector of the economy to the whole economy, consider the multisector multiplier discussed in Chapter one (Equation 1-17):

*The product of the residential sector was estimated as a combination of rental value and household production. See Appendix M for details.

$$\Delta Y_r = (I-m_r)^{-1} \times \Delta E_r \qquad (5\text{-}5)$$

where ΔE_r = vector of direct product losses in region r.

$(I-m_r)^{-1}$ = Leontief inverse matrix for region r.

ΔY_r = the vector of direct and indirect income change in region r.

Thus, to this point in the discussion, estimates of ΔE_r have been made.

$$\Delta E_{er} = \sum_{a=1}^{A} \Delta P_{ear} \qquad (5\text{-}6)$$

P_{ear} = loss in annual output due to damage state a, sector e, in region r.

The income loss computed is the loss of personal income due to the production lost due to forced inoperation. This value is calculated from the household row of the Leontief Inverse Matrix. Each element is a multiplier by which the output loss in each sector will be weighted to determine the total induced income loss.

For example, if the product loss in the Farming and Mining sector is $6 million, this loss would be multiplied by the multiplier for Farming and Mining in the Household sector row to compute the income loss. If a national case is assumed, the multiplier would be .5042 from Table 5-3, and the resulting additional income loss would be computed as approximately $3 million, as a result of the loss in production in the Farming and Mining Sector. Thus, the total income loss would be roughly $9 million.

Table 5-7 lists the income losses computed for severe wind, hurricane wind, tornado, storm surge, tsunami, and earthquake. The first row lists the potential output lost, or product-at-risk, by economic sector. The remaining rows furnish information on losses by hazard type. From the first row, we see that 24% of the total United States output in 1970 was generated in the manufacturing sector. This percentage of the total output can be compared with the proportion of the total predicted annual output losses incurred by the manufacturing sector for storm surge (6.0%). The difference in the proportion of output exposure to losses due to storm surge is caused by a combination of mechanisms in the hazard and exposure models. One factor is the lower exposure of the manufacturing sector to storm surge. The first line in the hazard loss row gives the proportion of the total national manufacturing output that is at-risk to storm surge as 17.2% compared with 20.8% for household sector, and 28.5% for the finance sector. These differences are due to the regional distribution of the various sectors and the coastal nature of the storm surge hazard.

Another factor influencing the lower proportion of manufacturing sector losses from storm surge is the vulnerability of the types of buildings used in manufacturing. The damage relationships of industrial structures (see Figure 3-5) for storm surge predict lower losses than are predicted for residential and commercial buildings of the same height.

Table 5-7 indicates that the highest loss in 1970 was from tornadoes, estimated to be nearly $303 million .

	HOUSEHOLD	FARMING AND MINING	CONSTRUCTION	MANUFACTURING	TRANSPORTATION & UTILITIES	RETAIL AND WHOLESALE TRADE	FINANCE	SERVICE	FEDERAL GOVERNMENT	STATE AND LOCAL GOVERNMENT	TOTAL
Total Estimated Product at Risk in 10^6 1970$	82,510.0	47,730.0	45,730.0	253,200.0	82,290.0	167,600.0	133,200.0	114,400.0	52,410.0	73,800.0	1,053,000.0
Percent of Total	7.8	4.5	4.3	24.0	7.8	15.9	12.6	10.4	5.0	7.0	100.0
SEVERE WIND											
Exposure Total = 100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Income Loss 10^3 1970$	637.0	58.0	32.1	161.2	53.6	368.4	380.1	279.8	52.1	67.8	2,090.1
Percent of Total Loss	30.6	2.8	1.5	7.7	2.6	17.6	18.2	13.4	2.5	3.2	100.0
STORM SURGE											
Exposure Total = 100	20.8	13.7	21.1	17.2	24.0	21.5	28.5	24.4	18.0	19.8	21.1
Income Loss 10^3 1970$	1,119.0	118.2	41.2	142.5	86.9	279.9	267.7	191.4	51.7	68.3	2,366.8
Percent of Total Loss	47.3	5.0	1.7	6.0	3.7	11.8	11.3	8.1	2.2	2.9	100.0
TSUNAMI											
Exposure Total = 100	10.3	3.9	9.7	8.5	11.5	10.6	11.5	11.6	11.1	11.5	10.1
Income Loss 10^3 1970$	291.4	1.0	4.9	8.2	151.3	80.1	77.5	90.0	13.9	8.9	727.2
Percent of Total Loss	40.1	.1	.7	1.1	20.8	11.0	10.7	12.4	1.9	1.2	100.0
TORNADO											
Exposure Total = 100	87.2	92.2	88.5	91.2	84.5	87.1	81.1	85.0	87.9	84.9	87.1
Income Loss 10^3 1970$	60,170.0	11,660.0	8,151.0	48,980.0	13,590.0	49,370.0	49,100.0	35,610.0	10,910.0	15,280.0	302,821.0
Percent of Total Loss	19.8	3.9	2.7	16.2	4.5	16.3	16.2	11.8	3.6	5.0	100.0
EARTHQUAKE											
Exposure Total = 100	71.9	72.8	71.3	68.5	72.7	71.8	75.1	74.6	75.9	72.7	72.1
Income Loss 10^3 1970$	653.3	184.3	86.1	363.9	168.4	268.4	316.1	207.2	191.3	211.8	2,650.8
Percent of Total Loss	24.7	7.0	3.2	13.7	6.4	10.1	11.9	7.8	7.2	8.0	100.0
HURRICANE (WIND)											
Exposure Total = 100	32.6	19.2	33.3	28.9	33.5	32.6	39.5	36.5	36.2	31.2	32.6
Income Loss 10^3 1970$	21,460.0	3,166.0	2,937.0	12,270.0	4,871.0	15,840.0	19,460.0	13,200.0	3,528.0	5,066.0	101,798.0
Percent of Total Loss	21.0	3.1	2.9	12.1	4.8	15.6	19.0	13.0	3.5	5.0	100.0

Table 5-7. Distribution of Income Losses in 1970 ($1000)

The next highest loss was from hurricane winds, totaling $102 million. The lowest level of loss was from the expected occurrence of tsunami, totaling $727,000. The household sector is most vulnerable to all hazards; severe winds caused 30.5% of their damage to households, for example, while only 1.5% of severe wind damage accrued to the construction sector. This sector suffered the lowest loss levels from all hazards except tsunami, where losses to the farming and mining sector were negligible. The relative immunity of farms and ranches to tsunami losses is due to the inland geographical distribution of wealth in this sector.

The Market Area Effect

Market Area Effects are those losses incurred by the buyer of a product which is supplied by a producer that is incapacitated due to the occurrence of a natural hazard. Chapter One describes the theory and method for the computation of this effect. A basic assumption in the computation is that costs of transportation are borne by the producer. Thus, the input coefficient in the transportation sector row of an input-output table will provide the proportion of costs that go for transportation expenses of each industry per unit of output produced.

The aggregated sectors described in Chapter Four are too gross for the determination of transportation costs. Thus, the input row for the original sector of the MRIO data entitled "Transportation and Warehousing" was used (Table 4-1, Chapter Four). Table 5-8 lists row coefficients by aggregated sector of the original transportation and warehousing sector from the national table. From Chapter One, the market area effect is calculated as the direct output lost multiplied by the transportation sector input coefficient. Therefore, using the national coefficients from Table 5-2, if the annual output loss in the mining and farming sector is estimated as $6.0 million, the loss to buyers of all mining and agricultural output due to the sudden necessity to go elsewhere for supplies will be estimated as 0.0239 times $6.0 million or approximately $122,000 in losses. The coefficient .02039 is the transportation cost estimated from the analysis in Chapter One. It is known that the transportation costs are doubled due to the event. Thus, the loss is just equal to the previous transportation costs. Therefore, $6 million in income loss is approximately 50 times the market area effect. This work is also made in light of the previously mentioned simplifying assumptions that go with input-output analysis.

HOUSEHOLDS	.02521
FARMING AND MINING	.02039
CONSTRUCTION	.03332
MANUFACTURING	.02355
TRANSPORTATION AND UTILITIES	.04368
WHOLESALE AND RETAIL TRADE	.01116
FINANCE, INSURANCE AND REAL ESTATE	.00451
SERVICE INDUSTRIES	.01032
FEDERAL GOVERNMENT	.00130
STATE AND LOCAL GOVERNMENT	.00043

Table 5-8. National Input Coefficient of Aggregated Productive Sectors from the Transportation and Warehousing Sector in 1963

However, the calculation of the market area effect only provides the sector where the cost originated and not where it is paid. To establish which sectors pay the increased transportation costs, we must determine which sectors buy the products that must be transported further. The proportion that each economic sector sells to other economic sectors is calculated from the matrix of output proportions. An example of such a matrix is shown in Table 5-9. This matrix gives the proportion of each sector's total output purchased by each other sector. For example, from Table 5-9 it can be seen that 46.50% of the output of the mining and farming sector is purchased by the manufacturing sector.

The computations listed in Table 5-9 were made with the use of the state level input-output tables. These results were then aggregated for the national totals. The regional coefficients appear to be significantly lower than the national coefficients.

FROM \ TO	FARMING & MINING 1	CONSTRUCTION 2	MANUFACTURING 3	TRANSPORTATION COMMUNICATIONS AND UTILITIES 4	WHOLESALE RETAIL TRADE 5	FINANCE INSURANCE & REAL ESTATE 6	SERVICES 7	FEDERAL GOVERNMENT 8	STATE & LOCAL GOVERNMENT 9	OTHER SECTORS 10	HOUSEHOLDS 11
FARMING & MINING — 1	.2141	.1204E-01	.4650	.3049F-01	.2329E-02	.3020E-01	.1271E-02	.1277E-02	.2257E-02	.1822	.5886E-01
CONSTRUCTION — 2	.8964E-02	.2253E-03	.1279E-01	.2221E-01	.3620E-02	.6685E-01	.8702E-02	.4986E-01	.1841	.6427	0.
MANUFACTURING — 3	.1433E-01	.4849E-01	.2858	.6512E-02	.1111E-01	.4838E-02	.2485E-01	.3844E-01	.6424E-02	.3647	.1946
TRANSPORTATION COMMUNICATIONS AND UTILITIES — 4	.2078E-01	.2891E-01	.1547	.8983E-01	.4028E-01	.2022E-01	.5710E-01	.2261E-01	.2317E-01	.3223	.2201
WHOLESALE RETAIL TRADE — 5	.1054E-01	.3534E-01	.6935E-01	.6823E-02	.1096E-01	.8245E-02	.1591E-01	.3790E-02	.7566E-03	.4409	.3974
FINANCE INSURANCE & REAL ESTATE — 6	.2913E-01	.5272E-02	.3552E-01	.1244E-01	.4367E-01	.6866E-01	.3605E-01	.1829E-02	.4726E-02	.3910	.3717
SERVICES — 7	.1046E-01	.2251E-01	.7772E-01	.1826E-01	.4402E-01	.3174E-01	.3924E-01	.2421E-01	.1305E-01	.3829	.3359
FEDERAL GOVERNMENT — 8	.2515E-02	.3165E-02	.8407E-01	.8269E-01	.1445	.1195	.1216	.1421E-01	.2305E-01	.2965	.1062
STATE & LOCAL GOVERNMENT — 9	.7025E-03	.2710E-02	.7188E-02	.3433	.3183E-01	.5166E-01	.1445E-01	.1422E-01	.1691E-02	.4870	.4526E-01
OTHER SECTORS — 10	.3692E-01	.4965E-03	.3130	.6724E-01	.3895E-01	.7756E-01	.9765E-01	.2426	.2838	-.2328	.7425E-01
HOUSEHOLDS — 11	.2153E-01	.6173E-01	.3099	.8150E-01	.1517	.4804E-01	.9835E-01	.1281E-01	.6623E-02	.1952	.1266E-01

Table 5-9. The Output Proportions Matrix of the U.S. Economy in 1963

Table 5-10 gives the distribution of the additional transportation costs that are estimated to be incurred by each sector.

	HOUSEHOLD	FARMING & MINING	CONSTRUCTION	MANUFACTURING	TRANSPORTATION COMMUNICATION & UTILITIES	RETAIL WHOLESALE TRADE	FINANCE & INSURANCE & REAL ESTATE	SERVICES	FEDERAL GOVERNMENT	STATE AND LOCAL GOVERNMENT	TOTAL
National Transportation Costs in 10^6 1970$	3,405	477	630	3,625	655	645	435	678	452	437	11,439
Percent of Total	29.8	4.2	5.5	31.7	5.7	5.6	3.8	5.9	4.0	3.8	100.0
SEVERE WIND											
Percent of Exposure	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Additional Costs in 1970$	6,485.0	917.0	1,362.0	5,892.0	1,360.0	2,081.0	1,020.0	1,601.0	592.0	491.0	21,801.0
Percent of Total	29.8	4.2	6.2	27.1	6.2	9.5	4.7	7.3	2.7	2.3	100.0
STORM SURGE											
Percent of Exposure	20.8	13.7	71.1	17.2	24.0	21.5	28.5	24.4	18.0	19.8	21.3
Additional Costs in 1970$	6,162.0	1,266.0	2,485.0	6,854.0	2,587.0	3,787.0	1,555.0	2,478.0	701.0	609.0	28,484.0
Percent of Total	21.6	4.4	8.7	24.1	9.1	13.3	5.5	8.7	2.5	2.1	100.0
TSUNAMI											
Percent of Exposure	10.3	3.9	9.7	8.5	11.5	10.6	11.6	11.6	11.1	11.5	10.5
Additional Costs in 1970$	3,555.0	492.0	1,053.0	1,808.0	1,338.0	1,054.0	588.0	1,215.0	903	407	12,453.0
Percent of Total	28.4	4.0	8.5	14.5	10.7	8.8	4.7	9.8	7.3	3.3	100.0
EARTHQUAKE											
Percent of Exposure	71.9	72.8	71.3	68.5	72.7	71.8	75.1	74.6	75.9	72.7	72.4
Additional Costs in 1970$	8,571.0	1,338.0	2,174.0	8,238.0	1,905.0	2,274.9	1,203.0	2,210.0	1,336.0	1,061.0	30,310.0
Percent of Total	28.2	4.4	7.2	27.2	6.3	7.5	4.0	7.3	4.4	3.5	100.0
TORNADO											
Percent of Exposure	87.2	92.2	88.5	91.2	84.5	87.1	81.1	85.0	87.9	84.9	86.7
Additional Costs in 1970$	1,079,000.0	143,700.0	144,100.0	1,053,000.0	193,900.0	236,200.0	135,100.0	197,600.0	114,700.0	103,300.0	3,450,600.0
Percent of Total	31.4	4.2	5.6	30.5	5.6	6.8	3.9	5.7	3.3	3.0	100.0
HURRICANE											
Percent of Exposure	32.6	19.2	33.3	28.9	33.5	32.6	39.5	36.5	36.2	31.2	33.1
Additional Costs in 1970$	358,700.0	32,420.0	68,920.0	271,600.0	68,080.0	87,520.0	54,070.0	78,650.0	36,300.0	35,780.0	1,092,040.0
Percent of Total	32.8	3.0	6.3	24.9	6.2	8.0	5.0	7.2	3.3	3.3	100.0

Table 5-10. The Supplier Incidence and Total Market Area Effects in 1970

To determine the incidence of the increase in cost by producing sectors requires multiplication by the proportion of output sold to each sector. For example, 100% of the value of all sectors is exposed to severe wind. The additional cost to the household sector for buying in the next market area is $6,485,000. This sum represents 29.8% of the total market area effects caused by severe wind.

Tornado effects are much more significant, however. In the residential sector 87.2% of total wealth is exposed to the tornado hazard, and the additional cost from purchasing the adjacent market area is $1,079,000.00 (in 1970 dollars). This sum represents 31.4% of total market area effects from tornadoes.

The table may also be used to compare market effects between hazards. For example, the Federal Government pays out 4.0% of all transportation costs levied, but in severe wind they only incur 2.7% of supplier cost loss. Therefore, this sector is not as highly exposed to severe wind losses as it is to tsunami losses, where 7.3% of market area effects are absorbed. This difference reflects the greater concentration of federally-owned building wealth in coastal areas.

Summary

This chapter has given the details and results of the application of the methods outlined in Chapter One for the estimation of the total economic impact of natural hazards. The state level distributions of these calculations for 1970 and 2000 are given in Appendix H. Appendix H also provides the savings of each of these losses after the application of specific mitigations to these hazards in the year 2000. The accuracy of the results of this analysis is strongly dependent on the input-output data, the relationships of damage type to time of inoperation, and the assumption of losses in income resulting from these periods of inoperation. Of all the portions of this study, this analysis may contain the weakest link. Very little is known of post-disaster behavior of the type dealt with here. Thus, most of this analysis is based on hypotheses that require some future validation.

Chapter Six

ANALYSIS OF SOCIAL IMPACTS

The impacts of natural hazards discussed to this point have been solely economic. These lend themselves to quantification for an overall picture of the effects of hazards on the population. However, there are other social impacts which accompany the occurrence of natural disasters, and these often become the most memorable aspects of the occurrence. The social impacts treated here do not comprise an exhaustive list, but rather they represent an attempt at a preliminary description of the pertinent social indicators which may provide insight for the decision-maker in his efforts to assess alternative mitigation procedures.

This chapter has four sections, one for each of the four social impact measures: number of lives lost, loss of homes, residential displacement (homelessness), and level of unemployment. The first section discusses the method used for the estimation of life loss from the estimates of building damages incurred. Section two contains a description of the method employed in deriving the number of housing units lost. Also estimated is the average value of the loss per home. The third section deals with a measure of residential dislocation. This measure - homelessness - is determined by adding the time of inoperation and the occupancy to the housing unit loss estimate. The fourth section deals with the estimate of unemployment which results from the income losses predicted in Chapter Five. These unemployment estimates are another way of presenting the income losses and should not be interpreted as an additional economic impact.

Estimations of Mortality

The following section describes a method for determining the level of life loss from estimates of structure loss. A relationship between damages (in constant 1970 dollars) and the number of lives lost was estimated from data available pertaining to past natural disasters. This relationship was based on assumptions that: the dollar amounts of damage recorded for an event, reflect only the structure damage, the lives lost are directly caused by the event (post disaster situations have no influence), the vulnerability of the population was constant, and the value of all structures in all events was the same. These assumptions constitute a significant simplification in comparison to the detail in the analysis of structure loss.

Dollar amounts of damage of past occurrences of natural hazards were supplied by insurance company records and include many types of damage such as contents losses. However, structure losses which were not compensated often go unnoted. For example, some insurance policies for earthquake may have a five percent deductible provision. Thus, if the larger proportion of earthquake damage is ceiling cracks and broken windows, these will not be reported by insurance companies. Additionally, many businesses and homes are not insured for water or earthquake damage. Because of these factors, insurance claims may be far from a total picture.

The number of lives lost which are reported are also subject to methodological shortcomings. The number of deaths may be directly related to the level of success of rescue operations, and may have little relation to the level of physical destruction or structure characteristics. The vulnerability of the population may be another important aspect. The concentration of population per structure, the strength associated with the event, the psychological impressions of the population, the availability of shelter, and the time of day of the occurrence certainly influence the number of casualties. Most of these factors are absent from the present model. Thus, no estimation method of casuality used can take into account all these factors. Further, more data on those parameters which is date and location specific is lacking from the available information.

A further complication in the construction of a life loss model concerns the relationship between value-at-risk and the potential dollar value of losses. A disaster in an area with a high value of building wealth per person will have more monetary damage per capita for an identical event than in an area of lower wealth per capita. The inability to estimate the precise location of the event, especially for flood data, makes the differences in building value per person difficult to use as a parameter in a life loss-to-monetary loss relationship. These data are available from the structure loss estimation model, but the location information concerning past events leads to problems in determining this aspect.

It has been noted in a variety of sources [Dacy and Kunreuther, 1969; U.S. Dept. of Commerce, 1972; National Bureau of Standards, 1974] that the relationship of deaths to pecuniary damage varies over time. By proposing a linear model for life loss (LL) and for amount of structure damage (SD), the following relationships are calculated:

$$LL = \alpha_1 + \beta_1 \, (YR) \qquad (6\text{-}1)$$
$$(SD)^{-1} = \alpha_2 + \beta_2 \, (YR) \qquad (6\text{-}2)$$
$$YR = \text{year of occurrence}$$

Thus, a model for life loss per structure damage would be:

$$(LL/SD) = \alpha_1 \, \alpha_2 + (\alpha_1 \, \beta_1 + \alpha_2 \, \beta_1) \, (YR) + \beta_1 \, \beta_2 \, (YR^2) \qquad (6\text{-}3)$$

or redefining terms

$$(LL/SD) = \hat{\alpha} + \hat{\beta}_1 \, (YR) + \hat{\beta}_2 \, (YR^2) + \varepsilon \qquad (6\text{-}4)$$

where ε is a disturbance term and ^ denotes estimated parameters. It is assumed that, with more recent data, the techniques for determining loss will become more accurate. Also, it is assumed that the distribution of rescue and health service will be more evenly distributed among different events. Thus, the disturbance will be less for more recent events and greater for older ones; a multiplicative disturbance term was used in a log form of the relationship:

$$(LL/SD) = 10^{(\hat{\alpha} + \hat{\beta}_1 \, (YR) + \hat{\beta}_2 \, (YR)^2} \cdot 10^{\varepsilon} \qquad (6\text{-}5)$$

This modeling structure was used to obtain the following results for hurricane and tornado:

Hurricane: *

$$(LL/SD) = 10^{\underset{(1.339)}{3.110} - \underset{(.053)}{.113}\,YR - \underset{(.000455)^*}{.000768}\,YR^2} \qquad (6\text{-}6)$$

R^2 = .350

Variance = .367

Degrees of Freedom = 38

*The figures in parenthese are the standard errors for the coefficients.

Tornado:

$$(LL/SD) = 10^{\underset{(.0630)}{.2450} + \underset{(0.158)}{.0350}\,(YR) - \underset{(.000504)}{.000613}\,(YR)^2} \; * \qquad (6\text{-}7)$$

$$R^2 = .645$$

Variance = .0876

Degrees of Freedom = 53

The forecasts of deaths for storm surge and hurricane wind impacts are not distinguishable for estimation of separate life loss relationships, so they are both assumed to be equally represented in the data. The 1970 forecast provided an estimate of the value for that year, removing the time bias. Figure 6-1 and 6-2 show plots of both the data and the estimated relationships. The estimates of life loss due to severe wind were also estimated from the relationship obtained from tornado. This is because of similarity, and because no source of data dealt solely with severe wind. Further, since no water related deaths could be due to severe wind, the hurricane relationship is not applicable for this hazard. Consequently, for hurricane and storm surge, .0956 deaths/million dollars damage, and for tornado and severe wind, .488 deaths/million dollars damage were used to calculate life loss estimates for the projected years. The death/damage ratio for tsunami was 2.432 (deaths/10^6 \$ building damage) and was calculated from the average of three tsunamis. Because a warning system was not present for those tsunamis, but is now available, the predicted deaths due to tsunami should be taken as an upper bound.

Darcy and Kunreuther [1969] proposed that deaths per million dollars damage declined over the period 1930-1964 due to warnings, stronger structures, and a higher wealth per capita. In order to examine this contention, it was necessary to estimate the wealth per capita exposed to minimize the effect of the change in structure value to determine the impact of time-dependent technological change factors. Due to data limitations, this was only performed with U.S. hurricane and earthquake data since 1933. For these hazards and time period, well-defined areas of impact and reliable economic estimates were available for analysis. Because no earthquake in the sample had a prior warning (while hurricanes have been predicted with increasing accuracy), a comparison of these two hazards can provide an indication of the influence of warnings versus building code requirements.

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*The figures in parentheses are the standard errors for the coefficients.

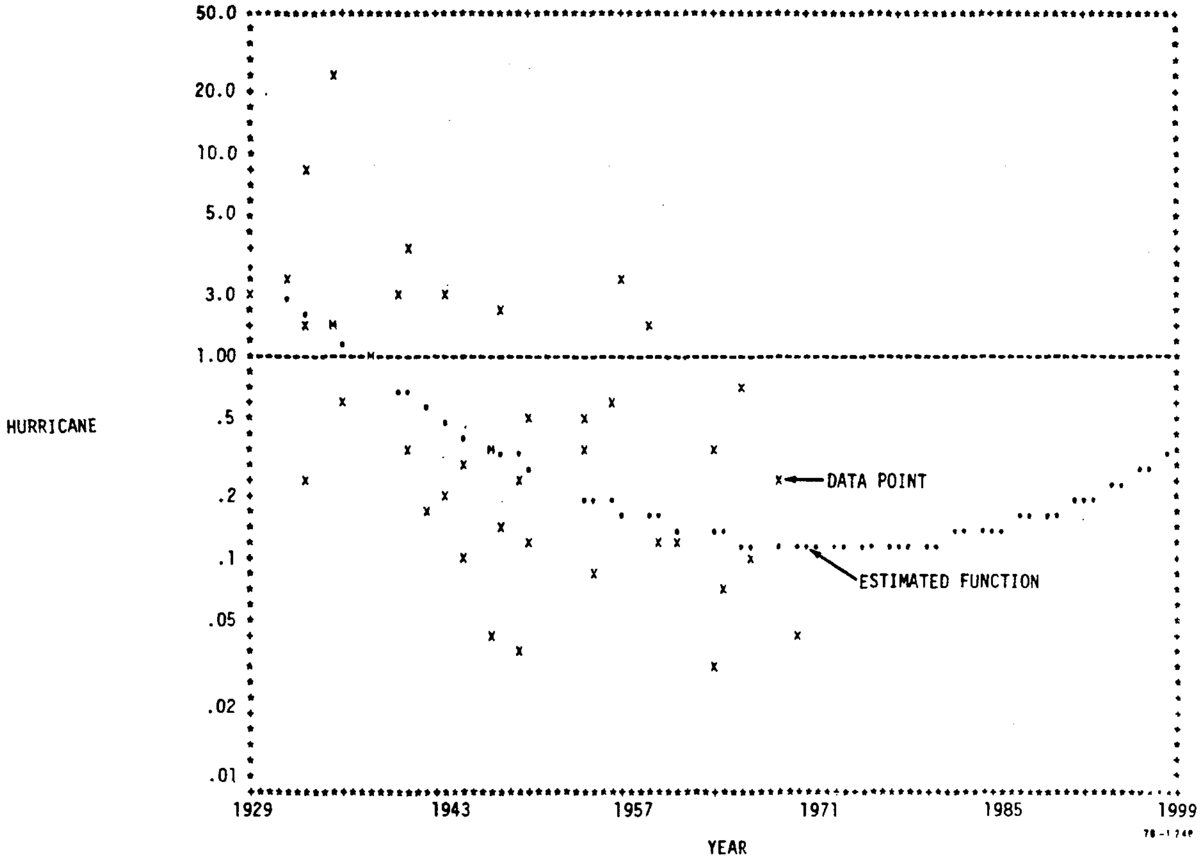

Figure 6-1. Plot of (Deaths/Million $ Damage) due to Hurricane Versus Year

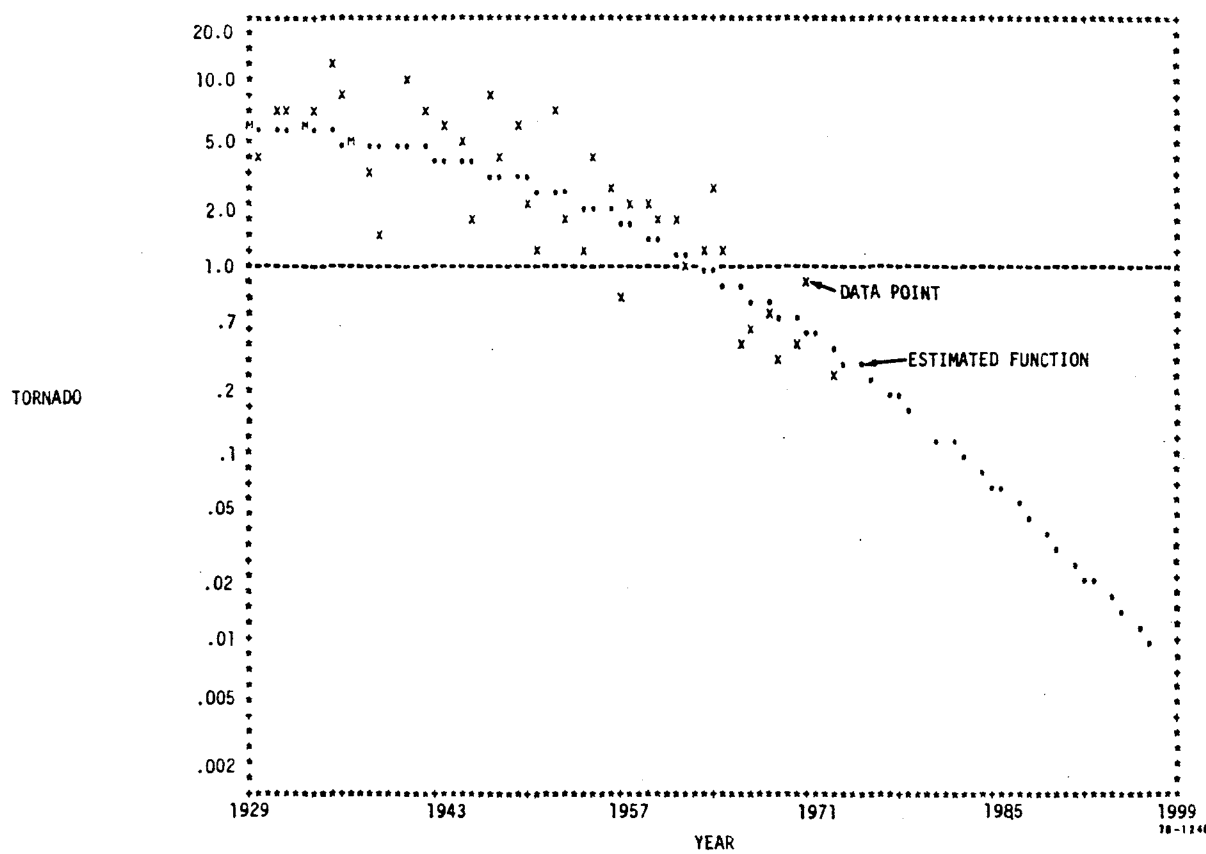

Figure 6-2. Plot of (Deaths/Million $ Damage) due to Tornado Versus Year

To account for the differences in structure value per capita in different locations at different periods in time, a relative value of structures per capita was computed to scale the dollar losses reported for each event. To account for the regional effect, the relative income per capita was used. The annual structures values per person were estimated for private structures, both residential and commercial. Using the estimates from the Bureau of Economic Analysis [1974], and from Young [1971], in constant 1967 dollars*, a yearly estimate of total private structure wealth was made. The estimated total population figure [U.S. Bureau of Census, 1971] for corresponding years was then used to compute a private structure value per capita, as shown in Table 6-1. These annual national estimates were then weighted by the interpolated relative per capita income in the area of primary effect for the year of the event, available by SMSA and BEA areas for years back to 1929 from the OBERS Projections [Water Resources Council, 1974].

For example, in the case of the 1933 earthquake in Long Beach, California, the relative per capita income for the Long Beach - Los Angeles SMSA was estimated as 1.41 times the national average in 1933. Therefore, the value of private structures was estimated as 1.41 of the 1933 national average value of structures per capita. From Figure 6-3, the relative structure value per capita in 1933 compared to 1970 can be read as approximately .79.

Thus, the relative structure value per capita in Long Beach, California in 1933 compared to the 1970 national average is (1.41)* (.79) or 1.12. Proceeding to "normalize" the dollar losses reported for the 1933 Long Beach earthquake, the dollar loss in 1967 dollars of 81.777 million is multiplied by 1.12 to yield a normalized dollar value of 91.590 million $1967. Table 6-1 lists the life loss, the normalized dollar losses, and the value per capita relative to the 1970 national average.

By weighting the damages by the ratio of the historical per capita value to the 1970 per capita structure value, the effect of the regional and time dependent factors of the variations in wealth-at-risk can be factored out. Then, the time effect is a better indicator of man's changing ability to cope with the occurrence of the disaster.

*Estimated with the double-declining balance and 85% of Bulletin F lifetimes techniques and S-3 survival curve (See Appendix E for details).

	LOCATION		YEAR	DEATHS	NORMALIZED (1) IN 1967$	RELATIVE STRUCTURE (2) VALUE/CAPITA
DATA FOR HURRICANE	KEY LARGO	FLORIDA	29.0	3.00	3554.47	.438
	COLUMBIA	TEXAS	32.0	40.0	60550.4	.300
	BROWNSVIL	TEXAS	33.0	40.0	86705.9	.356
	JUPITER	FLORIDA	33.0	2.00	20829.7	.507
	CPHATTERA	NOCAROLINA	33.0	21.0	9563.15	.269
	FLA KEYS	FLORIDA	35.0	408.	27559.5	.525
	MIAMI	FLORIDA	35.0	19.0	14978.9	.686
	CPHATTERA	NOCAROLINA	36.0	2.00	13294.2	.257
	PROVIDENC	RHODE IS	38.0	600.	723662.	.994
	CHARLESTO	SOCAROLINA	40.0	34.0	56527.6	.293
	MATAGURDA	TEXAS	41.0	4.00	16955.5	.802
	MIAMI	FLORIDA	41.0	5.00	1824.66	.869
	PT LAVACA	TEXAS	42.0	8.00	133950.	.402
	TORTUGAS	FLORIDA	44.0	18.0	190529.	.593
	PT LAVACA	TEXAS	45.0	3.00	92298.1	.402
	HOMESTEAD	FLORIDA	45.0	4.00	165404.	.606
	HILLSBORO	FLORIDA	47.0	51.0	277901.	.587
	MIAMI	FLORIDA	47.0	1.00	38363.5	.773
	KEY WEST	FLORIDA	48.0	3.00	41475.3	.581
	JUPITER	FLORIDA	49.0	2.00	124301.	.581
	FREEPORT	TEXAS	49.0	2.00	23539.3	.413
	CEDAR KEY	FLORIDA	50.0	2.00	7744.94	.586
	MIAMI	FLORIDA	50.0	4.00	52571.7	.733
	LONG IS	NEW YORK	54.0	21.0	67729.7	.740
	CAPE FEAR	NOCAROLINA	54.0	98.0	829235.	.373
		NOCAROLINA	55.0	7.00	262315.	.538
	GRAND ISL	LOUISIANA	56.0	15.0	67879.6	.407
	OAK GROVE	LOUISIANA	57.0	390.	398468.	.443
	BEAUFORT	NOCAROLINA	59.0	22.0	36819.8	.432
	FLA KEYS	FLORIDA	60.0	50.0	637354.	.753
	PT LAVACA	TEXAS	61.0	46.0	822160.	.550
	MIAMI	FLORIDA	64.0	3.00	161203.	.851
	ST AUGUST	FLORIDA	64.0	5.00	458374.	.562
	FRAKLIN	LOUISIANA	64.0	38.0	232768.	.573
	FLA AND L	FLORIDA	65.0	75.0	.185013E+07	.812
	PORTRICHE	FLORIDA	66.0	6.00	18243.1	.566
	COLUMBIA	MISSISSIPP	69.0	256.	.219346E+07	.589
	RAYMONDVI	TEXAS	67.0	15.0	450784.	.443
	CORPUSCHR	TEXAS	70.0	11.0	721315.	.540
DATA FOR EARTHQUAKE	LONG BEACH	CALIFORNIA	33.0	115.	91590.7	1.12
	HELENA	MONTANA	35.0	4.00	13380.4	.722
	IMPERIALVA	CALIFORNIA	40.0	9.00	18525.9	.767
	SANTABARBA	CALIFORNIA	41.0	*.	547.776	1.03
	PUGET SOUN	WASHINGTON	49.0	8.00	50613.0	.686
	KERN CO	CALIFORNIA	52.0	14.0	105041.	.713
	EUREKA	CALIFORNIA	54.0	1.00	2973.35	.871
	FALLON	NEVADA	54.0	*.	1025.59	.842
	OAKLAND	CALIFORNIA	55.0	1.00	1184.89	1.04
	SANFRANCIS	CALIFORNIA	57.0	*.	1112.00	1.06
	HEBGEN LAK	MONTANA	59.0	28.0	16958.9	.737
		HAWAII	60.0	61.0	38590.0	.744
	WEST COAST	WEST COAST	64.0	125.	546684.	.977
	PUGET SOUN	WASHINGTON	65.0	7.00	15749.7	.839
	SANTA ROSA	CALIFORNIA	69.0	*.	7901.30	.835
	SANFERNAND	CALIFORNIA	71.0	58.0	345011.	1.1[illegible]

(1) NORMALIZED TO THE 1970 STRUCTURE VALUE/CAPITA.

$$\text{NORMALIZED DAMAGES} = \frac{\text{(DAMAGES)}}{\text{(RELATIVE STRUCTURE VALUE/CAPITA)}}$$

(2) RELATIVE TO 1970 NATIONAL STRUCTURE VALUE/CAPITA.

76-1246

*NO DATA AVAILABLE

SOURCES FOR HURRICANE [Sugg, et al, 1971]
FOR EARTHQUAKE [Disaster Preparedness, 1972]

Table 6-1. Hurricane and Earthquake Data used in Time Effect Analysis

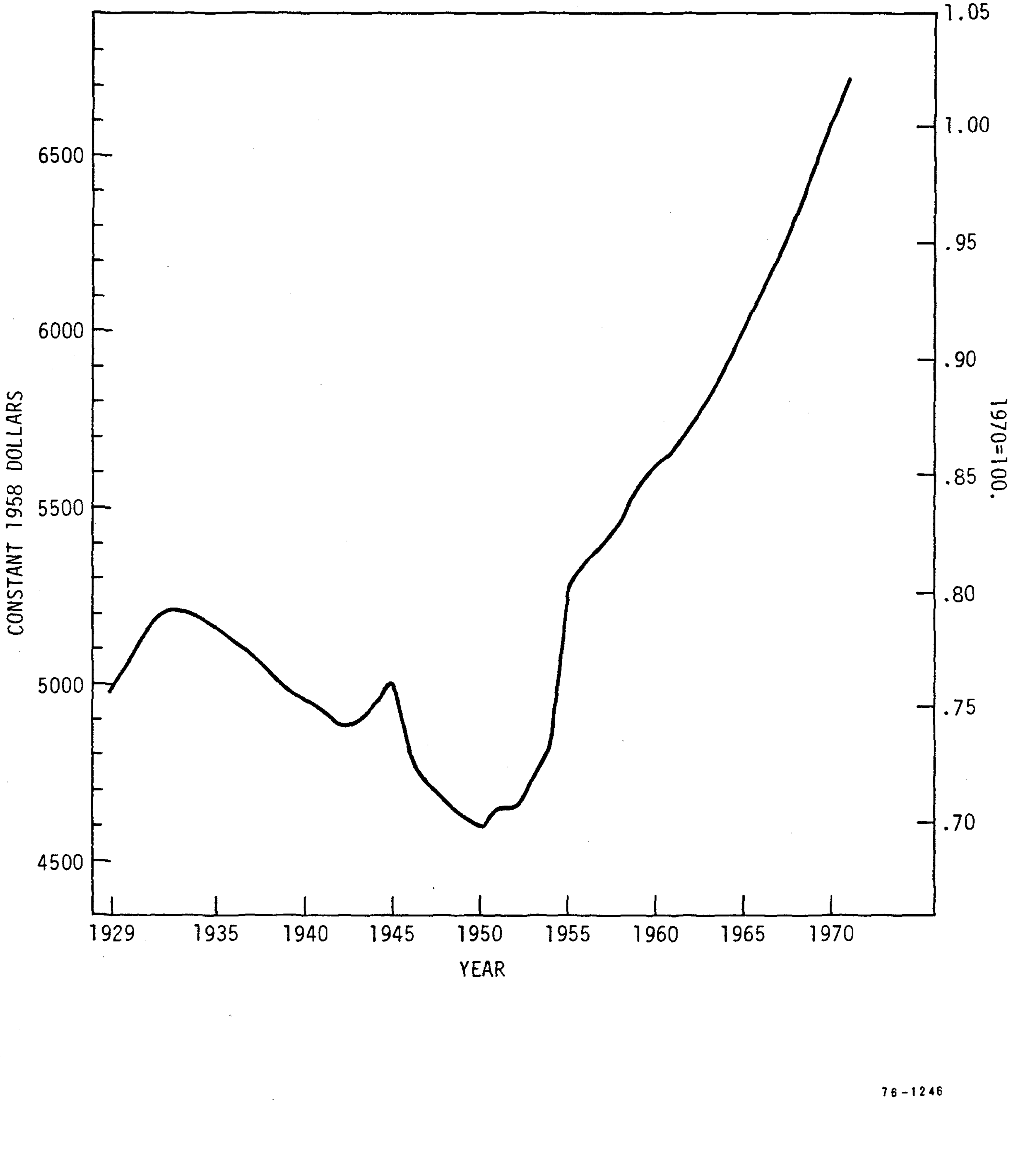

Figure 6-3. Private Structure Value per Capita in the U.S. 1939-1971

The relationship used by Blume [1971] for earthquake was of the form:

$$\text{Lives Lost} = \alpha \cdot (\text{Damages})^{B} \qquad (6\text{-}8)$$

A modification to this relationship was made to include the date of the event:

$$\text{Lives Lost} = \alpha \cdot (\text{Damages})^{B_1} \cdot (\text{yr} - 1900)^{B_2} \qquad (6\text{-}9)$$

The results for earthquake and hurricane, using the data in Table 6-1 are: (The values in parenthesis are the standard error of each estimate.)

Earthquake:

$$LL = \underset{\substack{(4.0927) \\ (t = 174.18)}}{712.88} \ \text{Billions \$ Damages}^{\substack{.813 \\ (.047) \\ (t = 17.29)}} * (\text{Yr}-1900)^{\substack{-.288 \\ (.129) \\ (t = 2.23)}} \qquad (6\text{-}10)$$

$R^2 = .75$
N = 12

Hurricane:

$$LL = \underset{\substack{(7937.3) \\ (t = 174.62)}}{1.386 \times 10^{6}} * \text{Billion \$ Damages}^{\substack{.747 \\ (.021) \\ (t = 35.57)}} * (\text{Yr}-1900)^{\substack{-2.506 \\ (.029) \\ (t = 86.41)}} \qquad (6\text{-}11)$$

$R^2 = .37$
N = 39

The equation for earthquake was used to estimate earthquake life loss. It is interesting that for hurricane the estimated exponent for the year is much greater than that estimated for earthquake. Also the t statistic for the year exponent for hurricane is significant at the 1% level while that for the year exponent for earthquake is not. The conclusion to be drawn is that the life loss-to-damage ratio for hurricane is affected much more by time than for the similar earthquake ratio. One of the greatest life-saving features available for the more recent hurricanes is the increased degree of warning.

Other factors that affect the death-to-damage ratio are the construction of sea walls and recognition of the need for barrier areas. In general, the higher frequency of destructive hurricanes compared to earthquakes appears to have led to a keener awareness of the hazard and a greater ability to prepare for its occurrence. Changes in building codes have taken place in both hurricane- and earthquake-prone areas. The significance of the negative exponent of the year in the earthquake equation, at the 5% level, may indicate the effectiveness of this process.

Because more data were not available, and because the available data were inconsistent, an analysis of the specific damage mitigations available for each hurricane was not possible. However, such an analysis may lead to a more accurate measure of the lifesaving effect of hurricane precautions.

Table 6-2 lists the life loss totals by hazard for 1970 and 2000 as calculated by the algorithms described above. The life loss estimates for landslide in 1970 were calculated from our estimate of 1.11 lives lost per million dollars of landslide building damage as given in Wiggins [1976]. No estimates for landslide in the year 2000 were made, due to data restrictions. Expansive soil is considered a "gradual" hazard, thus, it is not considered a killer. Because the methods for the estimate of riverine flooding are markedly different from the general method discussed here, no results are reported here for riverine deaths. The methods used for estimating the life losses can only be described as crude. The data as noted above are with different interpretations and pitfalls. A better method for assessing the life loss from natural hazard would require detailed investigations of the causes for specific deaths in past events. How many are due to structure failure? How many are the lack of emergency facilities? This question and similar questions cannot be answered with the sort of data now available. The foregoing is viewed as a warning to those who may be tempted to put unwarranted faith in the estimates produced here.

	1970	2000
EARTHQUAKE	272	400
TORNADO	392	920
HURRICANE	62	153
STORM SURGE	37	103
TSUNAMI*	20	44
SEVERE WIND	5	11
EXPANSIVE SOIL	NA**	NA**
LANDSLIDE	110	
RIVERINE FLOODING	NA+	NA

*These estimates assume no warning prior to event.

**Expansive soil does not have associated life loss estimates

+Riverine flooding life loss was estimated using a completely different methodology. See the waterborne hazards report for details.

Table 6-2. Life Loss by Hazard

Housing Losses

To estimate dollar losses to housing, the value of housing per capita was used to estimate the value-at-risk of residential structures. In estimating the number of houses destroyed, the value-at-risk was changed from dollars per capita to housing units* per capita. Thus, the estimated values of loss reflect the housing loss in terms of the number of such units lost.

The damage calculations were made by applying an annual average percent damage** to the values of the structures of a particular type construction at risk in a specific county. In computing the losses to housing, the values used were the number of units. Thus, if the number of housing units of a particular type construction in a county was assumed to be 10,000, and the annual probabilities of different damage states are given as in Table 6-3, then the aggregate number of housing units destroyed is 90.2. Of those, only 10 are totally destroyed (or 100% distribution), and those in the light, moderate, and heavy damage states account for over 40% of the total.

DAMAGE STATE	RANGE OF DAMAGE RATIOS	GEOMETRIC MEANS OF DAMAGE RATIOS	HYPOTHETICAL ANNUAL PROBABILITY OF OCCURRENCE	EFFECTIVE ANNUAL DAMAGE RATIOS	HOUSING UNITS AT RISK	HOUSING UNITS DESTROYED
LIGHT	.0005 - .0125	.0025	.100	.00025	10,000	2.5
MODERATE	.0125 - .0750	.0306	.050	.00153	10,000	15.3
HEAVY	.0750 - .6500	.2208	.010	.00221	10,000	22.1
SEVERE	.6500 - 1.0000	.8062	.005	.00403	10,000	40.3
COLLAPSE	1.0000	1.0000	.001	.00100	10,000	10.0
TOTAL				.00002		90.2

Table 6-3. Example of Estimates of the Distribution of Housing Losses

Hence, knowledge of the total number of housing units destroyed does not convey the scale of the risk of the hazard; knowledge of the number of housing units affected by damage in each damage state is more informative.

*A housing unit is defined as in the Census of Housing as: "a house, an apartment, a group of rooms, or single room occupied of intended for occupancy as separate living quarters...", [U.S. Dept. of Com. 1972, App-5]

**An assumption is made that the [repair/replacement] ratios are applicable to the determination of housing damage rates.

Utilizing the average damage ratio for each damage state, the total number of housing units affected can be estimated. For every house totally destroyed due to light damage, many more housing units had to be damaged, according to the .0025 rate (See Table 6-3),(e.g. one housing unit totally destroyed = .0025 * Number of housing units affected by light-damage state.)

From the above relationship it can be shown that the reciprocal of the average damage rate gives the number of houses affected for each house totally destroyed at each damage state.

In the example community shown in Table 6-3,with 10,000 housing units at-risk, there would be 16.56% chance that any one housing unit will be affected in any year. But,of those affected, over 60% will be in the category of light damage, and less than 10% will have damage ratios above .075%. Table 6-4 extends the example in Table 6-3 to show the number of housing units affected.

DAMAGE STATE	MEAN DAMAGE RATIO	NUMBER OF HOUSING UNITS AFFECTED PER HOUSING UNITS DESTROYED	HOUSING UNITS DESTROYED	HOUSING UNITS AFFECTED	PERCENTAGES IN EACH DAMAGED STATE
LIGHT	.0025	400.0	2.5	1000.0	60.4%
MODERATE	.0306	32.6	15.3	499.0	30.2%
HEAVY	.2208	4.5	22.1	9.9	6.0%
SEVERE	.8062	1.2	40.3	48.0	2.8%
COLLAPSE	1.0000	1.0	10.0	10.0	.6%
TOTAL			90.2	1656.0	100.0%

Table 6-4. Example Computation of Number of Housing Units Affected

Homelessness

In order to quantify the risk to housing, a time element and an occupancy factor were used to estimate the number of persons displaced given the computed levels

of housing loss. In Chapter One, the time of inoperation is presented for the buildings affected by each damage state. These can now be applied to the number of housing units destroyed at each level. Table 6-5 gives the times of inoperation, the number of housing units destroyed and the computed homelessness assuming a national average of 3 persons per housing unit in the example county. Thus, the number of people displaced in one year would amount to 92.3 or about 3% of the county's population of 30,000 living in the structure type, in this example.
To get a perspective on these results, one can examine the national average percent of "year round vacant for rent" housing units as recorded in the 1970 Census of Housing [Bureau of Census, 1972], which is 2.46%. Thus, the number of housing units vacant in this example community can be estimated as 246 or housing for 738 homeless persons. However, it cannot be assumed that no one would be homeless due to the occurrence of the hazard. The annual rates assume that every year a little of each possible disaster occurs, but this is not the case for those instances of a disaster where the effects are distributed over an area so wide that the local resources are totally overwhelmed by an occurrence (with the possible exception of tornado, storm surge, and tsunami which are characterized by relatively local scale). Also, the type of housing units destroyed and those vacant may be sufficiently dissimilar in type and rental costs that direct tenant transfer may be impossible.

DAMAGE STATE	HOUSING UNITS AFFECTED	TIME OF INOPERATION IN YEARS	PERSONS PER HOUSING UNIT	HOMELESSNESS (IN PEOPLE-YRS)
LIGHT	2.5	.00000	3.0	0.0
MODERATE	15.3	.00055	3.0	0.0
HEAVY	22.1	.02600	3.0	1.8
SEVERE	40.3	.50000	3.0	60.0
COLLAPSE	10.0	1.00000	3.0	30.0
TOTAL	90.2			92.3

Table 6-5. Example Estimation of Homelessness

Table 6-6 lists the expected number of homes destroyed, homes affected and homelessness for hurricanes, tornado, severe wind, tsunami, storm surge, earth-

HAZARD	# OF HUs TOTALLY DESTROYED (100% LOST)	# OF HUs AFFECTED BY SOME DAMAGE	HUs OUT OF SERVICE FOR ONE YEAR	PEOPLE DISPLACED FOR ONE YEAR (HOMELESSNESS)	HUs AT RISK X10[6]	AVG. VALUE HUs AT RISK (STRUCTURE ONLY)	AVG. VALUE OF HUs AFFECTED BY SOME DAMAGE IN 1970$	AVG. VALUE LOSS OF HUs AFFECTED IN 1970$	AVG. # OF PEOPLE/ HUs IN AREAS AT RISK	% CHANCE OF BEING AFFECTED IF IN EXPOSED AREA	% OF CHANCE OF BEING HIT ON NATIONAL SCALE
HURRICANE	28,190.	984,684.	10,388.0	34,508.0	20.76	17,400.0	16,000.0	980.0	3.34	2.210%	0.680%
SEVERE WIND	485.	16,314.	255.6	767.4	67.56	16,372.0	15,670.0	463.0	3.00	.024%	0.024%
TORNADO	30,970.	45,486.	25,044.6	88,144.0	60.01	16.081.1	16,215.0	11,548.5	3.52	.072%	0.064%
TSUNAMI	233.	1,369.	100.0	345.0	6.34	17,296.8	19,407.7	3,303.1	3.45	.022%	.002%
EARTHQUAKE	20,510.	2,805,925.	254.7	735.9	47.79	16,632.3	17,269.6	126.0	2.89	5.870%	4.150%
STORM SURGE	24,672.	515,595.	2,532.1	7,208.5	12.89	17,879.7	13,486.0	645.0	2.85	4.000%	0.760%
LANDSLIDE	--*		--*	--*	67.39	16,316.8	16,316.8	1.7	3.00	---*	---*
EXPANSIVE SOIL	--*		--*	--*	67.39	16,316.8	16,316.8	8.9	3.00	---*	---*

*Expansive soil and landslide did not have a damage state breakdown, thus only the averages are available for reporting

Table 6-6. Housing Losses by Hazard

quake, landslide, and expansive soil (data for riverine flood was not comparable). On a national scale, the gradual effect of the annual probabilities for different levels is more realistic due to the aggregation of the probabilities of many occurrences over a year.

The values of losses and of housing units at-risk are taken from the structure value calculations discussed in Chapter Four. The average number of persons per housing unit varies by hazard, and is based on the census of housing data. It should be noted that the structure value is per person, and that is based on the 1970 stock of buildings, in 1970 dollars.

Estimation of Unemployment

Using the income losses calculated in Chapter Four, the number of person-years of unemployment can be calculated from the ratio of payroll-to-employees for each economic sector. From the data in the MRIO study, estimates are available of the number of employees by sector and the payrolls by sector [Rodgers, 1972]. Table 6-7 lists these ratios.

ECONOMIC SECTORS	AVERAGE INCOME
HOUSEHOLD	1,681.5
MINING, FARMING	3,063.2
CONSTRUCTION	6,716.5
MANUFACTURING	6,712.6
TRANSPORTATION & UTILITIES	7,520.9
WHOLESALE AND RETAIL TRADE	4,646.0
FINANCE, INSURANCE, ETC.	5,887.1
SERVICES	4,464.8
FEDERAL GOVERNMENT	6,463.8
STATE AND LOCAL GOVERNMENT	5,860.5

Table 6-7. Average Income Per Employee in 1970$ in 1963

The income per employee ratios are available by state and were used to weight the income losses to derive the total unemployment by sector. The unemployment computed here is not the type of statistic often cited as a percentage of the work force, but is an unemployment statistic with a time dimension. An example of such a computation is the estimate of the unemployment due to a particular loss (from the earlier example in Chapter Five). In this example, a loss in income to the basic community sector (farming and mining) is given as $3.0 million dollars for a year due to a particular hazard's annual risk. From Table 6-7 we have an average of $3,063.2 dollars per employee annually. Thus, the loss of $3,000,000 of income could result in approximately 980 person-years of unemployment. This employment could be in the form of either 980 persons unemployed for a year or 11,760 persons unemployed for a month.

Table 6-8 lists the unemployment estimated for each sector due to hurricane (wind), severe wind, tornado, storm surge, tsunami and earthquake. Again, due to limitations in the expansive soil and landslide models, unemployment estimates were not calculated. The distribution follows the distribution of income loss. In this table, the percent refers to the proportion of total employees (last column). Person-years are those lost in 1970, and the percent distribution of the total refers to the percent of the total number employed who would lose their jobs. Thus, all employees working in the farming and mining sector are exposed to the severe wind hazards, yielding 19.1 person-years lost in 1970. About five percent of the total employed suffered some joblessness in this sector from severe winds. Again, the usual cautions pertaining to this study's county level data should be observed.

The percentage of the total loss listed by sector for each hazard demonstrates the regional variation of the hazards and/or the types of exposure.

The exposure given in terms of employee-years is higher than two estimates of the total employment for 1970. The number used as shown in Table 6-8 is 11.0% greater than as reported in the OBERs report [1974] and 12.2% higher than the value given in the statistical abstract [U.S. Dept. of Commerce, 1972]. These discrepancies arise to some extent because of the date of the input-output data, 1963, thus, the ratios of output per capita as given in Table 6-7 may tend to be low.

	HOUSEHOLD	FARMING & MINING	CONSTRUCTION	MANUFACTURING	TRANSPORTATION & UTILITIES	RETAIL & WHOLESALE TRADE	FINANCE & INSURANCE	SERVICES	FEDERAL GOVERNMENT	STATE & LOCAL GOVERNMENT	TOTAL
Estimated Employee Years	1,456.0	7,283.0	4,548.0	20,630.0	4,711.0	17,685.0	4,332.0	16,845.0	3,265.0	8,888.0	89,643.0*
Percent Distribution of Total	1.6	8.1	5.1	23.1	5.3	19.7	4.8	18.8	3.6	9.9	100.0
SEVERE WIND											
Percent of Exposure	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Person Years	37.9	19.1	5.6	28.1	8.4	95.0	77.0	77.7	9.5	14.6	372.9
Percent Distribution of Total	10.2	5.1	1.5	7.5	2.3	25.5	20.6	20.8	2.5	3.9	100.0
HURRICANE											
Percent of Exposure	32.9	21.5	34.4	30.5	34.0	32.6	39.2	35.7	36.3	32.7	32.9
Person Years	1,841.0	1,411.0	583.0	2,408.0	810.0	4,254.0	3,997.0	3,818.0	653.0	1,228.0	21,003.0
Percent Distribution of Total	8.8	6.7	2.8	11.5	3.9	20.2	19.0	18.2	3.1	5.8	100.0
TORNADO											
Percent of Exposure	92.7	94.0	90.6	91.6	85.2	88.4	82.6	87.4	87.8	87.5	88.5
Person Years	2,058	4,289.0	1,507.0	8,626.0	2,147.0	12,980.0	10,190.0	10,290.0	1,977.0	3,476.0	57,540.0
Percent Distribution of Total	3.6	7.5	2.6	15.0	3.7	22.6	17.7	17.9	3.4	6.0	100.0
TSUNAMI											
Percent of Exposure	8.0	3.3	7.6	7.2	10.7	9.4	10.8	9.4	11.3	8.4	8.6
Person Years	7.2	.3	.8	1.5	23.7	21.4	15.4	22.9	2.8	1.6	97.6
Percent Distribution of Total	7.4	.3	.8	1.5	24.3	21.9	15.8	23.5	2.9	1.6	100.0
EARTHQUAKE											
Percent of Exposure	80.7	71.9	70.1	67.8	72.3	70.8	74.2	73.0	76.0	71.2	71.4
Person Years	21.4	61.3	12.5	55.8	24.5	61.4	59.0	47.5	35.1	35.4	413.9
Percent Distribution of Total	5.2	14.9	3.0	13.5	5.9	14.8	14.3	11.5	8.5	8.6	100.0
STORM SURGE											
Percent of Exposure	20.8	14.2	21.2	17.7	24.3	21.0	27.7	23.2	18.1	19.9	20.9
Person Years	47.7	48.4	8.4	28.0	15.2	77.5	57.0	59.4	9.6	17.5	368.7
Percent Distribution of Total	12.9	13.1	2.3	7.6	4.1	71.1	19.5	16.1	2.6	4.7	100.0

*This estimate is 11.9% greater than the total employment estimated for 1970 in the OBERS report [1974] and 12.2% greater than the employment reported in the Statistical Abstract for 1970 [U.S. Bureau of the Census, 1972]

Table 6- 8. Distribution of Annual Unemployment by Economic Sector and Hazard in Person Years Unemployed

Summary

This chapter has presented some alternative measures of the severity of natural hazards besides dollar quantifiable economic losses. These losses have been calculated to afford another perspective on the influences of natural hazards and the effectiveness of mitigations to them. Appendix H furnishes the state distributions of these losses and the savings in the year 2000 afforded by selected mitigations. The estimates of life loss, which are from crude data and incomplete information about numerous factors affecting a person's survival of the estimates for homelessness and homes lost. The same caveats expressed for the reliability of the income loss data can be repeated for the estimates of unemployment. In summary, this chapter has presented some further calculations that can be made from the basic building loss model that can lend insight into other facets of the natural hazard phenomenon.

Chapter Seven

ASSESSMENT OF MODEL DATA

The essence of a mathematical model is its simplification of reality, choosing those features which are of sufficient importance to allow one to understand a phenomenon and predict, with reasonable confidence, a future state. The possible sources of error in a model can be as illuminating as the predictive value, for they can point out important parameters which may have been unnoticed in the development of the model. This chapter investigates possible sources of error in the natural hazard exposure model developed in this study. Because of the large number of calculations involved, it is not possible to suggest a precise specification of confidence intervals or similar indices of uncertainty.

This chapter provides two perspectives on the data and methods used in the complete model discussed above. These perspectives could be provided without extensive redesign of the complete model. The first section contains a cursory review of the data sources used in the development of the physical events and associated effects. This provides the needed context for the discussion of the two perspectives which follow. The second section examines the first of these perspectives, using an alternative level of geographic detail to characterize the exposure to a hazard. For example, one could use national income per capita (thus structure per capita) instead of introducing regional differences. The second perspective is examined in the third section, which details the effect of using total replacement building values as estimated by the model for 1970 rather than the total market value of private real property by state estimated from local property assessment in 1971.

Uncertainty in the Damage and Hazard Probabilities

To arrive at an estimate of a level of damage, two relationships are required. One is the damage algorithm or damage density matrix, which equates expected intensities of different hazards to various levels of structure loss. The second component is the probability that different hazard intensities will occur. The various damage-versus-intensity-of-hazard relationships that were available for each hazard emerged from different methodologies in almost every case.

For all of the air-related hazards, the same set of damage density matrices were used and all were constructed with the same survey data [Hart, 1976]. The water-related hazards, on the other hand, utilized damage algorithms calculated from data collected after the San Fernando, California earthquake of 1971 [Wiggins, 1976]. Landslide and expansive soil algorithms were also discussed in Wiggins (1976). The air-related hazards data were taken from a variety of data sources. The tornado hazard was defined by a regional history of occurrence. The intensities of the tornadoes were distributed by a fixed relationship dependent on the number per square mile per year. The hurricane hazard data came from the mean highest wind speed occurrence along the Gulf and Atlantic coasts, along with an assumed variance and a specific probability distribution (a joint log normal distribution for tornado area and windspeed, and the Frechet for severe wind and hurricane). The severe wind data was estimated from contour maps of the continental United States with average and standard deviation wind velocities for each of the four seasons. These values were then used with a probability distribution to derive the annual probabilities for each wind intensity [see Hart, (1976) for further details].

The water-related hazards were modeled from estimates of the population in close proximity to the coast, data from historical events, and determination of the "effective hazard" given the existence of structural protection for coastal communities. In both the tsunami model and the storm surge model, the populations at risk to varying water heights were estimated with a variety of different methods [see Lee, et al., (1976) for further details].

Earthquake hazard data were estimated from two sources. The first was the earthquake history of the United States, which gives the epicenter and estimate of magnitude for recent earthquakes. For earlier earthquake estimates, historical accounts of damage were used to create analogies to the physical magnitudes. Using a distribution of earthquake occurrences, each local history was fitted to a distribution to provide the probabilities of future occurrences. In order to provide the predicted future intensities, a map of the soil types for the United States was used to estimate the local soil's properties for transmitting earthquake energy. These soil types were computed from existing geological maps and a mean value was assigned to each county. The standard deviation of the seismicity had been computed but not the standard deviation of the soil type [Wiggins, et al., 1976].

The Sensitivity to Regionalization

Each set of county data, as described in Chapter Two, was estimated from regional data which differed in level of detail. Thus, data from the state, SMSA, and county level were used. Table 7-1 is a list of those elements of the county data base which have been replaced with national averages for the sensitivity analysis to check model accuracy. This was done to determine the change in accuracy which may be due to distributing estimates of annual building loss and percent of loss on a county basis. Because the other mitigation impacts calculated in this study are derived from building losses, their changes will be reflected by changes in building loss computations. Therefore, only the sensitivity of building losses will be explicitly examined.

HOUSING DATA FOR 1970	
Percent of Housing Units with Basements	53.34
Percent of Housing Units with Cement Slab Foundations	21.21
Percent of Housing Units Built Pre-1970	40.56
Percent of Housing Units that are Mobile Homes	3.06
Percent of Housing Units in Structures Greater than Four Floors	4.87
Percent of Housing Units in Structures With Five Units or More	14.52
Number of Persons per Housing Unit	3.002
ECONOMIC DATA	
Earning Data for 1980 in 1967$	
Total Income per capita	4,780.00
Agricultural Earnings per capita	95.00
Mining Earnings per capita	29.00
Construction Earnings per capita	232.00
Manufacturing Earnings per capita	982.00
Transportation Earnings per capita	262.00
Wholesale Earnings per capita	599.00
Finance, Insurance, and Real Estate Earnings per capita	217.00
Service Earnings per capita	672.00
Federal Government Earnings per capita	163.00
State and Local Government Earnings per capita	426.00
Employment per capita in 1970	.39
Slope of Population Projection	1,999,071.00
Intercept of Population Projection	163,876,440.00
Slope of Total Income Projection in 10^3 1967$	95,318.90
Intercept of Total Income Projection in 10^3 1967$	158,129.20
Local Income Perception Relative to National Income Perception	1.00
POPULATION DATA	
National Population Density (persons/square mile)	53.21

Table 7-1. National Average of County Level Data

Table 7-2 summarizes the changes in the resulting totals for cases where some of the regional rates were changed to national averages. It describes the variation in the estimates of both the annual damage rates and the total annual damages. These variations are not the same because the regionally-estimated values at risk will also be affected by the modifications in the data base. In this sensitivity analysis, four cases were studied. In the first case, only the housing factors used to estimate building types were given national average values. In the second case, the economic population factors were replaced with the national averages, while the county housing factors maintained the regional bias. The third case comprised a combination of the first two, in which the national averages for both housing and economic factors were used in each county. And in the fourth case, all the national averages were used, with the addition of the national average population density to compute a new county population. Note that this modification cannot be made to the storm surge and tsunami. Also, expansive soil and landslide were not included in this analysis because the economic and social factors of the exposure model were not used in the annual loss estimates.

From Table 7-2 it can be seen that severe wind is probably the most evenly-distributed hazard. This is demonstrated by the small variations caused by the use of national average values in place of the county values for housing and economic factors. The lower loss estimates for 2000 from hurricane, tsunami, and storm surge exemplify the faster growth characteristics of the coastal counties vulnerable to these hazards. Florida, one of the fastest growing states, sustains over 25% of the annual hurricane structure losses and over 40% of the annual storm surge structure loss. The higher loss values for earthquake are due to their high incidence in California where buildings are newer and built to stronger building codes; the national average tends to underestimate building strength. Using the national average for economic and population factors, the growth rates for the western states- particularly California, with over 60% of annual estimated structure loss due to earthquakes- are lower than with the regionalized data. This results in lower estimates for both the total damage and the rate of damage for earthquakes. The reason for the changes in the tornado results is not as obvious as the influences on the other hazards, due to the large area affected by the tornado hazard.

Use of the national average population density, in conjunction with average values for all other data distributed by county in the original methodology, simulates

	USING COUNTY LEVEL DATA		CASE 3		CASE 1		CASE 2		CASE 4	
			NATIONAL AVERAGE FOR ALL FACTORS % CHANGE		NATIONAL AVERAGE FOR HOUSING FACTORS % CHANGE		NATIONAL AVERAGE FOR ECONOMIC FACTORS % CHANGE		NATIONAL AVERAGE POPULATION DENSITY AND ALL OTHER FACTORS	
	1970	DAMAGE RATE %	DAMAGE RATE	DAMAGE	DAMAGE RATE	DAMAGE	DAMAGE RATE	DAMAGE	DAMAGE RATE	DAMAGE
HURRICANE										
1970	6.855×10^8	.100	+8.%	+6.%	+4.%	+3.%	+6.%	+5.%	+15.%	-65.%
2000	1.730×10^9	.103	0.%	-9.%	+4.%	+4.%	-2.%	-10.%	+ 7.%	-70.%
TORNADO										
1970	8.798×10^8	$.492 \times 10^{-1}$	-36.%	-34.%	-36.%	-39.%	-36.%	-34.%	-16.%	-30.%
2000	2.050×10^9	$.478 \times 10^{-1}$	-36.%	-38.%	-36.%	-39.%	-36.%	-38.%	-17.%	-34.%
SEVERE WIND										
1970	1.136×10^7	$.550 \times 10^{-3}$	+1.%	-5.%	+1.%	+1.%	+8.%	+5.%	+85.%	+79.%
2000	2.483×10^7	$.504 \times 10^{-3}$	+2.%	+3.%	+1.%	+1.%	+2.%	+2.%	+91.%	+74.%
STORM SURGE										
1970	4.416×10^9	.101	+12.%	+6.%	-4.%	+19.%	+11.%	+11.%	NA	NA
2000	1.178×10^9	.111	-4.%	-15.%	-5.%	-5.%	+4.%	-10.%	NA	NA
TSUNAMI										
1970	8.769×10^6	$.404 \times 10^{-2}$	-3.%	-13.%	+0.%	+0.%	-4.%	-13.%	NA	NA
2000	1.976×10^7	$.388 \times 10^{-2}$	-8.%	-20.%	+0.%	+0.%	-8.%	-20.%	NA	NA
EARTHQUAKE										
1970	6.552×10^8	$.438 \times 10^{-1}$	+8.%	+11.%	+21.%	+21.%	-11.%	-8.%	-26.%	-27.%
2000	1.177×10^9	$.329 \times 10^{-1}$	+8.%	+4.%	+17.%	+17.%	-8.%	-11.%	-22.%	-28.%

Table 7-2. The Effect on the National Annual Structure Value Lost Due to the Use of National Average Data Instead of Estimated County Data.

a situation where the exposure is homogeneous over the entire United States. A comparison of the estimated losses obtained through this procedure with those derived with the regionalized data, shows the regional distributions of the individualized hazards. Storm surge and tsunami could not be examined in this manner because their exposed populations do not depend on the county populations in the data base.

The hazard results that differed most significantly in this comparison are those for severe wind, reflecting high wind rates in the plains states (Wyoming, South Dakota, North Dakota, Montana, and Nebraska).* These states have lower than average population densities; thus, using the national average density to determine population results in higher loss estimates.

Predicted losses due to hurricane, however, are lower after modification due to the higher population densities that typify the coastal counties. In general, the new estimates are above the regionalized data estimates if the hazard occurs with higher frequency in counties with below-average population densities. Conversely, the new estimates are less than the regionalized estimates if the natural event occurs more frequently in urban counties with high population densities.

Much of the impact of the regional factors can be attributed to the differences between the characteristics of urban and rural counties exposed to each hazard. Table 7-3 indicates building losses in terms of urban or rural occurrence, where urban is defined as counties in designated SMSAs.** Because tsunami losses occurring in Alaskan and Hawaiian rural areas make up the largest proportion of tsunami losses, the use of the national averages will result in higher loss estimates due to the dominance of urban characteristics in the national averages. In Table 7-3 this can be seen in the proportionate damage rate for tsunami in rural counties of + 572% in 1970, which means the average damage rate in rural counties is 572% higher than the national average tsunami damage rate. Earthquake is exemplified as an urban risk where the proportionate 1970 national damage rate is 59% lower in rural counties than in urban areas. This is primarily due to the large urban earthquake exposure of Los Angeles, San Francisco, and Seattle.

*See Appendix H for the loss rates for all states.

**Many counties outside of SMSAs are not "rural" and parts of many SMSA counties are in fact rural; the term "rural" is used in this report to designate non-SMSA counties, or those which include no municipality larger than 50,000 population.

	ESTIMATED ANNUAL BUILDING LOSSES		PERCENTAGE OF DAMAGE OCCURRING IN:		PROPORTIONS OF NATIONAL DAMAGE RATE IN:		PERCENT OF NATIONAL VALUE OF BUILDINGS AT RISK IN:	
	DAMAGE 1970	DAMAGE RATE %	SMSA COUNTIES	NON SMSA COUNTIES	SMSA COUNTIES	NON-SMSA COUNTIES	SMSA COUNTIES	NON SMSA COUNTIES
HURRICANE								
1970	6.855×10^8	.100	83.%	17.%	- 3.%	+21.%	86.%	14.%
2000	1.730×10^9	.103	85.%	15.%	- 2.%	+17.%	87.%	13.%
TORNADO								
1970	8.798×10^7	$.492 \times 10^{-1}$	76.%	24.%	+ 1.%	- 2.%	76.%	24.%
2000	2.050×10^9	$.478 \times 10^{-1}$	79.%	21.%	+ 1.%	- 4.%	78.%	22.%
SEVERE WIND								
1970	1.136×10^7	$.550 \times 10^{-3}$	75.%	25.%	- 3.%	+11.%	77.%	23.%
2000	2.483×10^7	$.504 \times 10^{-3}$	77.%	23.%	- 2.%	+ 9.%	79.%	21.%
STORM SURGE								
1970	4.416×10^9	.101	77.%	23.%	-16.%	+170.%	92.%	8.%
2000	1.178×10^9	.111	80.%	20.%	-13.%	+139.%	92.%	8.%
TSUNAMI								
1970	8.769×10^6	$.404 \times 10^{-2}$	65.%	35.%	-69.%	+572.%	94.%	6.%
2000	1.976×10^7	$.388 \times 10^{-2}$	70.%	30.%	-74.%	+539.%	95.%	5.%
EARTHQUAKE								
1970	6.552×10^8	$.438 \times 10^{-1}$	92.%	8.%	+15.%	-59.%	80.%	20.%
2000	1.177×10^9	$.329 \times 10^{-1}$	92.%	8.%	+12.%	-54.%	82.%	18.%
LANDSLIDE								
1970	2.140×10^8	$.104 \times 10^{-1}$	76.%	24.%	- 1.%	+ 5.%	77.%	23.%
EXPANSIVE SOIL								
1970	1.130×10^9	$.552 \times 10^{-1}$	79.%	21.%	+ 3.%	- 9.%	77.%	23.%

Table 7-3. The Rural and Urban Characteristics of the Estimated Annual Building Losses

An Alternate Method of Building Value Computation; A Comparison by State

In estimating the value of structures at-risk in each state, the structure value per earning rate was used as described in Chapter Two. An alternative method for estimating structure value is the use of the assessed value of real property, which is employed to determine state and local property taxes and the ratio between assessed value and market value. In this section, both methods are used to estimate a value-at-risk by state. The comparison of these two values provides a means for evaluating the technique used in the present study. To make the comparison, details of the use of locally-assessed values are given below.

The U.S. Bureau of Census in the 1972 Census of Governments published figures of the locally assessed real values for all counties in the United States and assessment-to-sales ratios for over 2,000 counties. These estimates of assessment/sales ratios were used to estimate real market value in the counties in which they have been estimated. In those counties for which an estimate was not separately computed, the state average was used.

Table 7-4 shows a comparison of the estimated replacement value for buildings and the assessed real property values converted to estimated market prices. Nationally, this ratio comes to 0.997. However, it is expected that these series would not be equal because land is only part of the assessed value and that structure replacement value is usually higher than market value. The differences in this comparison by state are quite dramatic even though the total is almost equal. In addition, the national total shows SMSA counties have a ratio of 0.940 between estimates replacement values and the assessed real property values, while the non-SMSA counties' ratio is 1.190. This could be due to the higher proportion of real value that is land outside SMSAs than inside SMSAs.*

If values-at-risk for the assessed value technique are used, then damage estimates for tsunami and earthquake may be higher due to the greater values given in the West Coast States. In particular, Hawaii would have an estimated value-at-risk 60% higher ($12,274 million versus $7,684 million) than that used in the study, and California's exposure would be 26% greater. But other problems with the assessed

*In this comparison, the values estimated are assumed to both be 1970 values, actually the assessment values furnished are for FY 1971.

STATE	1 THE ESTIMATED PRIVATE REPLACEMENT STRUCTURE VALUE	2 ASSESSED MARKET VALUE OF ALL REAL PROPERTY	3 $\frac{\text{COLUMN 2}}{\text{COLUMN 1}} \times 100$	4 TOTAL POPULATION
AL	22159.38	16402.82	75.8	3444266.
AZ	14211.99	17775.35	125.	1772658.
AR	11758.52	13233.36	113.	1923239.
CA	193670.61	243863.25	126.	19963945.
CO	18945.49	22740.23	120.	2207259.
CT	31963.23	32071.41	100.	3032217.
DE	5092.26	5226.28	103.	548104.
DC	7576.92	8155.60	108.	756510.
FL	53614.52	77263.60	144.	6790360.
GA	35115.52	30235.27	86.1	4589981.
ID	5277.67	6479.51	123.	712837.
IL	113171.84	111309.00	98.4	11123874.
IN	43476.95	37041.93	85.2	5195332.
IA	22765.28	27639.82	121.	2825379.
KS	18366.47	19590.35	107.	2249071.
KY	22033.53	18895.55	85.8	3219345.
LA	26819.22	20618.56	76.9	3643180.
ME	7165.36	7957.66	111.	993722.
MD	36028.33	32621.21	90.5	3924604.
MA	55804.43	55229.44	99.0	5689170.
MI	80900.86	66283.43	81.9	8880122.
MN	33007.89	34700.86	105.	3804801.
MS	12539.34	10496.05	83.7	2216994.
MO	39520.59	24801.33	75.4	4677969.
MT	5282.86	5744.82	109.	694345.
NE	12293.81	15171.67	123.	1485321.
NV	4943.31	5631.10	114.	488738.
NH	6506.66	7345.10	113.	737681.
NJ	74906.52	67826.54	90.5	7172164.
NM	7125.86	6025.71	84.6	1016000.
NY	201717.87	179505.26	89.0	18241266.
NC	35169.33	34560.02	98.3	5084430.
ND	3999.97	3723.45	93.1	617792.
OH	94644.42	80235.41	84.8	10656535.
OK	19276.05	15544.64	80.6	2559463.
OR	16980.75	19478.44	115.	2091533.
PA	102873.53	84240.42	81.9	11797342.
RI	8409.65	6662.27	79.2	949723.
SC	16722.29	14362.83	85.9	2590210.
SD	4439.95	6016.38	136.	666257.
TN	26571.41	23662.33	89.1	3924927.
TX	90170.65	108600.62	120.	11196852.
UT	7953.10	6879.02	86.5	1059273.
VT	3272.24	4811.16	147.	444732.
VA	35955.99	32469.26	90.3	4652328.
WA	29721.53	34522.33	116.	3410519.
WV	12583.61	9384.89	74.6	1744237.
WI	36426.54	40745.46	112.	4417933.
WY	2713.37	2447.84	90.2	332416.
AK	2858.21	2824.51	96.8	273464.
HI	7684.97	12274.69	160.	769913.

Table 7-4. The Comparison Between Alternative Methods of Structure Value Estimates in 10^6 1970$ for 1970

value technique can also occur, such as the conversion from market value to replacement cost. The older a structure, the more divergent these two values will be. A further consideration in appraisal of this technique is the valuation of the class of structures excluded from tax assessment such as government structures and those owned by charitable organizations. It is interesting to note that the variation among states is not great: the mean ratio by state is 102 and the standard deviation is 20. The impact on national values and even state locals, would be less than error from other sources mentioned above if this method for building value estimated was used instead of the income base technique used in this study.

Summary

This chapter has shown that use of national average data results in relatively small changes in the annual loss estimate. Also, the method for estimating structure replacement costs is not dramatically different, in the aggregate, from a method based on local assessed valuations. However, the distribution among states may differ somewhat. It is difficult to perform a full sensitivity analysis on a model of this scale. This would require a treatment of all the data used and at least a consideration of the variance of each average value used. It is hoped that this chapter has answered some questions toward which such a complete analysis would be aimed.

Chapter Eight

SCENARIO ANALYSIS

In Chapter One, the annual loss technique was compared with the scenario technique for estimating the intensity and effects of future hazard events. The primary shortcomings of the scenario technique were given as: location specificity and an incomplete assessment of the probability of occurrence. However, sole reliance on an annual loss technique tends to diminish the influence of the rare catastrophe. Therefore, a scenario may provide a more accurate view of specific major events for the assessment of hazard mitigation. To this end, the annual loss technique developed in the preceeding chapters can be applied to a specific event to describe the impacts of such an event.

This chapter describes the adaptation of the annual loss model to scenario computation through the use of specific hazard intensities. The first section presents the physical models used to analyze two scenarios: Hurricane Camille (1969) and the San Francisco earthquake (1906). The second part describes the derivation of wealth-at-risk as estimated in 1970 and in the year 2000. The third section presents estimated results. The fourth section provides an income distribution view of these results and in the final section some mitigations are analyzed with a cost-benefit approach.

The Physical Models

In Chapter One (Equation 1-1), a potential hazard was described in the form of the hazard intensity vector, I_{hr}:

$$I_{hr} = \begin{bmatrix} \iota_1 \\ \iota_2 \\ \iota_3 \\ \cdot \\ \cdot \\ \cdot \\ \iota_l \end{bmatrix}_{hr}$$

where

J = total number of intensity levels of the hazard (varies by hazard)
ι_j = annual probability of the event of magnitude j
h = hazard
r = region

In the case of a scenario analysis, the ι_j are defined as actual event intensities while counties are the relevant regions. It should be noted that the event may be felt over a group of counties, and therefore the intensity will vary depending on the proximity of the county to the center of the event. (The epicenter of the earthquake, or the eye of the hurricane). The intensities are those used in the Hurricane Camille and San Francisco Earthquake Scenarios.

Since only the wind hazards had sufficient data to be modeled with the use of damage density matrices, the calculation of the wind damage due to Hurricane Camille was the only scenario that conformed to the theoretical model described above. In the case of the water damage caused by storm surge due to Camille, the scenario was modeled as a specific water height using the continuous damage algorithms described in Chapter Three. Also modeled in this manner were the earthquake losses in the description of the San Francisco Earthquake.

In order to determine the wind intensity probability vector for each affected county, the Wind Field for Camille, as presented in the U.S. Army Corps of Engineers' report on Camille was used. Figure 8-1 is a reproduction of these data. To use these data, the county boundaries were superimposed to provide the proportion of the area in each county to be affected by the different wind intensities. Table 8-1 gives the estimated proportions of each county by the range of wind intensity to which it was subject.

Using the proportions of county area in each wind intensity as the probabilities of being affected by these wind speeds, an intensity probability vector was calculated for the particular parts of each county. Thus, for Plaquemines Parish, Louisiana the intensity vector would be:

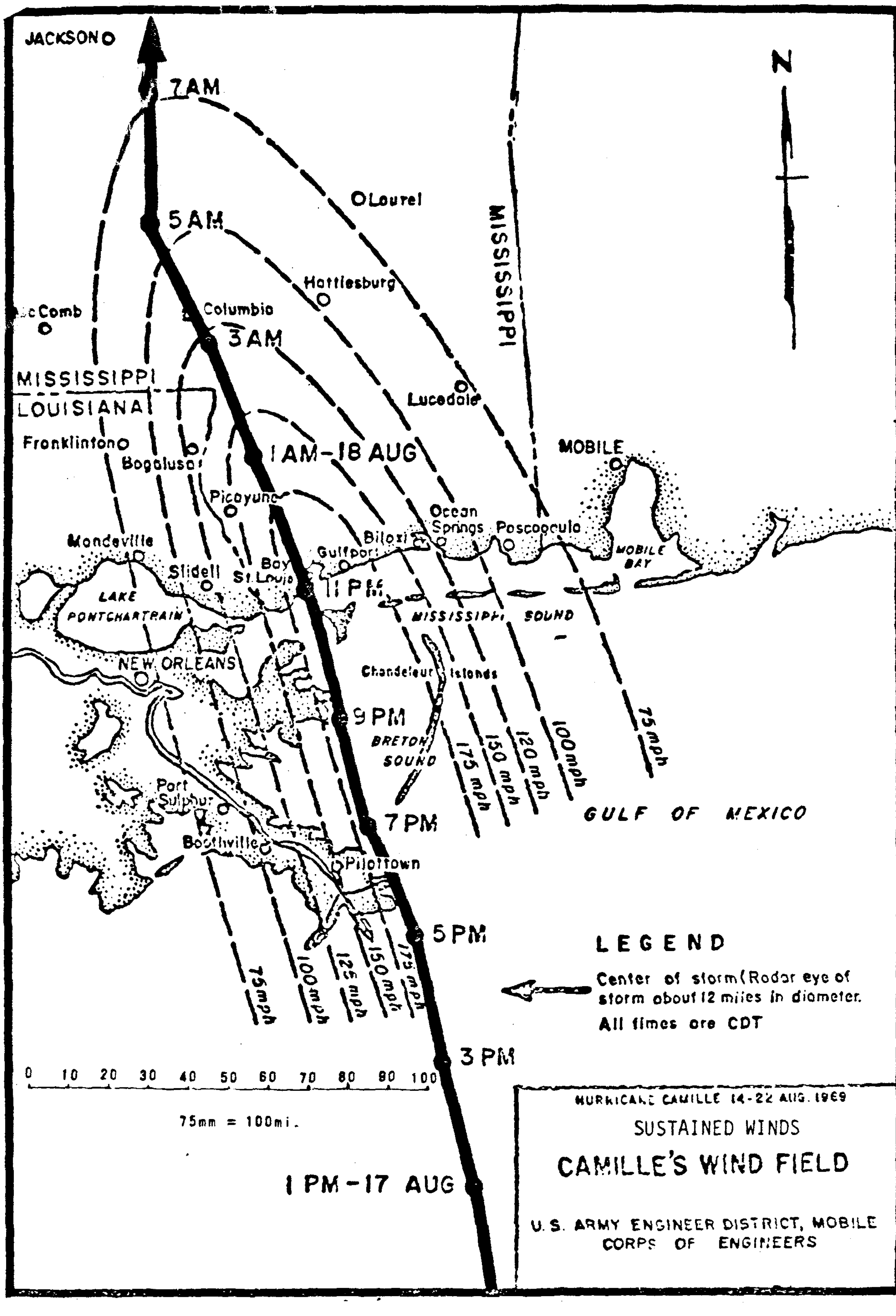

Figure 8-1. Camille's Wind Field

$$I_{hr} = \begin{bmatrix} .35 \\ .25 \\ .25 \\ .10 \\ .05 \\ .00 \end{bmatrix} \quad \begin{cases} h = \text{Hurricane Camille} \\ r = \text{Plaquemines LA.} \end{cases}$$

The intensity vectors were then multiplied by the damage density matrices for the structures exposed to Hurricane Camille by county. (see Equation 1-7 in Chapter One for an example of this procedure).

COUNTY	WIND SPEED RANGE (MPH)					
	<75	75-100	101-125	125-150	151-2000	>200
PLAQUEMINES, LA	35	25	25	10	5	
ST. BERNARD, LA	5	30	30	30	5	
ORLEANS, LA	40	30	30			
ST. TAMMANY, LA	10	30	30	30		
WASHINGTON, LA	25	40	20	15		
GREENE, MS	90	10				
PEARL RIVER, MS			40	60		
HANCOCK, MS					50	50
HARRISON, MS			20	30	30	20
STONE, MS	15	15	45	25		
JACKSON, MS	20	60	20			
GEORGE, MS	40	60				
WALTHALL, MS		75	20	5		
MARION, MS			70	30		
LAWRENCE, MS	5	90	5			
SIMPSON, MS	20	80				
JEFFERSON DAVIS, MS		40	60			
COVINGTON, MS		90	10			
JONES, MS	55	45				
PERRY, MS	25	60	15			
MOBILE, AL	99	1				
LAMAR, MS			60	40		
FORREST, MS		50	50			

Table 8-1. Distribution of Wind Speeds by Proportion of County Area

To determine the storm surge losses from Camille the U.S. Army Corps report provided a water height profile for the counties impacted. Figure 8-2 reproduces this data and gives the average heights used for those counties in the scenario area. A height of 20 ft. was used in Harrison County, Mississippi, and this height was then applied to the damage algorithm, by type of structure exposed in Harrison County.

For the 1906 San Francisco Earthquake scenario no detailed data is available to provide comparable intensities information (as is available for Hurricane Camille). Thus, a set of intensities was calculated from a hypothetical physical event equal to the estimates of the intensity of the San Francisco occurrence. This was done by establishing a Richter Magnitude of the event at 8.25. The energy of an earthquake of this magnitude was then distributed along the length of the estimated fault rupture.

The length of the fault was determined statistically, and a series of smaller earthquakes were positioned at 30-mile intervals along the fault. (Details of this method are given in Wiggins et al., 1974). The resulting intensities of the event were then calculated from a map of soil types in California to establish the soil dynamic amplification factors to model the transmission of this energy from the fault site. This technique resulted in the calculation of the intensity felt at different distances from the event's occurrence.

Given this procedure, the mean intensity for each county was used in conjunction with the damage algorithms of the type described in Chapter Three to determine the losses in 1970 and 2000.

Table 8-2 provides a tabulation by county of intensity levels in Modified Mercalli Intensities (MMI).

Therefore, it can be seen that, while the data needed to model the Hurricane Camille Scenario was available from historic data, the physical characteristics required in the scenario for a reconstruction of the 1906 San Francisco Earthquake had to be approximated. These data were either placed in a probability vector form as for wind hazards, or the average values were used as in the case of storm surge and earthquake.

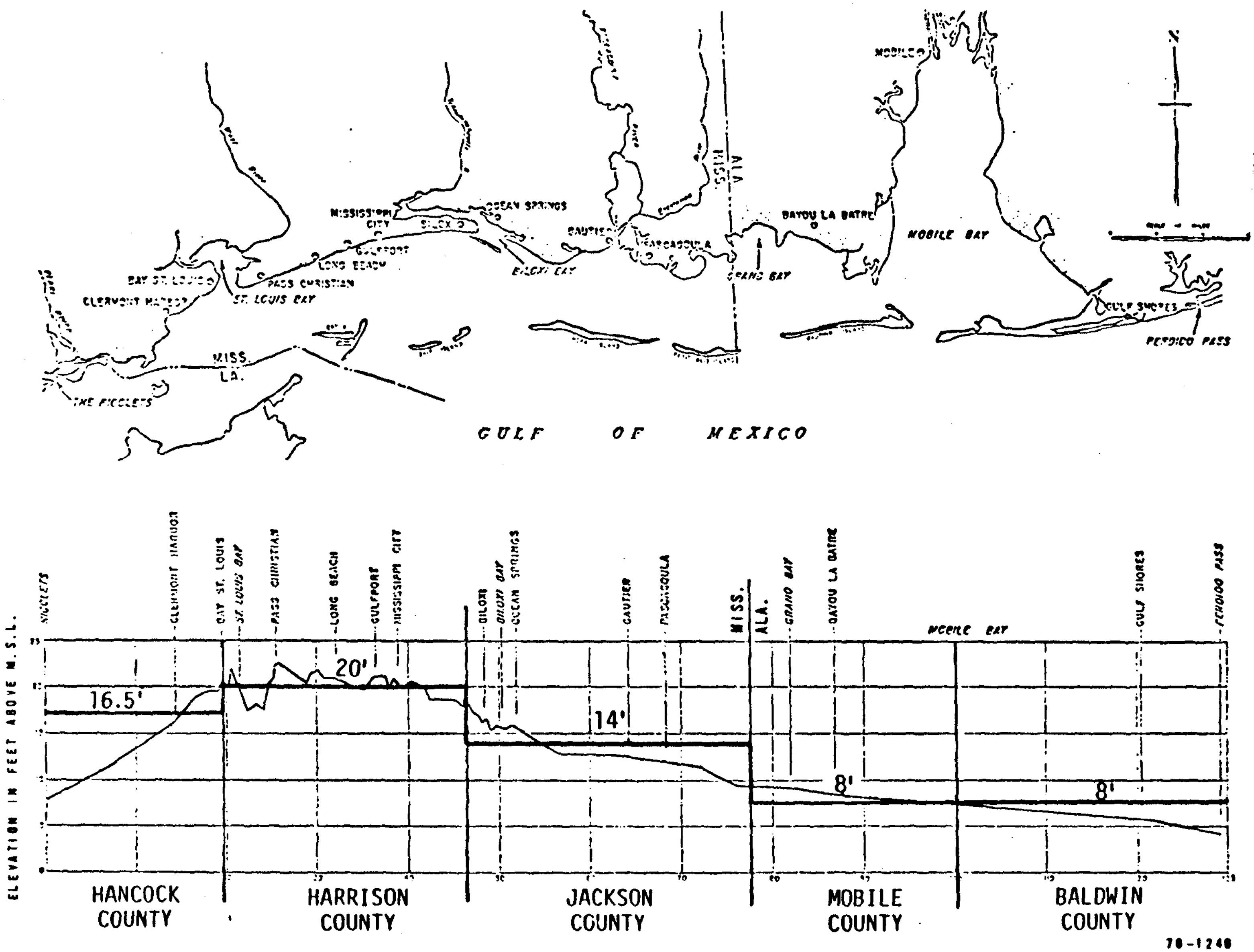

Figure 8-2. Hurricane Camille, High Water Profile.

MMI 9 and over	MMI 8 to 8.9
Monterey San Benito San Francisco San Mateo Santa Cruz	Alameda Contra Costa Marin Napa San Joaquin Santa Clara Solano Sonoma
MMI 7 to 7.9	**MMI 6 to 6.9**
Colusa Fresno Glenn Kings Lake Madera Mendocino Merced Sacramento Stanislaus Sutter Yolo Yuba	Amador Butte Calaveras El Dorado Humbolt Kern Mariposa Placer San Luis Obispo Tehama Tulare Tuolumne Douglas, NV

Table 8-2. The Intensities Felt by County (Modified Mercalli Intensities)

The Estimation of Wealth-at-Risk

The wealth-at-risk for the Hurricane Camille Scenario was calculated in the same manner as the estimates of wealth used in the annual loss model for hurricane, severe wind, and storm surge. Table 8-3 provides the wealth-at-risk by county in 1970. In the case of storm surge, the populations in the coastal flood plains are described in detail in Lee, et al., [1976]. However, the county level estimates were not available for the year 2000, and therefore a growth factor was applied to each county's 1970 aggregate wealth-at-risk. This growth factor was calculated from the per capita growth rate of income and the growth rate of the population. Note that the annual damage estimates of the wealth-at-risk in 2000 (which are found in the other chapters of this report) followed the sector growth rates discussed in Chapter Two. Unfortunately, these estimates were not available for the scenario calculations. Thus, the growth rate used was found from the first derivative of the composite growth of population and income available from the county data base described in Chapter Two. The formulation used is of the following form:

COUNTY	STATE	VALUE AT RISK IN MILL. 1970$	POPULATION IN THOUSANDS
BALDWIN	AL	448.0	59.4
MOBILE	AL	2,392.0	317.0
ESCAMBIA	FL	1,840.0	205.0
SANTA ROSA	FL	339.0	37.7
LIVINGSTON	LA	207.0	36.5
ORLEANS	LA	6,349.0	593.0
PLAQUEMINES	LA	205.5	25.2
ST. BERNARD	LA	547.6	51.2
ST. TAMMANY	LA	232.8	42.0
TANGIPAHOA	LA	373.0	65.9
WASHINGTON	LA	232.8	42.0
COVINGTON	MS	92.	14.0
FORREST	MS	383.0	57.8
GEORGE	MS	82.4	12.5
GREENE	MS	56.5	8.6
HANCOCK	MS	96.4	17.4
HARRISON	MS	1,210.0	135.0
JACKSON	MS	582.0	88.0
JEFFERSON DAVIS	MS	71.7	12.9
JONES	MS	373.0	56.4
LAMAR	MS	101.0	15.2
LAWRENCE	MS	61.8	11.1
MARION	MS	127.0	22.9
PEARL RIVER	MS	154.0	28.7
PERRY	MS	60.0	9.1
SIMPSON	MS	111.0	19.9
STONE	MS	53.6	8.1
WALTHALL	MS	69.3	12.5

Table 8-3. The Value of Buildings At-Risk in 1970, in Those Countries Affected by The Hurricane Camille Scenario

$$P = \alpha + \beta \, YR \quad \begin{cases} P = \text{population} \\ \alpha = \text{intercept} \\ \beta = \text{slope} \\ YR = \text{year} \end{cases}$$

$$I = \gamma + \Theta \, YR \quad \begin{cases} I = \text{per capita income by county or SMSA} \\ \alpha = \text{intercept of growth} \\ \Theta = \text{slope of per capita income growth} \end{cases}$$

Hence, the growth of total income becomes a composite of these growth rates.

$$P.I = \gamma\alpha + [\alpha\,\Theta + \beta\,\gamma]\; YR + \beta\,\Theta\; YR^2 \tag{8-1}$$

Taking the first derivative with respect to year, and evaluating at 1970, we get:

$$d\;PI/d\;yr = (\alpha\,\Theta + \beta\,\gamma) + 2\,\beta\,\Theta\;(1970) \tag{8-2}$$

This is the growth rate that was used. However, it may be high because this calculation takes a quadratic function at a specific point and applies a linear slope to the remaining portion. Figure 8-3 gives a graphic example of this problem where the growth rate is taken as the slope of the growth at 1970, but when translated to a linear rate this overestimates the growth in 2000. Because of this problem, the growth rates in some counties tend to be higher than those determined by the computation in 2000 using the economic distribution growth rates.

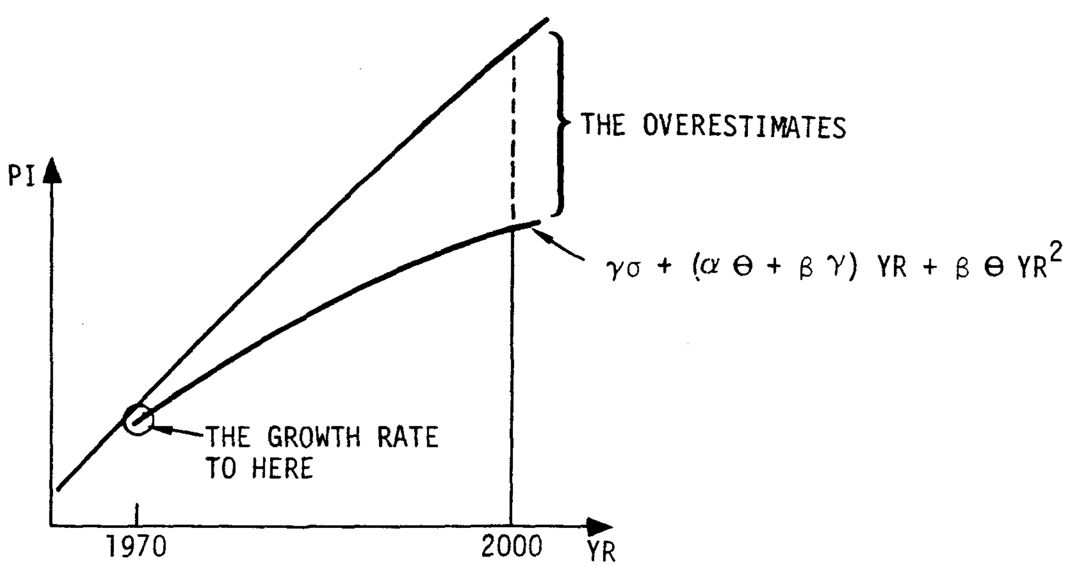

Figure 8-3. Comparison of Growth Rates

For the San Francisco Earthquake an additional problem was encountered. The losses for this scenario were not calculated using the exposure model described in this report, but from damage rates calculated for an earlier report, [Wiggins, et al., 1974]. This procedure used the same damage algorithms as discussed in this report, but the value of structures at-risk was calculated in a different manner.

An assessed real property value technique was used in this earlier study, (see Chapter Seven for a comparison of the type of method used here). Thus, to make these estimates comparable, the values-at-risk for the counties in California were taken from the technique used in the present report and the structure damages were calculated for 1970 and 2000 by application of the damage rates calculated in the earlier report. Table 8-4 lists this wealth data for 1970 by county. Again, the value-at-risk used in 2000 was calculated in the manner described above for the Hurricane Camille scenario. The vulnerability of structures, however, was from the earlier report which used a comparable method to the estimation of vulnerability discussed in this report.

Estimation of Losses

In calculating these scenario results, the technique of estimating income, supplier and contents losses was not available. Neither were the procedures for calculating the home use, life loss, and unemployment. Therefore, in order to calculate these factors for the scenarios, aggregate ratios of these losses to building losses were used. Table, G-2 and G-5 in Appendix G provide some of the data used in constructing these ratios of income, supplier and contents losses to the building losses. Also calculated are ratios of building losses to unemployment, life loss and loss of home use (homelessness). Table 8-5 provides the ratios of these factors calculated for hurricane. The rate of 2.2 for total economic losses was taken from annual tornado data, because it is the hazard with the most severe annual loss (see Figure 4-3). However, the multiplier for life loss, * unemployment, and homelessness are hazard specific annual rates.

*Note from Chapter 6 that hurricane and storm surge are given the same life loss estimating function.

COUNTY	STATE	VALUE AT RISK IN MILL.1970$	POPULATION IN THOUSANDS
ALAMEDA	CA	15,800.0	1,073.2
ALMADOR	CA	97.5	11.9
BUTTE	CA	856.0	101.9
CALAVERAS	CA	112.0	13.5
COLUSA	CA	104.0	12.4
CONTRA COSTA	CA	8,190.0	558.4
DOUGLAS	CA	80.8	6.8
EL DORADO	CA	368.0	43.8
FRESNO	CA	3,870.0	413.0
GLENN	CA	147.0	17.5
HUMBOLT	CA	914.0	99.7
KERN	CA	3,430,0	329.1
KINGS	CA	532.0	66.0
LAKE	CA	164.0	19.5
MADERA	CA	321.0	41.5
MARIN	CA	3,050.0	206.0
MARIPOSA	CA	46.5	6.0
MENDOCINO	CA	468.0	51.1
MERCED	CA	808.0	104.6
MONTEREY	CA	2,580.0	250.0
NAPA	CA	869.0	79.1
PLACER	CA	864.0	77.3
SACRAMENTO	CA	7,050.0	631.5
SAN BENITO	CA	154.0	18.2
SAN FRANCISCO	CA	10,500.0	715.7
SAN JOAQUIN	CA	3,070.0	290.2
SAN LIUS OBISBO	CA	891.0	106.0
SAN MATEO	CA	8,200.0	556.2
SANTA CLARA	CA	11,100.0	1,064.7
SANTA CRUZ	CA	1,040.0	123.8
SOLANO	CA	1,890.0	169.9
SONOMA	CA	1,680.0	204.9
STANISLAUS	CA	1,630.0	194.5
SUTTER	CA	352.0	41.9
TEHAMA	CA	248.0	29.5
TULARE	CA	1,500.0	188.3
TUOLOMNE	CA	171.0	22.7
YOLO	CA	1,020.0	91.2
YUBA	CA	376.0	44.7

Table 8-4. The Value of Buildings at-Risk in 1970, in Those Countries Subject to Loss Due to The San Francisco Earthquake Scenario

LIFE LOSS	= 8.78 10^{-8} *	BUILDING LOSSES
TOTAL ECONOMIC LOSSES (INCOME, SUPPLIER, COUNTIES & BUILDINGS)	= 2.2 *	BUILDING LOSSES
UNEMPLOYMENT	= 1.65 10^{-5} *	TOTAL ECONOMIC LOSSES
HOMELESSNESS	= 1.37 10^{-5} *	TOTAL ECONOMIC LOSSES

Table 8-5. Hurricane Multipliers for Other Losses Used in Hurricane Camille Scenario

Table 8-6 provides the ratios used for the calculations for storm surge.

LIFE LOSS	= 8.78 10^{-8} *	BUILDING LOSSES
TOTAL ECONOMIC LOSSES (INCOME, SUPPLIER, CONTENTS & BUILDINGS)	= 2.2 *	BUILDING LOSSES
UNEMPLOYMENT	= 4.34 10^{-7} *	TOTAL ECONOMIC LOSSES
HOMELESSNESS	= 4.41 10^{-6} *	TOTAL ECONOMIC LOSSES

Table 8-6. Storm Surge Multipliers for Other Losses Used in Hurricane Camille Scenario

Because more than half of the annual building losses due to earthquake are in the light and moderate damage states (see Figure 4-3), the multipliers computed from annual data for total economic losses, unemployment and homelessness are lower than those expected from such a severe event as the San Francisco Earthquake. Hence, the multiplier for the ratio for calculating total economic losses is also the 2.2 multiplier from annual tornado losses. However, the unemployment and homelessness rates are developed from earthquake data and values, one for counties with building damage rates from 1.25 to 7.50% and another for damage rates from 7.50 to 65.00%. These multipliers are given in Table 8-7.

Figure 8-4 gives the results from the Hurricane Camille scenario for 2000 and the losses documented for the actual event in 1969 as listed in the U.S. Army Corps of Engineer's report. Due to the influence of possible low reporting error in the data for the actual event, a high rate of growth for the affected area, and the errors in the techniques of estimation, the results for 2000 are approximately

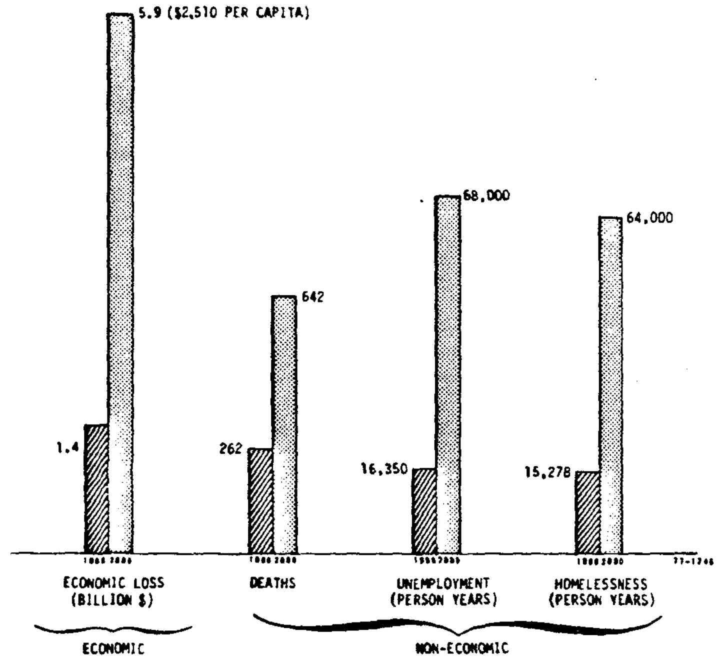

Figure 8-4. Loss Comparisons - 1969 Event vs. 2000 Scenario of Hurricane Camille

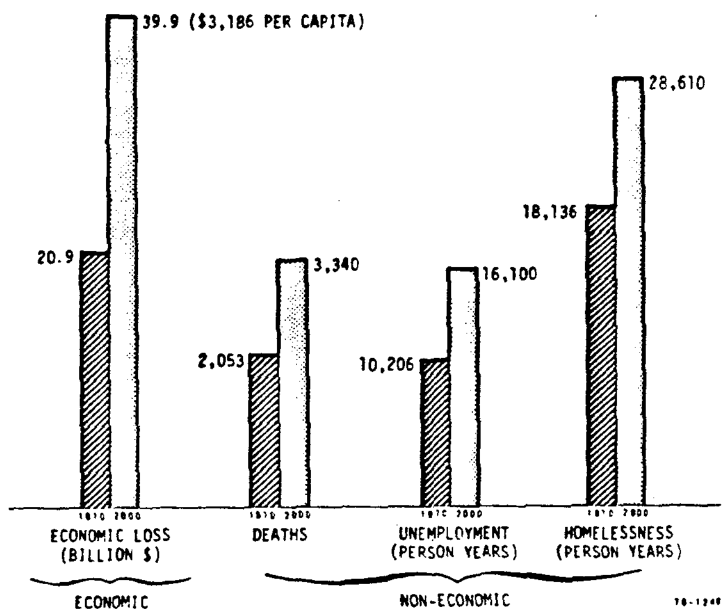

Figure 8-5. Total Economic Loss Comparison - 1970 and 2000 Scenario San Francisco Earthquake

TOTAL ECONOMIC LOSSES (INCOME, SUPPLIER, CONTENTS & BUILDINGS)		= 2.2 * BUILDING LOSSES
UNEMPLOYMENT	(FOR DAMAGE RATES BETWEEN 1.25% and 7.50%)	= $1.04\ 10^{-8}$ * TOTAL ECONOMIC LOSSES
	(FOR DAMAGE RATES BETWEEN 7.50% and 65.00%)	$4.95\ 10^{-7}$ * TOTAL ECONOMIC LOSSES
HOMELESSNESS	(FOR DAMAGE RATES BETWEEN 1.25% and 7.50%)	= $1.85\ 10^{-8}$ * TOTAL ECONOMIC LOSSES
	(FOR DAMAGE RATES BETWEEN 7.50% and 65.00%)	$8.78\ 10^{-7}$ * TOTAL ECONOMIC LOSSES
LIFE LOSS		= $3.404\ 10^{-7}$ * BUILDING LOSSES

Table 8-7. The Multiplier for Other Losses from the San Francisco Scenario

four times those reported for 1969.

Figure 8-5 provides a comparison between the estimated losses due to the reoccurrence of the San Francisco Earthquake in 1970 and also in 2000. The data from the actual event of 1906 are not really comparable, thus Figure 8-6 shows the effects of growth and structure stock changes. (Pre-1933 structures in California are assumed to be built to lower lateral strength criteria; thus by 2000 few structures of this type remain in the building stock).

Analysis of the Distribution of Damages by Income Class

This section describes a means for evaluating the impact of scenario losses by income class.* First, a description of this method is given. Then, a description of the results of its application to the Hurricane Camille and the San Francisco Earthquake loss data is provided.

By distributing the economic losses due to a scenario event with regard to the

*Income class as used here refers to the income groups defined in the 1970 census by ranges of annual family income: A - below $3,000. B - $3,000 to $4,999, C - $5,000 to $6,999, D - $7,000 to $9,999, E - $10,000 to $14,999, F - $15,000 to $24,999, and G - $25,000 and over.

INCOME CLASS	FAMILIES	INCOME	DAMAGE	INCOME/ DAMAGE
A	16.7	2.9	3.1	.94
B	12.7	5.8	6.8	.85
C	13.6	9.3	11.8	.79
D	26.8	25.9	20.9	1.24
E	18.4	26.2	29.0	.90
F	8.9	20.3	21.0	.97
G	2.9	9.6	7.4	1.30
	100.0	100.0	100.0	

Hurricane (Wind only) Camille Scenario

INCOME* CLASS	FAMILIES	INCOME	DAMAGE	INCOME/ DAMAGE
A	16.7	2.8	2.7	1.04
B	13.2	6.0	6.3	.95
C	14.0	9.6	11.3	.85
D	25.6	24.9	21.4	1.16
E	18.9	27.0	30.2	.89
F	8.9	20.4	21.2	.96
G	2.7	9.3	6.9	1.35
	100.0	100.0	100.0	

Hurricane (Camille) Scenario, Total of both Storm Surge and Wind

INCOME CLASS	FAMILIES	INCOME	DAMAGE	INCOME/ DAMAGE
A	19.6	3.3	2.1	1.57
B	13.5	6.1	5.2	1.17
C	14.5	9.8	10.4	.94
D	18.0	17.3	22.2	.78
E	21.2	30.0	32.3	.93
F	10.0	22.6	21.6	1.05
G	3.2	10.9	6.2	1.76
	100.0	100.0	100.0	

Storm Surge Alone (Camille) Scenario

INCOME CLASS	FAMILIES	INCOME	DAMAGE	INCOME/ DAMAGE
A	8.3	1.0	.8	1.25
B	8.8	2.9	2.2	1.32
C	10.1	5.0	4.2	1.19
D	18.0	12.7	11.3	1.12
E	28.1	29.2	28.6	1.02
F	20.8	34.5	36.9	.93
G	5.9	14.7	15.9	.92
	100.0	100.0	100.0	

Earthquake (1906 San Francisco) Earthquake Scenario

Table 8-8. Distribution of Families, Income, and Damage by Income Class

*The Distribution by Income Classes are based on the Family Income Distribution from the 1970 Census. Used, by County.

distribution of family income, an incidence of loss by income class can be computed. Table 8-8 presents the distribution of total population, income, and damage by income class for all the counties affected by the Hurricane Camille Scenario for Storm Surge and Hurricane wind losses. By comparing the share of the total income by class with the share of the total damage, the ratio of income share to damage share (R.I.D.) can be calculated to provide an indication of the incidence of damage by income class. The share of total damage incurred by each income class was estimated by apportioning the total damages for 1970 in the county by the proportion of total income earned in the county by each income class and multiplying by the number of families in each class by county. Table 8-8 gives the total income proportions and the total damage proportions over all counties in the Hurricane Camille and San Francisco Earthquake Scenarios.

Table 8-9 below gives the R.I.D. for each income class from the data in Table 8-8. If the R.I.D. is greater than 1 for an income class, then a higher proportion of total income than total damage is incurred by the income class. If the R.I.D. is less than 1, the income class gets a higher proportion of total loss than of total income, and thus suffers more than proportionately.

INCOME CLASS	MEDIAN INCOME	STORM SURGE + HURRICANE (INCOME/DAMAGE)	STORM SURGE (INCOME/DAMAGE)	HURRICANE (INCOME/DAMAGE)	EARTHQUAKE (INCOME/DAMAGE)
A	1,500	1.04	1.57	.94	1.25
B	4,000	.95	1.17	.85	1.32
C	6,000	.85	.94	.79	1.19
D	8,500	1.16	.78	1.24	1.12
E	12,500	.89	.93	.90	1.02
F	20,000	.96	1.05	.97	.93
G	30,000*	1.35	1.76	1.30	.92

Table 8-9. The Ratio of Income-to-Damage Proportions (R.I.D.)

*A value of $30,000 assumed for incomes over $25,000.

One of the possible difficulties with this analysis arises from the manner in which the damages were allocated by income class. That is , the lowest income groups may own no physical wealth and the highest may be renting out all the physical wealth. Therefore, the R.I.D. for the lowest income group may be underestimated and overestimated for the highest income group. However, due to a lack of more detailed information concerning the distribution of real property ownership, it is assumed that it follows the distribution of income.

Figure 8-6 is a plot of the values of R.I.D. versus the median income for each group. By inspection of Figure 8-9, a general trend of the incidence of damage by the median income can be observed. The change in R.I.D. as median income increases by scenario and hazard are given below:

$\frac{\Delta RID}{\Delta MI} < 0$ for earthquake   MI = median income

$\frac{\Delta RID}{\Delta MI} > 0$ for storm surge

$\frac{\Delta RID}{\Delta MI} > 0$ for hurricane wind

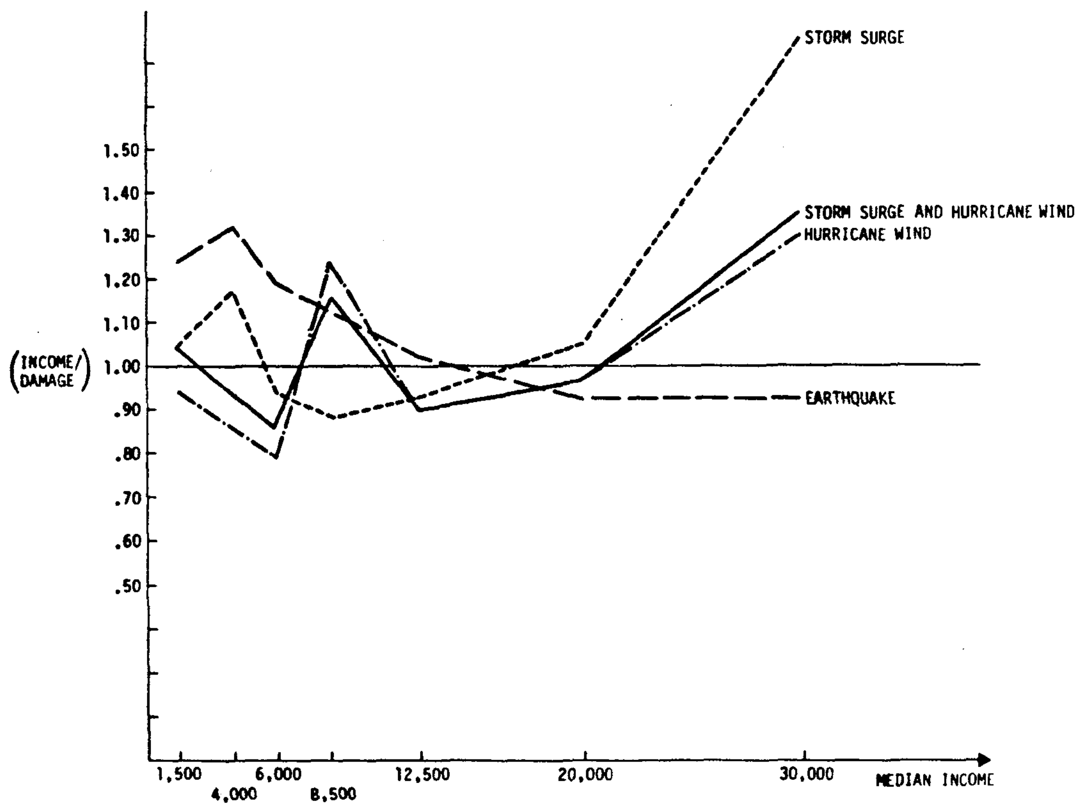

Figure 8-6. The Ratio of the Income Share to Damage Shown by Median Income of Income Class for Different Scenarios

These rates imply that the losses due to earthquake have a higher incidence to higher income classes than to lower income classes. For storm surge and hurricane just the opposite seems to hold, the proportion of income to damage is greater for the wealthier income groups, implying a higher incidence of losses on poorer income classes. These can be explained by the relatively low income distribution of those counties subject to losses in the Hurricane Camille scenario, while the relatively wealthy urban San Francisco area bears the brunt of the earthquake scenario losses.

Cost-Benefit of Building Code Mitigations

This section discusses the cost-benefit analysis as it is applied to the scenario analysis. Much of this section draws on the material in Chapter Nine. However, to keep the treatment of the scenario methodology in one chapter it is included here. (It may help to read Chapter Nine before this section). The benefits referred to here are the savings of losses resulting from the implementation of a building code prior to the occurrence of the scenario event. The costs are the increased construction costs incurred by those persons constructing buildings according to the stronger code in the period from the code's implementation to the event's occurrence. The first part of this section presents the theoretical concepts involved. The second part describes the parameters of the specific building codes examined, and the third part provides some of the results from the scenario computations.

It is assumed that the building code is put into effect in 1980 and the scenario event occurs in 2000. In this case, costs of constructing stronger buildings are incurred as a stream of costs over the twenty years from 1980 to 2000. The savings are those that result from the stronger construction of those buildings built in the period from 1980 to 2000, at which time the event occurs. Thus, the cost-benefit analysis compares a stream of opportunity costs to a single savings or benefit total at the time of the event, at the year 2000. This analysis is somewhat the reverse of normal cost benefit evaluation of public expenditures where the benefits are a stream and the costs are a lump-sum.

The costs are a function of the growth rate for the building stock from 1980 to 2000. For the Hurricane Camille scenario, this growth rate was calculated as .81

times the growth rate from 1970 to 2000. For the San Francisco Earthquake Scenario the growth from 1980 to 2000 was established by subtracting the estimate of the building value in 1980 from the established value for 2000. The 1980 value is assumed to be 1.34 times the value in 1970 in all counties. This term, and the one for the Hurricane Camille Scenario, were calculated from the aggregate state level growth rates in the area under the assumption of uniform growth over this period. Also, in the calculations of the costs for the storm surge hazard of Hurricane Camille only, the new construction in the area of innundation was used, and not the new construction in the entire county as in the case of the cost for the wind and earthquake mitigations.

Thus, costs incurred in 1980 are twenty-years-old in 2000 and the value of expenditures 20 years ago (assuming evaluation in constant 1970 to remove the effect of inflation) can be evaluated by determining the value of an alternative return available if the same value was invested along with the original cost.

cost in 20 years = original cost + (opportunity cost)
for original cost over
20 years at a specific
interest rate)

This alternate return or opportunity cost will be established by a discount rate.

The original cost component can be computed from the following equation:

$$TC = CF * TV \qquad (8\text{-}3)$$

where:

TC = cost of building code mitigation
CF = cost factor for the building code,
(the increased cost of construction)
TV = the value of construction built from 1980-2000

From Chapter Nine and Appendix J the following values for the cost factors of the building codes (CF) are given as:

Wind	3 x UBC	CF = .051
Storm Surge	4ft elevation of flood proofing	CF = .166
Earthquake	2* UBC Zone 3	CF = .095

Equation (8-3) would represent the total cost without consideration for the opportunity cost of funds which could be used for alternate purposes. To determine the opportunity cost a stream of costs is needed. Therefore, the assumption is made that the costs occur linearly and thus annual costs are assumed to be equal to the total cost (TC) divided by twenty years.

The costs for each year will be appreciated by the return that could be gained from investment. Let FC be the full cost including opportunity cost. Then:

$$FC = \overset{1999}{\frac{TC}{20}} + \overset{1998}{\frac{TC}{20}e^{i}} + \overset{1997}{\frac{TC}{20}e^{i2}} + \dots + \overset{1980}{\frac{TC}{20}e^{i20}}$$

or

$$FC = \frac{TC}{20}\sum_{t=0}^{20} e^{it} \approx \frac{TC}{20}\int_{0}^{20} e^{it}\,dt$$

Using this approximation: $FC = \frac{TC}{20}\left(\frac{e^{i20} - 1}{i}\right)$ (8-4)

This can be rewritten as:

$$FC = TC * B_i \qquad (8\text{-}5)$$

Where $B_i = \left[\frac{(e^{i20} - 1)}{20i}\right]$ (8-6)

B_i is therefore a function of the interest rate i.

Listed below are a set of B_i for various interest rates.

$B_{.000} = 1.000$

$B_{.029} = 1.355$

$B_{.061} = 1.957$

$B_{.100} = 3.195$

$B_{.150} = 6.362$

The application of the cost factors with an appropriate value of B_i by county provides the value of the full costs of the mitigation FC. These can then be compared to the savings due to the mitigation in each county. The savings are computed from the total economic losses saved, as described in the preceding section of this chapter by application of the ratio of 2.2 to the building losses saved by the mitigation. Thus, total savings (TS) for a county are given as:

$$TS = 2.2 * PS * TV * DR \qquad (8\text{-}7)$$

where:

PS = The proportion of building losses saved by the implementation of the building code mitigation

DR = The damage rate caused by the scenario occurrence to the structures built from 1980 to 2000.

TV = The value of the new construction from 1980 to 2000

The San Francisco Earthquake scenario values of PS (the proportion of building loss saved) were computed as .38 for the 2 * UBC Zone 3. For wind losses due to Hurricane Camille, a value for PS of .64 was used for the 3 * UBC Wind Building Code in all counties. For storm surge, the proportion of building losses saved due to the 4 ft. mitigation were calculated by individual county.

Figure 8-7 presents the cost-to-loss reduction ratios calculated by county for the mitigations of wind and water hazards of the Hurricane Camille Scenario assuming an interest rate of 6.1%. Note that the mitigation for wind design would yield higher savings than costs in all the counties from St. Tammany, La. To Pearl River, Ms. These are the counties the hardest hit by the scenario event, and therefore have the greatest loss reductions from the mitigation. In the case of the water hazard, only Harrison County, Ms. is close to being cost effective (costs equalling loss reductions).

Figure 8-8 provides the results for the application of the 2 UBC Zone 3 load specifications building code in all the counties affected by the San Francisco scenario earthquake assuming a 6.1% interest rate. Note that, in this case, only a few counties are in a position of having a cost-effective building code mitigation and, again, these are the counties the hardest hit by the scenario event.

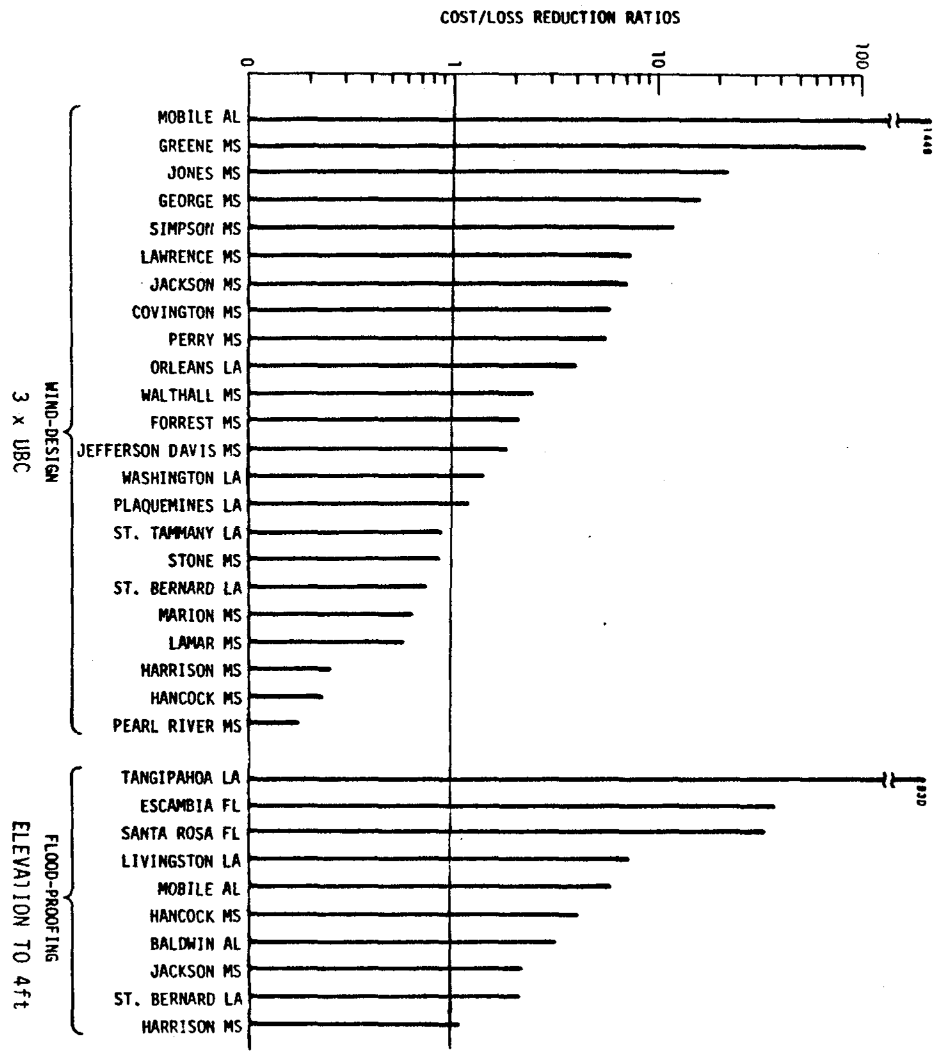

Figure 8-7. Cost/Loss Reduction Ratios for Mitigations in 2000

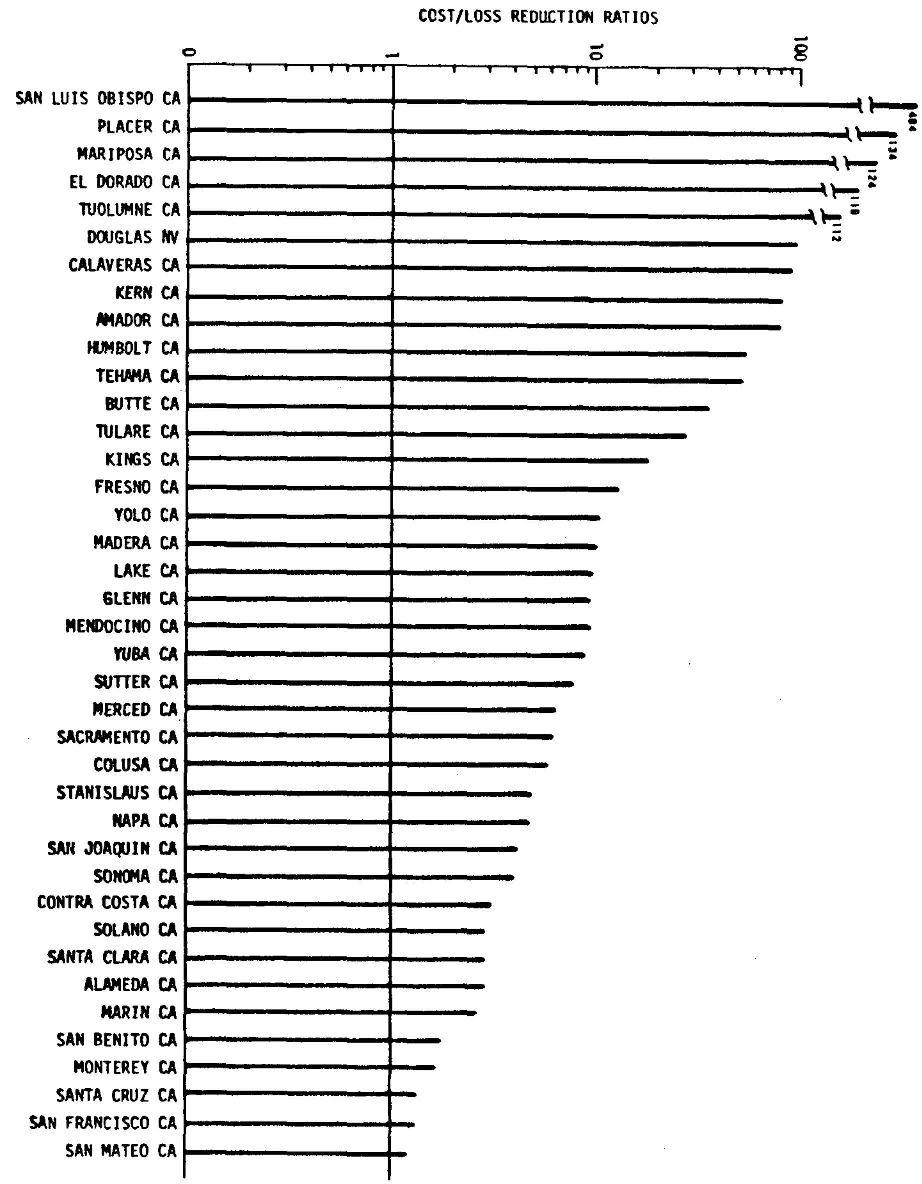

Figure 8-8. Cost/Loss Reduction Ratios for San Francisco Earthquake Scenario, With Mitigation, in 2000

These results point out one of the faults of using the scenario type analysis: the myopia caused by the consideration of only one event and not the accumulated risk over all possible events. In the case of the San Francisco Earthquake scenario, some of the counties that have such high ratios of costs of mitigations to-benefits (Kern County, in particular) are likely sites to feel the effects of other major earthquakes. However, from the point of view of the San Francisco Earthquake, the savings do not warrant the costs of a stronger building code. These results may be reversed if the scenario methodology is replaced by the annual loss method.

Summary

This chapter has dealt with the scenario for hurricane and earthquake. The exposure data used in these scenarios is not the same in 2000 as that available for the annual loss models, but the damage calculations are made using the same techniques. The distribution of damages by income class was not done on the annual loss scale, because the income distributions by county were not available on the county level data base. However, this analysis may be used in the future on an annual basis. The cost-benefit section demonstrated a major shortcoming of the scenario technique where only one event is considered. Reference to Chapter Nine will show the annual loss alternative. However, the scenario technique does serve to dramatize the awesome potential for loss from a single event, and it does provide a basis for analysis for future policy decisions.

Chapter Nine

MITIGATIONS AND COST BENEFIT ANALYSIS

This chapter presents some applications of the model described in the previous chapters. Specifically, a number of mitigations to various natural hazards are evaluated. The first section considers a set of general mitigations from the perspective of the losses saved annually to the year 2000. The second section describes the use of benefit-cost analysis to the building code mitigations (especially for storm surge, earthquake, and the wind hazards). Because the implementation of a land use policy involves costs that cannot be generalized in a straightforward manner (requiring the evaluation of alternate land uses that varies by location) a cost analysis is performed only for the mitigations which take the form of building codes. Therefore, costs have been estimated solely on the basis of the construction procedures. Some results of these calculations are presented as examples. In the final section of this chapter, a general overview of the application of this model is provided. Because the expansive soil and landslide hazards do not lend themselves to the same type of mitigations, they are not referred to here. Also, due to the nature of the riverine flood model, these mitigations are not discussed either.

Evaluation of Potential Mitigations

Each of the hazards* modeled was provided with a series of potential mitigations to loss that fell into two categories: land use or building code. The land use mitigations are avoidance measures in which the hazardous areas, when they can be delineated, are avoided by limiting future levels of property and lives present. The building code mitigations are those actions which result in lower vulnerability in a composite manner in which the total sum of strengthening measures are identified with a specific building code such as the Uniform Building Code. The methods used for modeling each mitigation will be detailed in this section.

*Riverine flooding mitigations are not discussed here but reference should be made to (Lee, et al., 1976) for details of these mitigations. Landslide and expansive soil are not provided with mitigations in this report either though the Wiggins, et al., (1976) report does include some forms of mitigation.

In the case of tsunami, two mitigations of the avoidance (land use) type were simulated. As in the case of other mitigations discussed below, these mitigations are put into effect in 1980. These mitigations are basically limits to the population and property allowed to grow in areas at-risk to tsunami. Such areas were defined according to the 50-year flood plain and the 100-year flood plain. These areas were defined by the exposure data that provided populations and property at-risk by flood plain. The projected growth in these areas was restricted to a zero growth rate, thus no new construction occurred within these limits after 1980. The annual value of building losses reduced (savings) for 2000 and the aggregated building value savings in 2000 over the period from 1980 are given in Table G-1 in Appendix G. The aggregations of the annual savings were discounted at a variety of discount rates. Figures D-1 and D-2 in Appendix D give a perspective on the shape of the various cumulative savings and losses resulting from consideration of alternative discount rates. When aggregation of a stream of savings (benefits) is done over time, an appropriate discount rate is required to allow disparate streams to be compared at a particular point in time. In this case, and the subsequent discussion of other hazard mitigation, 1970 is the point chosen for perspective. Thus, the percentage savings compared in Table G-1 will vary with the discount rate due to the relative points in time the losses saved occur versus the time frame of the non-mitigated losses. Appendix H also provides the annual savings by state and other risks.

Storm surge mitigations were simulated in a similar manner to those for tsunami, however, a building code mitigation was also examined. In the case of storm surge, the land use mitigation was given by the definition of the 50-year flood plain and, as in the tsunami model, this was simulated by a growth restriction after 1980 in the areas so designated. Also included in the mitigation to storm surge was the use of a flood proofing building code in which all buildings in the 100-year flood plain were protected against losses up to 4 ft.* This mitigation (as we will note in the next section) could be the result of two alternative building practices: either elevation of the structure or flood-proof construction.

*In the subsequent section we also deal with a 2 ft. flood-proofing mitigation that is given in a benefit cost context.

Again Appendix G and D provide the summary results of the building savings in the same manner as described for the tsunami results. Table G-2, and Figures D-3, and D-4 provide these results. Also, Appendix H gives the savings resulting from these mitigations distributed by state and defines savings for other units in addition to buildings.

Severe wind, tornado, and hurricane all share the identical mitigations in the form of building codes put into force in 1980 for all new construction. These codes are defined in terms of the wind specifications in the Uniform Building Code. The Uniform Building Code specifies strength factors to be applied in structure design. To simulate alternate codes, these factors were modified by scaling them by 1.5 or by 3.0 and the resulting alternative codes are used in this analysis.*

The implications of the disproportionate regional allocation of savings from these mitigations are discussed in the following section. As with tsunami and storm surge, results for the wind mitigations are given in Appendix D, G, and H.

The alternative mitigations for earthquake (as for wind) are also given in terms of the Uniform Building Code, but these building codes are defined in terms of earthquake zones delineated in the code. Three zones are specified in the U.S. and the <u>de facto</u> strength assumed for all structures, except in California, in UBC Zone 2. In California, a strength of Zone 3 is assumed. Thus, the mitigation is the application of Zone 3 design specifications in the rest of the U.S., regardless of zone delineated in the code.

As in the above-mentioned hazards, the results of this alternative are also given in Appendices D, G, and H. Thus, the savings in California are given as zero for this mitigation due to the assumption that the building code in California is already at UBC Zone 3. This is the only case, however, where specific existing building codes are used in the determination of structure vulnerability.

A Cost-Benefit Analysis of Alternative Building Codes

To evaluate building codes as potential mitigations to natural hazards requires

*For more detail in these definitions see [Hart, 1976].

consideration of the cost of their use in comparison with their effectiveness in the reduction of future losses. This comparison employs the basic framework of cost-benefit analysis. With the assumption that the additional cost of building a structure to a stronger code be compensated by the savings in potential losses over the building's life, a critical value for the annual rate of damage can be established. For example, if the chance of having an earthquake in Alabama is low, then the potential savings in earthquake losses for a building built to the specifications of a strong earthquake code will not equal the additional costs of building to this code. However, in California where the annual rate of expected losses is higher, the costs of the same code are equal to, or less than, the savings due to the higher level of anticipated savings accruing to enforcement of the stronger code. Due to the relationship between the potential losses and the cost-benefit ratio, an observation of the damage rate alone can provide an indication of the relationship between the costs and benefits of alternative mitigations in different locations. A means to do this involves the definition of a "break-even point" where the damage rate insures that the savings will equal the costs of the mitigation. Because only storm surge, earthquake, and the wind hazards have applicable building code mitigations they are the only hazards referred to in this section.

Determination of the value of the breakeven point requires two quantities. First, the increase in cost dictated by the building code, and second, the total estimated savings over the life of the building that is attributable to the building code. The costs of the building codes have been estimated by a number of authors. [SEAOC, 1970; S.K. Leslie and J.M. Briggs, 1972; W.D. Carson, F.I.A., 1976]. Appendix J contains a summary and analysis of various estimates of the incremental increase in construction cost due to building code provisions.

In order to assign a value to the benefits of a building code mitigation, the annual savings projected for the structure is calculated through the determination of four parameters. The first of these is the annual amount of damage predicted to occur due to the existence of a risk to buildings from a specific natural hazard. The second factor is the proportion of the damage saved due to the mitigation. This proportion is based on the definition of the mitigation. For instance, in the case of the wind hazards, expert opinion was used to specify the proportion of losses which could be saved from a specific mitigation. For earthquake, the savings were estimated through simulation of implementation of the mitigation. The third parameter required is the time over which the savings accrue. In this case, it will represent the life of a building constructed to code. The fourth parameter is an interest rate at which future money compared to value in the present. This rate provides an equivalent "present value" of an income stream over time. The remainder of this section defines the breakeven point in rigorous terms, and presents an example for wind hazard building code mitigation.

The breakeven point for the relationship between total costs versus savings of mitigation is found from the estimation of the present value of the damage rate at which the present value of the total savings over the building life equal the mitigation cost. This calculation occurs at the point of the mitigation investment.

The mitigation cost is defined as:

$$MC_k = C_k \cdot V \tag{9-1}$$

where;

MC_k = the mitigation costs for building type k

C_k = the proportional increase in construction costs due to the mitigation of building type k

V = the value of the building before mitigation

Thus the mitigation cost is assumed to be a lump sum added to the initial cost of construction, and no increases in maintenance cost are considered because maintenance would probably not be affected by a change in building design. However, a constant factor for maintenance that could be considered as a lump sum addition to the construction costs of the mitigation would change nothing that follows.

The discounted total savings from the mitigation over the life of the building is a function of the annual loss rate, the life of the building, the annual savings (either regional or national), the building value, the discount rate of the future earnings to present value, and ratio of total economic losses to building losses by hazard nationally.

Therefore,

$$TS_{hkr} = S_h \cdot DR_{hrkl} \cdot V\ (1 + C_k) \cdot \left[\frac{1-e^{-iL_k}}{i}\right] \cdot MS_h \tag{9-2}$$

TS_{hkr} = the discounted total savings from the mitigation to structure type k in region r, from hazard h

S_h = the portion of the annual structure losses saved due to the mitigation to hazard h

DR_{hrkl} = the annual proportion of value lost due to the hazard, h, in the region r, to structure type k, to wealth type 1 (building wealth)

V = the value of the structure before mitigation

$(1+C_k)$ = the multiplier to determine new value of the building type k after mitigation

$\frac{1-e^{-iL_k}}{i}$ = the discounted life of the building

i = discount rate

L_k = life of building type k

MS_h = the ratio of total economic losses to building losses for hazard h, nationally*

By looking at this equation in parts, it can be seen that it merely estimates the annual savings and discounts these savings over time. The first four terms provide the non-discounted annual building values saved. The fifth term aggregates and discounts these savings for the building's life, and the sixth term multiplies these savings to account for the other risks that are also saved in addition to building losses alone. This equation along with the equation for the costs can be equated to find the value of DR that yields the point when costs equal benefits, or where:

$$MC_k = TS_{hkr} \qquad (9\text{-}3)$$

*The value for MS could be regionalized, however, only to the state level since only state input-output data is used.

Thus,

$$C_k \cdot V = S_h \cdot \overline{DR}_{hrkl} \cdot V \cdot (1+C_k) \cdot \left[\frac{1-e^{-iL_k}}{i}\right] \cdot MS_h \quad (9\text{-}4)$$

simplifying and solving for $\overline{DR}_{hrkl}$

$$\overline{DR}_{hrkl} = \left[\frac{C_k}{(1+C_k)}\right] \cdot \left[\frac{1}{S_h \cdot MS_h}\right] \cdot \left[\frac{i}{1-e^{-iL_k}}\right] \quad (9\text{-}5)$$

Let:

$$\hat{C}_k = \frac{C_k}{(1+C_k)} \quad (9\text{-}6)$$

$$\alpha_{ik} = \frac{i}{1-e^{-iL_k}} \quad (9\text{-}7)$$

$$\hat{S}_h = S_h \cdot MS_h \quad (9\text{-}8)$$

Substituting (9-6), (9-7) and (9-8) into (9-5) we derive

$$\overline{DR}_{hik} = \frac{\hat{C}_k}{\hat{S}_h} \cdot \alpha_{iL_k} \quad (9\text{-}9)$$

Note that the breakeven damage state is not a function of region or the value of the building but of hazard, structure type, life of the structure, and the discount rate. The value of the buildings does not enter this evaluation because the assumption is that these mitigations are continuous, and therefore could be applied in any amount. Note also that the damage rate is a parameter defined by geographic location. Thus, the breakeven point can be used to identify those areas where the use of the mitigation is warranted. Appendix H provides appropriate building damage rates by state. Note that these aggregates over the entire state may be misleading for local scale hazards such as storm surge, because the entire county is included in the calculation of the damage rate instead of just that part of the county at-risk to coastal flooding. To compute the breakeven damage rate $\overline{DR}_{hrkl}$ values for $\hat{C}_k$, S_{kh}, and α_{iL} are needed. The sources for these terms are given below.

Table 9-1 defines different types of construction in terms of the de facto strength of the Uniform Building Code assumed without provisions for wind hazard. The values of c and $\hat{c}$ provide the cost increments for the increased strength costs of the stronger building codes. In the case of earthquake, the de facto UBC zone assumed is Zone 2 and the costs are the needed increments to bring these up to the mitigation strength. The mitigation given as 2 x UBC Zone 3 refers to a "super" earthquake code in which the lateral strength factors established for Zone 3 are doubled. Results for this mitigation are given only in this section. For storm surge, the two possible methods of providing no losses up to a certain height are flood proofing, a type of construction where no damage occurs to the structure, and elevation of the structure. Note that a 2 ft. flood protection measure is also computed for comparative purposes. Results for this mitigation also appear in this section.

Table 9-2 lists the values for the proportion of building losses saved (S_{kL}). The mitigation savings to wind hazards were derived by survey of nine experts (see Hart, 1976 for details). The savings for earthquake were computed for each state by simulating the performance of stronger building code for all structures. A similar procedure was followed for storm surge, where damages were recalculated based on the assumption that all structures were raised 4 ft. The reduction in losses associated with this mitigation were calculated for each state. For both Storm Surge and Earthquake, the average savings S_{kh} by mitigation are given in Table 9-2. The standard deviation of the value is also given. Appendix J provides the individual state value of the savings to storm surge and earthquake. Table 9-3 presents the ratios of total economic losses to building losses by hazard and year (MS_h). The average value for 1970 and 2000 was used. For wind hazards, the total for hurricane, tornado, and severe wind was used. To arrive at a value for $\hat{S}_h$ the product of MS_h and S_{kh} is used (equation 9-8).

Table 9-4 provides the values of α which are given as a function of both a discount rate (i) and a structure life (L). These values are computed from the expression given in Equation (9-7).

For example, the breakeven damage rate for a wood frame structure of less than three stories which was mitigated to wind load 1.5 UBC would have the following values of S, MS, and $\hat{c}$. The value for α would be dependent on the assumptions made for the expected life of the structure and the discount rate. We let

WIND COST	UBC WIND LOADS			
	1.5		3.0	
	c	$\hat{c}$	c	$\hat{c}$
Concrete +3 stories (frame and non-structural modifications defacto .75 UBC)	.031	.030	.060	.057
Steel +3 stories (frame and non-structural modifications defacto .75 UBC)	.025	.024	.062	.058
Brick 1-3 stories Concrete block (frame and non-structural modifications defacto .75 UBC)	.033	.032	.095	.087
Wood Frame 1-2 stories (defacto .75 UBC)	.010	.010	.030	.029

EARTHQUAKE	UBC ZONE 3	
	c	$\hat{c}$
Concrete +3 stories (frame and non-structural modifications defacto UBC Zone 2)	.038	.037
Steel +3 stories (frame and non-structural modifications defacto UBC Zone 2)	.027	.026
Brick or Concrete Block 1-3 story (non structural modification defacto UBC Zone 2)	.065	.061
Wood Frame, 1-2 story (frame and non-structural modification defacto UBC Zone 2)	.020	.020

FLOODPROOFING MITIGATION				
	4 FT PROTECTION		2 FT PROTECTION	
	c	$\hat{c}$	c	$\hat{c}$
Residential with Basement	.376	.273	.333	.250
Residential w/o Basement	.093	.085	.053	.050
Commercial with Basement	.103	..093	.074	.069
Commercial w/o Basement	.066	.062	.038	.037

ELEVATION OF BUILDING				
	4 FT PROTECTION		2 FT PROTECTION	
	c	$\hat{c}$	c	$\hat{c}$
Masonry Building (Other than fill foundation)	.272	.214	.227	.185
Wood Frame Building (Other than fill foundation)	.176	.150	.139	.122
Wood Frame on Slab	.139	.122	.083	.077

Table 9-1. Mitigation Cost Factors by Structure Type (See Appendix J for the data used to construct this table).

WIND HAZARDS				(VARIATION BY EXPERT)
1.5 UBC WIND LOAD	AVERAGE S_h SD	.37 (.29)	N = 9	
3.0 UBC WIND LOAD	AVERAGE S_h SD	.59 (.35)	N = 9	
STORM SURGE (VARIATION BY STATE)				
4 FT FLOOD PROOFING OR ELEVATION	AVERAGE S_h SD	.976 (.031)	N = 18	
2 FT FLOOD PROOFING OR ELEVATION	AVERAGE S_h SD	.902 (.056)	N = 18	
EARTHQUAKE (VARIATION BY STATE)				
ZONE 3 UBC	AVERAGE S_h SD	.217 (.085)	N = 50	
2X ZONE 3 UBC or ZONE S	AVERAGE S_h SD	.684 (.042)	N = 51	

Table 9-2. Proportion of Losses Saved Due to Mitigation, S_h

		1970$ 10^6	RATIO MS_{1970}	2000$ 10^6	RATIO MS_{2000}	MS AVERAGE
EARTHQUAKE	TOTAL	778.7	1.192	1552.0	1.321	1.256
	BUILDINGS	653.0		1175.0		
TORNADO	TOTAL	1651.5	1.887	5219.0	2.536	2.212
	BUILDING	875.0		2058.0		
HURRICANE	TOTAL	1057.1	1.541	3526.1	2.024	1.783
	BUILDINGS	686.0		1742.0		
SEVERE WIND	TOTAL	18.0	1.622	53.1	2.141	1.882
	BUILDINGS	11.1		24.8		
STORM SURGE	TOTAL	641.4	1.451	2342.5	1.992	1.722
	BUILDINGS	442.0		1176.0		
TSUNAMI	TOTAL	14.9	1.713	40.4	2.040	1.877
	BUILDINGS	8.7		19.8		
WIND AVERAGE	TOTAL	2726.6	1.734	8798.2	2.300	2.017
	BUILDINGS	1572.1		3624.8		

Table 9-3. The Ratios of Total Economic Loss To Building Loss, MS_h (See Appendix L for the details of this analysis).

Discount Rates (i)						Building Lives (L)
0.0	2.9	6.1	10.0	15.0	20.0	
0.050	0.066	0.086	0.116	0.159	0.204	20.0
0.040	0.056	0.078	0.109	0.154	0.200	25.0
0.033	0.050	0.072	0.105	0.152	0.200	30.0
0.025	0.042	0.067	0.102	0.149	0.200	40.0
0.020	0.037	0.064	0.101	0.149	0.200	50.0
0.017	0.035	0.063	0.100	0.149	0.200	60.0
0.013	0.033	0.062	0.100	0.149	0.200	75.0
0.010	0.031	0.061	0.100	0.149	0.200	100.0

Table 9-4. Values of α Based on Different Discount Rates, and Building Lives

$\hat{C} = .010$

$S = .370$

$MS = 2.017$

$\hat{S} = .746$

$$\overline{DR} = \frac{\hat{C}}{\hat{S}} \alpha = .0134 \alpha \qquad (9\text{-}10)$$

If a life of 100 years and a discount rate of 0.0 is assumed, then $\alpha = .010$ and

$$\overline{DR} = .000134 \qquad (9\text{-}11)$$

However, if the life of the building is 20 years and the discount rate is assumed to be 20%, then $\alpha = .204$ and

$$\overline{DR} = .00273 \qquad (9\text{-}12)$$

To compute the average breakeven or cost feasible damage rate for different building codes requires an examination of a mix of structure types to calculate the average cost of implementation. The mix of structure types is estimated from national averages for these factors. Table 9-5 provides the proportions used

EARTHQUAKE	PROPORTION	ZONE 3	2X ZONE 3
CONCRETE +3 STORIES	25.42%	.038	.130
STEEL +3 STORIES	25.42%	.027	.088
BRICK RESIDENTIAL 1-3 STORIES	8.05%	.065	.180
WOOD FRAME RESIDENTIAL 1-3 STORIES	41. 05%	.020	.060
AVERAGE COST FACTOR		.030	.095

WIND	PROPORTION	1.5 UBC	3.0 UBC
CONCRETE +3 STORIES	25.42%	.031	.060
STEEL +3 STORIES	25.42%	.025	.062
BRICK RESIDENTIAL 1-3 STORIES	8.05%	.033	.095
WOOD FRAME RESIDENTIAL 1-3 STORIES	41.05%	.010	.030
AVERAGE COST FACTOR		.021	.051

FLOOD PROOFING	PROPORTION	2 FT. PROTECTION	4 FT. PROTECTION
RESIDENTIAL WITH BASEMENT	27.52%	.333	.373
RESIDENTIAL WITHOUT BASEMENT	27.08%	.053	.093
COMM. & IND. WITH BASEMENT	25.82%	.074	.103
COMM. & IND. WITHOUT BASEMENT	22.58%	.038	.066
AVERAGE COST FACTOR		.132	.166
ELEVATION	PROPORTION	2 FT PROTECTION	4 FT PROTECTION
MASONRY	16.40%	.227	.272
WOOD FRAME	17.73%	.139	.176
WOOD FRAME OR SLAB	65.87%	.083	.136
AVERAGE COST FACTOR		.117	.165

Table 9-5. National Average Building Code Cost Factors

to establish the average cost factors for the building code mitigations for storm surge, earthquake, and wind. Using the average cost factor derived in this manner, a set of breakeven damage rates was calculated for each mitigation. This set of damage rates corresponds to an assumed average building life of 50 years and a discount rate of 6.1% which together yield a value for α of .064. The set of average breakeven damage rates is given in Table 9-6 for cost-saving relationships of 1.-to-.75, 1.-to-1., 1.-to-1.25, 1.-to-1.50, 1.-to-1.75 and 1.-to-2.0. Thus, if the cost savings relationship is 1.-to-1.50 there are 1-1/2 times as much savings as cost.

Through the use of the average mix of structure types, an average breakeven point for all regions and average set of building types can be computed and applied by county, based on county damage rates. Also, once a particular county is found to be above the breakeven point (e.g. a 1.-to-1. cost savings relationship) the savings net of the additional construction costs can be calculated. In addition, a return rate of savings over the cost can also be determined by county. Hence, a county's investment in a building code mitigation can be seen as resulting in a direct payoff in savings of losses over the life of the stronger buildings.

The net savings for those counties which meet the above criteria is computed from the difference between total savings and total cost.

$$NS = TS_{hkr} - MC_k \qquad (9\text{-}13)$$

where NS = net savings, or from (9-1) and (9-2)

$$NS = \left\{ S_h \cdot DR_{hr} \cdot V \cdot (1 + D_k) \cdot \left[\frac{1 - e^{-iL_k}}{i}\right] \cdot MS_h \right\} (-C_k \cdot V) \qquad (9\text{-}14)$$

by substitution we get the form:

$$NS = V \cdot C_k \cdot \left[\frac{DR_{hr}}{\overline{DR}_{hrkl}}\right] - 1 \qquad (9\text{-}15)$$

Thus, for any county with a damage rate above the breakeven damage rate:

$DR_h/\overline{DR}_{hrkl} > 1$, $NS > 0$ and net savings will be positive.

Therefore, in order to calculate the net savings on buildings constructed between

WIND HAZARDS COST-SAVINGS RELATIONSHIPS	1.5 UBC COST FACTOR = .021	3.0 UBC COST FACTOR = .051
1. to .75	1.35 E-3	2.18 E-3
1. to 1.00	1.80 E-3	2.90 E-3
1. to 1.25	2.25 E-3	3.62 E-3
1. to 1.50	2.70 E-3	4.34 E-3
1. to 1.75	3.15 E-3	5.06 E-3
1. to 2.00	3.60 E-3	5.80 E-3

EARTHQUAKE COST-SAVINGS RELATIONSHIPS	ZONE 3 UBC COST FACTOR = .030	2X2 ZONE 3 UBC COST FACTOR = .095
1. to .75	6.62 E-3	5.87 E-3
1. to 1.00	8.82 E-3	7.82 E-3
1. to 1.25	1.10 E-2	9.78 E-3
1. to 1.50	1.32 E-2	1.17 E-2
1. to 1.75	1.54 E-2	1.37 E-2
1. to 2.00	1.76 E-2	1.56 E-2

STORM SURGE COST-SAVINGS RELATIONSHIPS	4 FT. ELEVATION + FLOOD PROOFING COST FACTOR = .166	2 FT. ELEVATION COST FACTOR = .117	2 FT. FLOOD PROOFING COST FACTOR = .132
1. to .75	5.68 E-3	3.92 E-3	4.70 E-3
1. to 1.00	7.57 E-3	5.49 E-3	6.27 E-3
1. to 1.25	9.46 E-3	7.06 E-3	7.84 E-3
1. to 1.50	1.14 E-2	8.63 E-3	9.41 E-3
1. to 1.75	1.32 E-2	1.02 E-2	1.10 E-2
1. to 2.00	1.52 E-2	1.18 E-2	1.26 E-2

Table 9-6. Breakeven Damage Rates for National Average Building Type Mix Assuming a Building Life of 50 Years, and a Discount Rate of 6.1% (α = .064)

1980 - 2000 requires both the value of new building between 1980 - 2000, which provides a value of (V) for each county and the "investment" spent for stronger structures as the proportion of the value of structure built. The net rate of return, or percent savings, is then defined as the ratio of the total net savings to the total cost of implementation.

$$PS = \frac{NS}{MC_k} \cdot 100 \qquad (9\text{-}16)$$

where;

PS = percent saved

which reduces to;

$$PS = \left[\frac{DR_{hr}}{DR_{hrkl}} - 1\right] \cdot 100 \qquad (9\text{-}17)$$

Thus the ratio of the county damage rate due to a specific hazard to the national average breakeven rate for a particular building code mitigation are all that are needed to compute the percentage return on the investment in building codes. By summing the net savings in all the counties that satisfy this criteria, we can compute the total net savings from buildings constructed stronger between 1980 - 2000.

Note that net savings consist of the present value of a flow of annual net savings from the date of construction (1980 - 2000) for the life of the building (under the assumption of a 50 year life from 2030 - 2050). Figure 9-1 below gives a three dimensional view of the net savings from a time perspective. The sloping return after the structure life is due to the assumption of a non zero discount rate.

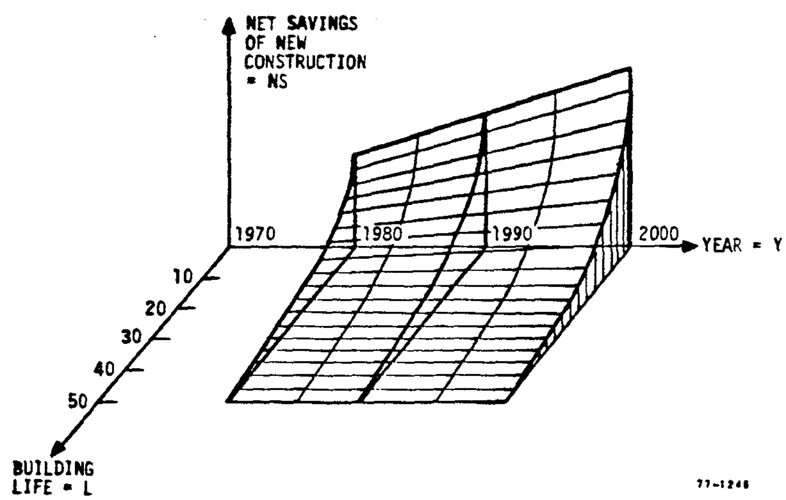

Figure 9-1. A Time Perspective of Aggregate Net Savings

Table 9-7 provides a summary of the results of the net savings and rates of return for the sample of building code mitigations considered. Note that the 4 ft. elevation and flood proofing have almost the same aggregate costs from Table 9-5 (.166 compared to .165). Thus, they are treated as the same mitigation in an aggregate analysis due to the national structure-type distribution. However, for a local analysis with a different structure distribution, this may not hold. Table 9-7 only presents the results from the assumption of a 1-to-1 cost savings ratio, though the results for the alternate ratios can also be computed. Again, it should be emphasized that the savings presented represents a case where the 2000 mitigation is only put in effect for those new structures built from 1980 - 2000, and the savings are then calculated over the life of these buildings which extends past 2000. A detailed discussion of these results is available in the summary document for this study. However, it may be noted that few counties have a damage rate significant enough to warrant the use of the earthquake mitigations. (with a 1.-to-.75 cost saving return, five additional non-California counties would also be included). The total wind hazards provides a summary for tornado, hurricane, and severe wind where the regional aspects are not as dominant as in the storm surge and earthquake results.

Summary

This chapter defined the mitigations used in this report in terms of their impact on the loss calculations. In the cost-benefit analysis, the building code mitigations were only applied in the areas where they have been shown to result in a positive return. Thus, the counties identified as likely candidates for implementation could be used to delineate building code zones much like those already used in the Uniform Building Code specifications for earthquake. The breakeven points for each building code could also be specified by structure type, hence some counties may be designated to require codes only for certain structures.

Basic problems with this cost-benefit analysis relate to the potential errors in the estimation of the costs and savings and the use of solely-economic criteria for a decision that has many social consequences. Ideally the cost-benefit analysis would provide the distribution of the costs and benefits by classes of people who are impacted the most severely, such as the elderly who often have a large proportion of their wealth in the form of older real property. In summary, the use of cost benefit analysis requires a thorough appreciation of the assumptions employed in its calculation.

	NO. OF COUNTIES WHERE IN EFFECT	NET SAVING 10^6 1970$	TOTAL COST OF MITIGATION 10^6 1970$	NET RATE OF RETURN
EARTHQUAKE UBC ZONE 3*	2	62.7	22.5	279.1 %
2 x UBC ZONE 3	3	496.1	719.6	68.9 %
STORM SURGE 4 ft Elevation 4 ft Flood-proofing	17	996.7	2,173.0	45.9 %
2 ft Flood-proofing	18	1,347.0	1,939.0	69.5 %
2 ft Elevation	25	2,170.0	8,173.0	26.5 %
TOTAL WIND HAZARDS				
1.5 x UBC	229	6,729.0	9,984.0	67.4 %
3.0 x UBC	72	5,598.0	7,984.0	70.1 %

Table 9-7. Total Cost, Net Savings and Net Rate of Return for Selected Hazard Mitigations Applied in Counties with a Cost-Saving Relationship of 1-to-1 or Better

*Not applied in California

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Appendix A

SUMMARY OF TERMS USED IN TEXT

This appendix provides a list of terms used in this report. Most of these expressions appear in the the theoretical treatment of Chapter One and Chapter Nine. Also included in this appendix are the structure types used to define the vulnerability of structures by hazard type. This appendix has been provided to furnish an overall view of the general model.

Major Terms Used

AU_{hr} = Number of persons unemployed annually due to hazard h in region r.

c_k = The proportional increase in construction cost due to the mitigation on building type k.

$\hat{c}_k$ = The effective cost factor on building type k.

D_{hk} = Damage probability matrix for hazard h and structure type k. (δ_{aj})*

ΔE_r = Vector of autonomous changes in expenditures in region r. $(\Delta\varepsilon_e)$*

DR_{hrkf} = Wealth damage ratio due to hazard h in region r in structure type k to wealth type f.

$\overline{DR}_{hk1}$ = The breakeven damage rate for a mitigation to structure type k, for hazard h of building wealth. (wealth type 1)

ΔY_{hr} = Vector of income changes in region r due to hazard h. $(\Delta\psi_e)$*

HL_{hrk} = Homelessness vector per damage state for hazard h, region r, structure type k. (Ω_a)*

I_{hr} = Intensity probability vector for hazard h, region r. (ι_j)*

i = Discount rate applied to future losses and savings.

*Elements of matrix or vector

L_k = The life of a potential structure type k.

LL_h = Mortality rate vector per damage state for hazard h. (λ_a)*

LW_{href} = Annual loss in wealth due to hazard h, region r, economic sector e, and wealth type f.

M_r = Matrix of marginal propensities to consume for region r. (ε_e')*

MC_k = The mitigation cost to structure type k.

MS_h = The ratio of total economic losses to building losses for hazard h nationally.

NTL_{hrk} = Number of dwellings of structure type k in region r lost due to hazard h.

NUM_{rh} = Number of dwellings of structure type k in region r.

P_{rc} = Annual product of sector e in region r.

PL_{hre} = Proportion of sector e in region r housed in structure type k.

S_{hrk} = Damage state vector for hazard h, region r, and structure type k. (δ_a)*

SV_{kh} = The proportion of annual structure losses due to hazard type h saved due to mitigation applied to structure type k.

TL_{hrk} = Total time lost due to hazard h in region r to producers housed in structure type k.

TW_{hr} = Total wealth lost vector for damage state for hazard h in region r. (θ_a)*

V_{refky} = Value of wealth in region r for economic sector e in structure type k of wealth type f in year y.

*Elements of matrix or vector

$TV_{re_{fy}}$ = Value of wealth in region r, for economic sector e, in structure type k, of wealth type f, in year y.

W_f = Wealth effect vector for wealth type f. (ω_a)*

$(W/P)_y$ = Wealth per capita in year y.

Wn_{yh} = Existence of warning system for hazard h in year y.

TLF_r = Total labor force in region r.

E/P_{er} = Ratio of employees per product produced for sector e in region r.

Subscripts

	Range		Range
h = Hazard	1→H	e = Economic sector	1→E
r = Regions	1→R	a = Damage sector	1→A**
j = Intensity	1→J**	f = Wealth type	1→F
k = Structure type	1→K**	p = Wealth/capita	1→P
		y = Year	1970-2000

Number of elements of each subscript

H = 8 hazards

1. Hurricane
2. Severe Wind
3. Tornado
4. Storm Surge
5. Tsunami
6. Earthquake
7. Landslide
8. Expansive Soil

R = 3132 (counties and county equivalents in the U.S.)

J = Number of Intensity classes by hazard type, (see descriptions of hazard models)

k = 10 building types for Hurricane, Severe Wind, and Tornado:

*Elements of matrix or vector

**Dependent on Hazard model

1. 1-3 story wood frame residential
2. 1-3 story wood frame commercial, financial, and service
3. 1-3 story concrete and masonry wall residential
4. 1-3 story metal commercial, financial, and service
5. 1-3 story concrete and metal commercial and industrial
6. 4 or more story steel ductile frame
7. Mobile home with engineered tie downs
8. Mobile homes without tie downs
9. Windows in structures less than 4 stories
10. Window damage for 4 or more story structures

k = 11 Building Types for Storm Surge and Tsunami

Building Categories

1. 1 story residential with basement
2. 1 story residential without basement
3. 2 or more story residential with basement
4. 2 or more story residential without basement
5. Commercial, financial, service structure with basement, 1-2 story
6. Commercial, financial, service structure with basement, 1-2 story
7. Commercial, financial, service structure with basement, 2>story
8. Commercial, financial, service structure without basement, 2>story
9. Mobile homes
10. Value of all non-residential
11. Value of port facilities/sq. mile (tsunami only)

k = 4 Building Types for Earthquake

1. Pre 1933 in California, Pre 1940 in the rest of the U.S. Commercial and Industrial buildings
2. Post 1933 in California, Post 1940 in the rest of the U.S. Commercial and Industrial buildings
3. Pre 1933 in California, Pre 1940 in the rest of the U.S. Residential buildings
4. Post 1933 in California, Post 1940 in the rest of the U.S. Residential buildings

K = 1 Building Type for Landslide and Expansive Soil (only one category of buildings was modeled).

E = 11 economic sectors

	Sectors		SIC wde
1.	Agriculture	Combined in some analyses	1 - 9
2.	Mining		10 - 14
3.	Construction		15 - 17
4.	Manufacturing		19 - 39
5.	Transportation and Communications		40 - 49
6.	Wholesale and Retail Trade		50 - 59
7.	Finance, Insurance, and Real Estate		60 - 69
8.	Services		70 - 89
9.	Federal Government		91
10.	State and Local Government		93
11.	Households, Individuals		

A = 6 damage states for Hurricane, Severe Wind, Tornado, Storm Surge, and Tsunami

1. None
2. Light
3. Moderate
4. Heavy
5. Very Severe
6. Collapse

A = 1 damage state for Landslide and Expansive Soil

F = 2 wealth types

1. Building Value (replacement value)
2. Contents Value (inventory, capital equipment and consumer durables, replacement value)

Appendix B

SMSA AND NON-SMSA STATE HOUSING CHARACTERISTICS DATA

The data in these tables were used for estimation of the county structure types described in Chapter Two. These data are cross-section data of housing characteristics as they appear in the 1970 Census of Housing. The non-SMSA state statistics were calculated by subtracting the number of units in the SMSAs in each category from the state totals. When an SMSA was in more than one state and it could not be distinguished by state it was excluded. In California when all basements in SMSAs were subtracted from the state total a negative result was obtained so the state level proportions were reported for this item. The proportions listed are given below and the SMSA and state codes are given in the following pages.

Definition of Abreviations Used in the Following Tables

POP/RES	= Population per housing units *100
PC 5 - UNITS	= Percentage of housing units in structure 5 or more units
PC MOB HM	= Percentage of housing units in mobile homes
PC PRE 1939	= Percentage of housing units in structures built in 1939 or before
PC WT BSMT	= Percentage of housing units in structures with basements
PC WT CCSL	= Percentage of housing units in structures with concrete slab foundations
PC OTHER F	= Percentage of housing units in structures with other foundation types
PC POP OUT	= Percentage of SMSA population not in central city
PC CHNG 60	= Percentage change in population from 1960
PP DENSITY	= Population density in person per square mile
PC 4 FL +	= Percentage of housing units in structures of four floors or more

SMSA NUMBERS

1. New York, N.Y.
2. Los Angeles-Long Beach CA
3. Chicago, IL
4. Philadelphia, PA -NJ
5. Detroit, Mich.
6. San Francisco-Oakland CA
7. Washington D.C. -Md.-Va
8. Boston, Mass.
9. Pittsburgh, PA
10. St. Louis,Mo.-IL
11. Baltimore, Md.
12. Cleveland, Ohio
13. Houston, Tex.
14. Newark, NJ
15. Minneapolis-St.Paul Minn.
16. Dallas, Tex
17. Seattle-Everett, WA
18. Anaheim-Santa Ana-Garden Grove, CA
19. Milwaukee, WI
20. Atlanta, GA
21. Cincinnati,Ohio-Ky-Ind.
22. Paterson-Clifton-Passaic, NJ
23. San Diego, CA
24. Buffalo, NY
25. Miami,FL
26. Kansas City, KS
27. Denver, CO
28. San Bernardino-Riverside, CA
29. Indianapolis,IN
30. San Jose, CA
31. New Orleans, LA
32. Tampa-St. Petersburg,FA
33. Portland, Oreg-WA
34. Phoenix, AZ
35. Columbus, OH
36. Providence-Pawtucket-Warwick,RI-Mass.
37. Rochestor, NY
38. San Antonio, Tex.
39. Dayton, Ohio
40. Louisville, Ky-IN
41. Sacramento, CA
42. Memphis, Tenn.-AR
43. Fort Worth, Tex.
44. Birmingham, AL
45. Albany-Schenectady-Troy, NY
46. Toledo, OH,MI
47. Norfolk-Portsmouth,VA
48. Akron, OH
49. Hartford, CT
50. Oklahoma City, OK
51. Syracuse, NY
52. Gary-Hammond-E. Chicago, IN
53. Honolulu, Hawaii
54. Ft. Lauderdale-Hollywood,FL
55. Jersey City, NJ
56. Greensboro-Winston-Salem-High Point, NC
57. Salt Lake City,UT
59. Omaha, NE-IA
60. Nahville,Tenn.
61. Grand Rapids,MI
62. Youngstown-Warren,OH
63. Springfield-Chicopee Holyoke,MA
64. Jacksonville, FA
65. Wilmington,Del-NJ-Md.
66. Richmond,VA
67. Flint, Mich.
68. Tulsa, OK
69. Orlando, FA
70. Fresno, CA
71. Tacoma, WA
72. Harrisburg, PA
73. Charlotte, NC
74. Knoxville, Tenn.
75. Wichita, KS
76. Bridgeport, CT
77. Lansing, MI
78. Mobile, AL
79. Oxnard-Ventura,CA
80. Canton, OH
81. Davenport-Rock Is.-Moline,IA
82. El Paso, Tex.
83. New Haven, CT
84. Tucson AZ
85. W. Palm Beach, FA
86. Worcester, Mass
87. Wilkes-Barre-Hazleton, PA
88. Peoria, IL
89. Utica-Rome, NY
90. York, PA
91. Bakersfield, CA
92. Little Rock-N.Little Rock, AR
93. Columbia, SC
94. Lancaster, PA
95. Beaumont-Port Arthur Orange, TX
96. Albuquerque, NM
97. Chattanooga, TN-GA
98. Trenton, NJ
99. Charleston, SC
100. Binghamton, NY-PA
101. Greenville, SC
102. Reading, PA
103. Austin, TX
104. Shreveport,LA
105. Newport News-Hampton VA
106. Madison, WI
107. Stockton, CA
108. Spokane, WA
109. Des Moines, IA
110. Baton Rouge, LA
111. Corpus Christi, TX
112. Fort Wayne, IN
113. South Bend, IN
114. Appleton-Oshkosh, WI
115. Las Vegas, NV
116. Rockford, IL
117. Duluth-Superior, MN-WI
118. Santa Barbara, CA
119. Erie, PA
120. [illegible]
121. Jackson, MS
122. Lorain-Elyria, OH
123. Huntington-Ashland, W. Va.-KY-OH
124. Augusta, GA-SC
125. Salinas-Monterey, CA
126. Vallejo-Napa, CA
127. Pensacola, FL
128. Columbus,Ga-AL
129. Colorado Springs, CO
130. Scranton, PA
131. Ann Arbor, MI
132. Evansville, IN-KY
133. Lawrence-Haverhill, MA-NH
134. Charleston, W.VA
135. Raleigh, NC
136. Huntsville, AL
137. Hamilton-Middletown,OH
138. Saginaw, MI
139. Eugene,OR
140. Lowell, MA
141. Fayetteville, NC
142. Waterbury, CT
143. New London-Groton-Norwick, CT
144. Stamford,CT
145. Macon, GA
146. Santa Rosa, Ca.
147. Kalamazoo, MI
148. Montgomery, AL
149. Modesto, CA
150. Durham, NC
151. Brockton, MA
152. Savannah, GA
153. Salem, OR
154. Wheeling, W. VA-OH
155. McAllen-Pharr-Edinburg, TX
156. Roanoke, VA
157. Lubbock, TX
158. Terre Haute, IN
159. Atlantic City, NJ
160. Lexington, KY
161. Lima, OH
162. Racine, WI
163. Galveston-TXCity,TX
164. Lincoln, NE
165. Steubenville-Weirton, OH-W.VA
166. Champaign-Urbana, IL
167. Cedar Rapids, IA
168. Springfield, IL
169. Fort Smith, AR-OK
170. Muskegon-Muskegon Heights, MI
171. Green Bay, WI
172. Springfield, OH
173. Topeka, KS
174. Springfield, MO
175. New Bedford, MA
176. Fall River,MA-RI
177. Waco, TX
178. Lake Charles,LA
179. New Britain, CT
180. Asheville, NC
181. Amarillo, TX
182. Jackson, MI
183. Portland, ME
184. Brownsville-Harlingen San Benito, TX
185. Anderson, IN
186. Provo-Orem,UT
187. Altoona, PA
188. Biloxi-Gaulfport,MA
189. Waterloo, IA
190. Mansfield, OH
191. Muncie, IN
192. Petersburg-Colonial Heights, VA
193. Wichita Falls, TX
194. Ogden, UT
195. Decatur, IL
196. Lynchburg, VA
197. Vineland-Millville-Bridgeton, NJ
198. Reno, NV
199. Fargo-Moorhead, ND-MN
200. Norwalk, CT
201. Pueblo, CO
202. Kenosha, WI
203. Bay City, MI
204. Sioux City, IA
205. Tuscaloosa, AL
206. Monroe, LA
207. Abilene, TX
208. Boise City,ID
209. Lafayette, La.
210. Lafayette-W.Lafayette, IN
211. Manchester, NH
212. Lawton, OK
213. Wilmington, NC
214. Gainesville, FL
215. Bloomington-Normal,IL
216. Tallahassee, FL
217. Texarkana, TX-AR
218. Fitchburg-Leominster, MA
219. Tyler, TX
220. Sioux Falls, SD
221. Gadsden, AL
222. Odessa, TX
223. Dubuque, IA
224. Albany, GA
225. Billings,MT
226. St. Joseph, MO
227. Pine Bluff,AR
228. Rochester, MN
229. Sherman-Denison, TX
230. Great Falls, MT
231. Columbia, MO
232. La Crosse, WI
233. Pittsfield, MA
234. Owensburg, KY
235. Danbury, CT
236. Laredo, TX
237. Lewiston-Auburn, ME
238. San Angelo, TX
239. Nashua, NH
240. Bristol, CT
241. Midland, TX
242. Bryan-College Station TX
243. Meriden, CT.

STATE NUMBERS AND POSTAL ABBREVIATIONS

1. AL- Alabama
2. AZ- Arizona
3. AR- Arkansas
4. CA- California
5. CO- Colorado
6. CT- Connecticut
7. DE- Delaware
8. DC- District of Columbia
9. FL- Florida
10. GA- Georgia
11. ID- Idaho
12. IL- Illinois
13. IN- Indiana
14. IA- Iowa
15. KS- Kansas
16. KY- Kentucky
17. LA- Louisiana
18. ME- Maine
19. MD- Maryland
20. MA- Massachusetts
21. MI- Michigan
22. MN- Minnesota
23. MS- Mississippi
24. MO- Missouri
25. MT- Montana
26. NE- Nebraska
27. NV- Nevada
28. NH- New Hampshire
29. NJ- New Jersey
30. NM- New Mexico
31. NY- New York
32. NC- North Carolina
33. ND- North Dakota
34. OH- Ohio
35. OK- Oklahoma
36. OR- Oregon
37. PA- Pennsylvania
38. RI- Rhode Island
39. SC- South Carolina
40. SD- South Dakota
41. TN- Tennesse
42. TX- Texas
43. UT- Utah
44. VT- Vermont
45. VA- Virginia
46. WA- Washington
47. WV- West Virginia
48. WI- Wisconsin
49. WY- Wyoming
50. AK- Alaska
51. HI- Hawaii

SMSA NO.	POP/HESS	PCS-UNITS	PCMOBHM	PCPRE1930	PCWTHSMT	PCWTCCSL	PCOTHERF	PCPOPOUT	PCCHNG60	PPDENSITY	PC4FL+	POPULATION
1	298.85	51.54	.11	53.83	90.97	7.42	1.61	31.75	7.23	5397.3	44.55	11528649.
2	277.18	27.20	1.45	25.26	14.72	48.89	36.39	54.85	14.13	1728.2	2.34	7032075.
3	304.91	28.78	.68	48.38	83.18	10.15	6.66	51.74	10.86	1876.1	8.99	6978947.
4	313.92	14.16	.72	51.42	86.15	9.88	3.47	59.55	9.86	1356.0	4.57	4817914.
5	318.21	13.63	1.15	37.33	82.82	9.21	7.96	64.00	10.42	2151.6	3.33	4199931.
6	275.39	26.36	.81	36.79	42.34	32.28	25.36	65.35	14.82	1254.9	7.44	3109519.
7	305.18	39.05	.63	21.62	76.33	17.57	6.10	73.54	27.66	1216.5	17.64	2861123.
8	309.10	21.36	.20	63.83	93.77	4.69	1.34	23.28	6.10	2790.3	9.30	2754000.
9	304.49	11.10	1.33	54.41	92.14	4.37	3.49	78.33	-.17	787.6	3.17	2401245.
10	301.35	11.63	2.16	41.58	82.51	10.37	7.11	73.63	10.93	573.8	2.74	2363017.
11	317.26	14.87	1.20	39.55	81.71	11.97	6.32	56.21	12.89	916.6	3.25	2070670.
12	305.32	19.27	.82	45.94	83.55	12.42	4.02	63.61	7.49	1358.9	6.13	2064194.
13	297.36	17.23	2.22	15.26	2.08	65.21	32.71	37.88	28.55	315.8	.73	1985031.
14	309.98	25.55	.10	51.92	92.87	5.43	1.70	79.39	9.00	2646.4	10.78	1856556.
15	315.51	22.35	1.24	39.14	90.86	6.01	3.13	56.94	18.28	660.6	3.05	1813647.
16	294.04	19.42	1.79	17.71	2.81	52.29	44.91	45.70	26.66	340.9	.59	1555950.
17	278.12	20.86	2.55	30.04	52.99	22.03	24.98	58.87	22.13	336.2	5.90	1421869.
18	307.20	17.55	3.82	7.19	25.21	70.13	4.65	68.57	50.44	1816.4	.22	1420386.
19	314.36	14.83	.46	45.59	95.70	2.73	1.57	48.87	8.89	964.1	3.12	1403688.
20	308.75	22.85	1.75	18.06	44.92	28.15	26.93	64.24	26.83	805.0	1.72	1390164.
21	306.07	17.02	1.40	45.71	82.98	10.39	6.64	67.30	8.40	644.1	4.33	1384851.
22	312.61	16.49	.31	44.11	91.72	6.02	2.25	79.19	12.65	3182.2	5.23	1358794.
23	301.92	17.95	4.93	16.74	8.72	55.79	35.48	48.68	23.92	318.6	1.05	1357854.
24	311.26	8.40	.80	55.60	86.94	6.75	6.31	65.67	3.13	848.0	1.85	1349211.
25	291.66	31.76	2.19	14.54	5.94	77.42	16.64	73.51	26.25	620.9	7.58	1267792.
26	287.71	15.73	1.43	37.79	61.14	9.01	9.25	59.49	12.87	455.2	3.11	1253916.
27	300.39	20.58	2.39	26.29	66.79	17.42	15.79	56.00	24.29	335.4	4.90	1227529.
28	273.68	7.60	6.27	14.26	6.91	61.86	31.23	72.96	29.16	41.9	.03	1143146.
29	301.11	13.72	2.49	38.94	52.90	23.65	23.45	28.56	14.90	360.4	1.43	1109882.
30	316.70	18.21	2.92	12.08	12.45	42.13	45.41	58.04	39.67	819.0	.92	1064714.
31	303.31	13.44	1.42	34.20	4.75	53.07	42.18	43.22	13.26	529.5	1.36	1045809.
32	257.11	11.16	8.49	16.90	1.90	64.95	33.15	51.16	23.72	777.1	1.43	1012594.
33	282.39	16.04	3.04	37.04	53.91	20.38	25.70	62.03	16.55	276.5	3.49	1009129.
34	305.20	12.85	7.26	9.65	2.96	81.65	15.39	39.79	31.42	104.7	.70	967522.
35	309.31	15.24	1.90	34.22	76.89	16.07	7.04	41.04 (1)	17.01 (1)	613.3	1.08	916228.
36	305.73	11.73	.55	57.57	93.38	4.35	2.27	-0.00	-0.00	1341.7	1.77	911000.
37	314.45	12.63	2.00	53.69	91.08	4.93	3.98	66.39	17.00	301.1	1.59	882667.
38	331.51	11.26	2.18	24.06	3.23	54.04	42.73	24.19	17.11	440.8	.71	856014.
39	312.35	10.30	2.64	33.43	59.51	29.52	10.97	71.27	14.46	497.8	1.03	853286.
40	307.53	12.23	1.75	34.55	60.94	21.43	16.63	56.26	12.27	910.3	1.10	826553.
41	266.03	12.89	2.99	17.09	10.89	44.66	44.45	68.26	21.87	233.0	.34	800592.
42	325.15	15.15	1.27	22.34	11.05	54.59	34.36	16.96	12.41	565.0	1.44	770120.
43	295.47	11.96	2.46	19.14	2.65	56.28	41.08	48.29	24.76	474.2	.24	762048.
44	302.76	8.64	2.53	33.50	32.75	25.36	40.89	59.25	2.40	271.7	.92	739274.
45	298.71	10.36	2.74	50.62	88.90	5.35	5.75	64.51	9.06	325.3	2.32	727766.
46	313.87	8.95	2.73	49.88	66.45	13.36	20.19	48.47	8.94	455.6	1.01	692571.
47	338.97	14.12	1.89	22.90	9.09	42.78	47.23	38.35	15.00	1003.6	1.34	680600.
48	317.49	9.17	2.15	41.92	82.54	11.85	5.61	59.33 (1)	10.88 (1)	750.5	2.23	679239.
49	312.78	21.73	.44	39.59	94.42	3.93	1.65	-0.00	-0.00	985.1	3.87	664000.
50	262.46	11.05	3.89	24.09	10.25	51.34	38.41	42.75	20.14	299.1	.93	640859.

Table B-1a. SMSA Housing Characteristic Data

SMSA NO.	PCP/RESS	PC S-UNITS	PC MOBHM	PC PRF1930	PC WTBSMT	PC WTCCSL	PC OTHERF	PC POPOUT	PC CHNG60	PPDENSITY	PCAFL+	POPULATION
51	315.11	13.51	3.00	53.06	88.42	5.37	6.21	58.87	11.35	262.9	2.35	635946.
52	329.70	11.13	2.20	37.81	71.15	16.49	12.37	17.84	14.18	676.0	1.45	633367.
53	361.39	29.27	.05	16.02	13.01	55.89	31.15	18.32	20.47	1055.7	9.33	629176.
54	262.28	25.93	4.01	3.93	2.94	87.43	9.63	30.15	46.15	508.7	7.76	620100.
55	283.82	43.92	.15	77.23	93.83	4.83	1.33	57.12	-.24	12963.1	26.13	609266.
56	359.91	6.87	4.26	25.53	38.60	22.89	38.51	43.55	13.85	273.6	.50	603895.
57	341.89	12.13	1.83	29.60	71.99	15.42	12.56	68.32	19.70	525.6	2.56	557635.
58	350.73	8.88	2.04	56.49	89.76	5.91	4.32	30.90	9.45	500.5	1.25	543551.
59	302.71	13.10	2.43	25.26	37.43	27.59	34.98	35.55	15.23	331.6	1.71	540142.
60	310.31	17.32	1.60	42.93	86.84	8.02	5.14	17.19	14.32	352.1	2.37	541108.
61	321.51	5.44	2.51	44.79	88.72	5.67	5.59	53.24	14.34	379.7	.56	539225.
62	319.53	6.14	2.14	45.69	85.43	9.53	5.04	51.94 (1)	5.04 (1)	520.4	.90	536003.
63	309.03	19.43	.82	55.00	94.50	3.63	1.67	-0.00 (1)	-0.00 (1)	992.5	9.55	530000.
64	303.69	10.29	4.17	20.93	3.12	51.09	45.79	0.00	13.89	690.4	.79	526865.
65	304.89	14.05	1.59	29.54	29.78	34.42	35.80	51.71	15.87	433.4	1.34	518319.
66	322.00	11.85	2.74	33.55	73.94	15.22	10.84	33.89	17.06	428.7	1.65	499493.
67	330.45	5.98	3.48	35.89	77.72	8.78	13.49	51.01	16.19	382.0	.31	496658.
68	277.83	9.89	2.66	29.07	12.37	40.25	47.38	30.40	12.15	126.1	1.11	476945.
69	294.41	10.28	4.96	13.03	2.56	68.17	29.27	76.63	25.59	352.3	.93	425003.
70	307.91	8.57	2.06	26.08	13.46	40.40	46.14	59.80	11.42	69.2	.18	413953.
71	350.69	13.73	3.82	32.86	33.93	31.32	34.76	52.28	21.76	245.2	1.91	411027.
72	298.61	9.18	3.10	49.55	88.54	5.63	5.83	83.29	9.49	252.8	1.78	410626.
73	311.64	10.24	3.68	19.32	20.76	26.91	52.32	41.04	22.62	346.9	.79	409370.
74	290.44	10.80	3.61	29.17	48.12	16.54	35.34	56.20	8.06	282.3	1.97	400337.
75	289.77	7.45	3.75	29.77	48.19	21.63	30.18	28.77 (1)	1.98 (1)	159.0	.67	389352.
76	313.99	15.68	.50	43.63	90.71	5.63	3.66	-0.00 (1)	-0.00 (1)	2015.5	4.39	389000.
77	326.83	13.54	3.41	41.28	81.10	10.05	8.86	55.91	21.00	222.3	1.09	378423.
78	314.72	3.69	3.10	21.59	3.18	37.55	59.27	49.38	3.53	133.7	.10	376690.
79	335.17	9.45	4.25	12.81	3.96	68.19	27.86	56.15	47.10	202.1	.55	376430.
80	313.31	6.07	1.92	46.97	91.03	5.05	3.88	70.39	8.56	646.2	.63	372210.
81	209.91	9.25	2.80	49.73	84.11	9.29	6.60	46.05	11.93	212.8	1.03	362638.
82	355.08	19.09	2.48	22.99	12.19	75.28	12.52	10.30 (1)	12.59 (1)	339.6	.51	359291.
83	304.18	18.21	.42	48.22	92.51	4.94	2.55	-0.00 (1)	-0.00 (1)	1453.1	4.11	356000.
84	295.89	11.90	9.39	12.47	4.05	79.67	16.27	25.02	24.46	38.1	.66	351667.
85	258.09	21.29	5.03	13.71	3.05	77.53	19.42	83.44 (1)	34.59 (1)	172.4	4.42	348753.
86	318.43	11.64	.74	61.33	94.50	3.73	1.77	-0.00 (1)	-0.00 (1)	725.7	3.35	344000.
87	221.74	5.59	1.25	79.74	95.29	2.27	2.43	73.91	-1.36	365.5	.99	342301.
88	303.89	7.71	1.91	45.07	79.30	11.69	9.01	52.87	8.35	189.7	.91	341979.
89	310.98	8.87	4.12	63.78	89.23	4.73	7.04	56.15	2.85	128.1	1.57	340477.
90	303.40	4.79	4.61	53.40	88.23	4.59	7.18	24.66	11.93	229.6	.73	329540.
91	209.74	5.38	4.52	20.85	6.88	53.09	40.12	78.68	11.29	40.4	.04	329162.
92	204.77	8.09	4.25	24.15	12.02	25.14	62.84	40.21	15.89	217.3	1.32	323296.
93	343.56	7.39	5.75	18.62	13.79	21.50	64.71	60.73	19.22	220.4	.85	322880.
94	318.04	6.35	4.33	55.07	88.91	4.85	6.25	61.95	12.93	337.9	.48	319693.
95	392.05	5.07	2.19	26.91	1.18	42.07	56.75	37.35	3.14	241.2	.13	315943.
96	329.57	9.52	3.94	13.29	9.46	56.40	34.14	22.89	16.97	270.1	1.02	315774.
97	203.59	7.05	3.58	32.09	35.37	21.03	43.60	50.67	7.14	306.5	.62	304927.
98	315.19	15.04	.40	48.45	84.00	8.19	3.91	77.67	16.22	1332.7	2.92	303849.
99	328.51	9.67	7.21	20.11	4.04	26.14	69.82	78.63	6.30	147.7	1.04	302672.
100	302.56	9.58	4.92	59.07	90.22	2.08	7.70	79.47	14.59	144.5	1.28	299502.

Table B-1b. SMSA Housing Characteristics Data (cont.)

SMSA NO.	POP/RESS	PC 5-UNITS	PC MOBHM	PC PRE1939	PC WTRSMT	PC WTCCSL	PC OTHERF	PC POPOUT	PC CHNG60	PP DENSITY	PC 4FL+	POPULATION
101	301.63	4.39	6.01	27.51	24.92	16.39	58.69	70.18	7.07	229.0	.50	296382.
102	293.19	7.48	2.70	63.44	90.42	4.81	4.77	14.55	28.22	342.8	1.19	295516.
103	292.65	19.57	2.53	10.31	5.70	58.59	35.71	38.00	4.49	291.2	.93	294703.
104	298.88	5.40	2.01	26.85	3.75	41.80	54.45	38.00	4.49	168.7	.49	294703.
105	334.35	14.29	2.96	18.39	8.25	41.03	50.72	11.30	23.16	1150.2	.78	292159.
106	315.77	22.02	1.52	36.46	93.12	3.94	2.94	40.31	23.49	242.1	3.35	290272.
107	300.34	11.00	3.43	29.93	21.34	35.52	43.13	62.71	13.86	205.1	.90	290206.
108	289.11	12.49	2.50	43.60	61.10	7.61	11.10	40.35	3.16	163.5	2.89	287487.
109	291.14	14.34	1.84	46.64	88.26	6.01	5.73	29.71	6.92	481.7	2.84	286101.
110	320.64	10.89	2.11	16.20	2.41	50.55	47.04	41.73	19.33	621.3	.30	285167.
111	320.40	8.29	2.33	14.59	2.75	39.85	57.40	28.09	6.40	166.0	.53	284632.
112	310.72	8.57	3.18	40.11	60.32	26.28	13.41	36.37	17.21	418.0	1.31	280455.
113	319.89	5.46	1.55	48.43	77.54	14.67	7.78	54.99	3.20	307.7	.81	280031.
114	343.07	3.94	1.74	51.74	89.56	4.43	6.01	59.95	16.22	197.1	.15	276891.
115	294.44	18.93	11.04	3.59	3.03	79.39	17.57	53.79	53.52	34.7	.14	273288.
116	315.65	10.11	2.62	38.60	85.75	6.12	6.13	45.58	15.43	339.2	1.87	272063.
117	294.16	9.87	2.84	64.79	92.62	4.31	12.86	49.75	-4.24	35.9	1.53	265350.
118	297.74	19.02	4.29	20.09	9.13	59.48	31.39	73.39	36.08	96.5	.43	264324.
119	317.59	5.35	3.16	56.26	89.52	3.88	6.60	59.82	4.92	324.3	.46	263654.
120	312.49	5.64	3.02	66.43	89.95	3.50	6.55	63.71	-6.31	147.7	.84	262822.
121	326.38	7.74	2.16	20.23	4.77	29.54	65.70	40.17	14.50	154.5	.40	258906.
122	338.74	7.35	2.02	37.53	71.65	18.65	9.70	48.67	15.32	518.9	1.31	256843.
123	291.15	5.37	3.45	50.04	40.90	15.50	43.60	59.11	-.41	180.7	.81	253743.
124	326.92	7.40	4.78	25.70	9.88	26.86	63.26	76.15	14.53	178.0	.77	253460.
125	328.95	12.56	3.63	21.33	11.94	37.91	50.25	65.58	20.08	75.2	.61	253071.
126	310.38	9.43	4.58	21.74	15.05	30.25	48.70	56.62	19.51	154.4	.08	249081.
127	315.01	5.17	6.00	18.66	3.04	42.98	53.98	75.29	16.33	143.2	.20	243375.
128	327.24	12.13	5.30	24.07	9.99	39.80	50.21	35.21	8.63	214.6	.24	238584.
129	323.64	16.88	4.69	23.40	57.69	19.08	23.93	42.36	39.09	109.4	2.10	235972.
130	296.72	6.39	1.34	80.04	94.84	2.57	2.59	55.53	-.18	515.7	1.36	234107.
131	327.78	25.56	1.88	30.07	77.21	14.50	8.28	57.24	26.34	329.3	2.46	234103.
132	294.16	6.82	2.67	46.30	57.46	15.37	27.17	40.34 (1)	4.25 (1)	218.6	.73	232775.
133	298.10	16.58	1.11	62.33	93.36	4.25	2.37	-0.00	-0.00	1115.4	2.07	232230.
134	291.13	6.94	3.86	43.23	49.32	15.18	35.50	63.84	-10.20	253.0	1.21	229515.
135	321.11	10.51	4.44	23.75	27.53	26.16	46.32	46.40	25.49	266.3	.85	228453.
136	328.51	6.97	4.28	17.71	11.45	25.23	63.32	39.43	32.59	169.3	.44	228239.
137	325.65	7.33	2.64	39.63	74.38	13.93	11.18	48.19	11.99	480.3	.77	226207.
138	334.78	4.92	2.37	44.52	61.20	14.48	24.26	57.79	13.19	270.0	1.17	219743.
139	300.26	10.80	5.73	20.01	12.15	36.07	51.76	64.21	23.65	49.8	1.32	213358.
140	288.00	15.02	.45	51.92	91.40	5.97	2.34	0.00	0.00	-0.0	1.91	-0. (2)
141	373.21	6.23	11.08	12.62	8.40	22.04	69.49	74.51 (1)	30.01 (1)	374.2	.05	212042.
142	311.49	13.93	.81	50.13	93.89	3.83	2.28	-0.00 (1)	-0.00 (1)	963.1	4.13	209000.
143	320.13	10.35	3.08	46.60	83.84	8.98	7.16	-0.00 (1)	-0.00 (1)	562.2	1.76	208666.
144	294.24	19.05	.01	42.70	87.58	8.33	4.09	67.85	19.13	1607.5	8.42	194586.
145	310.32	7.96	3.96	24.53	12.83	29.15	58.02	47.22	12.57	325.5	.50	206342.
146	265.35	6.85	5.53	26.52	13.91	27.27	58.62	75.16	28.07	127.7	0.00	204855.
147	324.76	10.36	2.30	40.77	83.39	10.90	5.71	57.06	15.80	358.6	.61	201550.
148	299.92	6.22	2.55	27.93	7.35	48.24	44.41	33.28	.79	142.4 (3)	.32	201325.
149	298.00	6.31	4.05	24.68	14.21	31.80	53.99	0.00	0.00	0.0	.06	0. (2)
150	317.27	12.64	3.35	26.80	25.92	39.99	43.59	40.57	18.61	0.0	.75	199358.

Table B-1c. SMSA Housing Characteristics Data (cont.)

Table C-1d. SMSA Housing Characteristics Data (cont.)

SMSA NO.	POP/RESS	PC S-UNITS	PC MOBHM	PC PRE1939	PC WTRBSMT	PC WTCCSL	PC OTHERF	PC POPOUT	PC CHNG60	PP DENSITY	PC 4FL+	POPULATION
151	289.00	10.76	.52	55.12	89.52	6.28	2.20	0.00	0.00	0.0	1.04	-0. (2)
152	304.92	6.49	3.46	30.97	4.94	40.00	55.07	36.75	-.26	0.0	.83	187767.
153	299.30	9.96	5.70	32.26	24.19	20.78	55.03	63.25	21.04	0.0	.74	166558.
154	292.54	4.98	3.15	67.86	84.64	6.07	9.05	73.34	-4.18	0.0	1.45	182712.
155	372.24	3.60	1.87	22.03	1.68	38.00	59.65	60.59	.35	0.0	.38	181535.
156	203.78	9.62	2.13	36.53	79.28	10.62	10.10	49.05	12.47	0.0	.24	181436.
157	306.50	10.07	2.44	13.15	6.07	57.54	36.39	16.73	12.84	0.0	.37	179295.
158	282.97	3.42	4.39	65.76	60.37	12.70	26.93	59.38	1.76	0.0	.60	175143.
159	255.35	18.78	1.63	46.76	47.09	33.19	19.12	72.55	8.09	0.0	7.35	175043.
160	263.01	22.20	2.33	27.80	46.92	23.10	29.98	37.46	24.35	0.0	1.12	174323.
161	315.57	4.29	3.80	57.51	59.63	12.32	26.05	68.23	6.19	0.0	.40	171472.
162	326.12	7.52	.49	46.65	92.24	4.39	3.37	43.90	17.01	0.0	.41	170838.
163	275.11	10.17	2.63	23.49	4.66	48.30	47.04	40.63	17.34	0.0	.58	169612.
164	203.47	13.34	2.42	44.77	88.03	6.76	5.22	10.72	7.56	0.0	2.60	167972.
165	312.06	3.65	3.70	51.16	86.74	3.96	7.26	64.60	-1.29	0.0	.65	165627.
166	333.51	18.66	6.79	34.15	51.42	25.55	23.03	44.71	18.69	0.0	1.10	163261.
167	302.79	11.27	2.78	45.41	65.17	9.33	5.50	31.66	16.12	0.0	.85	163213.
168	283.39	8.28	3.62	50.73	74.18	11.50	14.32	42.77	9.17	0.0	1.06	161335.
169	281.94	3.61	3.07	35.80	6.78	20.45	72.77	60.47	15.78	0.0	.11	150421.
170	351.41	5.35	1.54	41.32	91.69	3.26	5.04	60.35	4.75	0.0	.22	157426.
171	321.45	4.82	2.09	41.86	72.52	12.15	15.34	44.24	20.96	0.0	.83	156244.
172	313.98	5.51	2.75	47.12	71.36	17.46	11.18	47.74	16.34	0.0	.82	157115.
173	299.10	11.03	3.64	39.09	67.52	17.02	15.47	19.31	9.04	0.0	1.77	155322.
174	282.29	8.37	3.96	40.76	34.50	19.19	46.32	20.92	17.43	0.0	.23	152929.
175	288.00	11.72	.40	71.44	94.59	2.51	2.35	0.00	0.00	0.0	.87	-0. (2)
176	289.00	17.27	.52	67.96	95.18	2.86	1.95	0.00	0.00	0.0	1.72	-0. (2)
177	281.00	7.32	.85	30.13	2.72	34.59	62.69	35.24	-1.72	0.0	.42	147553.
178	319.69	3.17	3.29	19.50	1.87	37.78	60.36	46.08	-.04	0.0	.04	145435.
179	288.00	16.26	1.49	45.12	92.76	4.42	2.82	0.00	0.00	0.0	3.68	-0.
180	287.20	6.71	6.48	38.59	64.73	9.36	25.86	59.98	10.33	0.0	.67	145056.
181	247.72	7.29	1.72	19.28	8.07	44.35	47.59	11.77	-3.53	0.0	.93	144396.
182	325.14	3.72	5.15	52.76	81.76	7.16	11.08	67.70	7.87	0.0	.65	143274. (2)
183	268.00	16.55	.84	63.55	95.44	1.33	3.23	0.00	0.00	0.0	5.76	-0. (2)
184	345.35	5.23	2.43	20.79	2.14	41.22	56.65	27.76	-7.64	0.0	0.00	140368.
185	296.91	4.78	3.62	46.68	43.97	19.21	36.82	46.39	9.12	0.0	.57	138451.
186	346.92	8.29	2.67	32.59	67.30	18.11	14.60	42.10	22.34	0.0	0.00	137776.
187	361.15	4.61	3.90	70.38	91.72	2.08	6.20	53.19	-1.41	0.0	.66	135556.
188	323.92	6.38	8.53	20.90	2.26	42.60	54.95	33.44	11.21	0.0	.66	134542.
189	322.17	7.73	2.79	45.34	90.55	4.15	5.30	42.88	7.65	0.0	.78	132916.
190	312.61	4.87	2.74	43.21	84.64	7.81	8.15	56.92	9.41	0.0	.13	129097.
191	312.55	6.11	3.43	42.86	39.66	24.36	35.97	46.43	14.15	0.0	.15	129219.
192	352.67	7.35	4.36	35.46	18.71	30.23	51.05	59.78	17.18	0.0	0.00	128609.
193	289.69	5.88	3.04	31.59	4.27	43.04	52.69	23.51	-1.58	0.0	.25	127621.
194	326.40	9.22	1.02	34.30	74.78	13.88	11.34	44.35	12.30	0.0	1.09	126276.
195	366.37	7.78	3.73	45.10	70.47	11.56	17.98	22.37	4.44	0.0	.92	152010.
196	316.84	6.50	4.41	42.31	63.78	13.43	22.78	52.88	10.34	0.0	.74	123474.
197	311.76	7.72	2.73	48.50	81.90	9.82	8.27	26.36	11.97	0.0	.34	121374.
198	272.07	19.02	10.37	19.30	29.27	27.55	43.19	39.65	30.06	0.0	0.00	121068.
199	348.74	16.41	4.00	44.24	86.88	4.15	8.96	30.77	11.82	0.0	1.36	120239.
200	288.00	13.77	.75	38.69	84.65	10.35	5.00	0.00	0.00	0.0	1.84	-0. (2)

Table B-1d. SMSA Housing Characteristics Data (cont.)

SMSA NO.	POP/RESS	PCS-UNITS	PCMOBHM	PCPRE1930	PCWTRSMT	PC-TCCSL	PCOTHERF	PCFCPOUT	PCCHNG60	PPDENSITY	PPC4FL+	POPULATION
201	315.84	8.39	3.73	40.03	62.46	15.93	21.61	16.92	-.40	0.0	1.43	118238.
202	317.27	5.25	2.43	47.83	86.71	5.26	3.03	33.07	14.67	0.0	.48	117217.
203	305.39	4.30	4.66	48.72	69.83	9.44	20.73	57.10	8.78	0.0	.72	117339.
204	206.05	10.09	2.97	66.05	88.02	4.89	7.09	25.82	-3.29	0.0	1.31	116180.
205	327.29	8.96	4.56	22.37	16.13	20.07	57.80	43.09	6.02	0.0	1.39	110029.
206	313.18	4.55	2.83	22.26	2.88	41.41	55.71	51.13	11.89	0.0	.11	115387.
207	281.89	4.54	2.18	27.49	2.85	41.57	55.55	21.06	-5.63	0.0	.40	113959.
208	302.31	6.79	6.54	29.83	45.65	16.75	37.40	32.97	16.72	0.0	.55	112230.
209	302.25	4.35	4.21	19.38	2.40	39.21	56.40	36.46	22.84	0.0	.20	109716.
210	320.79	15.44	5.39	39.71	63.33	20.72	15.95	41.14	18.52	0.0	.99	109373.
211	288.00	19.14	1.00	62.91	95.99	1.58	2.44	0.00	0.00	0.0	3.41	-0. (2)
212	339.92	7.56	4.79	19.34	5.60	46.05	48.35	30.51	16.04	0.0	.20	108144.
213	264.75	7.22	6.92	25.60	5.56	21.39	73.05	56.69	14.18	0.0	.16	107219.
214	312.55	16.60	7.62	16.17	1.99	56.71	41.30	38.18	23.29	0.0	1.32	104764.
215	314.06	9.06	6.13	54.27	77.99	8.46	13.55	36.40	19.65	0.0	.94	104363.
216	316.37	14.20	9.62	13.67	7.64	42.70	49.67	33.04	27.97	0.0	.34	103047.
217	282.37	4.49	3.23	27.71	2.58	27.32	70.10	48.42	9.43	0.0	0.00	101193.
218	288.00	10.05	1.45	62.19	93.13	3.75	3.12	0.00	0.00	0.0	2.22	-0. (2)
219	295.72	2.10	1.51	27.39	3.83	30.66	65.52	40.17	11.07	0.0	.14	97096.
220	313.92	9.23	3.59	46.06	89.91	4.07	6.02	23.11	9.07	0.0	1.08	95209.
221	204.37	3.16	2.90	32.30	16.12	17.01	66.86	42.49	-3.01	0.0	0.00	94144.
222	301.85	6.51	4.69	4.03	2.20	59.10	36.70	14.16	.88	0.0	0.00	91805.
223	358.85	7.28	3.10	58.84	93.98	1.94	4.08	30.90	11.66	0.0	.31	90609.
224	331.80	5.56	5.21	14.77	3.35	42.16	54.49	18.96	15.57	0.0	0.00	89539.
225	301.00	8.84	5.16	35.40	69.17	12.06	18.77	28.51	9.56	0.0	.47	87367.
226	270.75	8.58	2.53	69.52	64.67	5.32	10.01	16.11	-4.22	0.0	.16	85915.
227	301.58	5.72	3.85	30.56	2.47	25.00	72.53	31.64	4.64	0.0	0.00	85329.
228	315.44	14.55	4.03	37.38	90.03	4.84	5.13	35.67	22.08	0.0	2.45	84101.
229	263.49	3.68	3.23	38.80	3.85	28.99	67.16	34.85	12.23	0.0	0.00	83225.
230	301.13	13.19	5.24	38.34	70.62	9.85	19.53	25.57	10.25	0.0	1.70	81804.
231	312.86	16.12	10.49	28.25	52.01	19.90	28.19	27.19	31.77	0.0	2.04	80911.
232	317.78	5.97	3.49	56.28	88.73	3.70	7.57	36.04	9.95	0.0	1.24	80468.
233	288.00	9.02	.68	63.47	94.98	3.56	1.46	0.00	0.00	0.0	.68	-0. (2)
234	313.93	4.47	3.51	34.96	29.27	25.22	45.52	36.48	11.19	0.0	0.00	79486.
235	288.00	6.23	2.07	38.15	88.70	6.26	5.04	0.00	0.00	0.0	1.21	-0. (2)
236	377.23	4.20	2.26	32.01	2.41	45.72	51.87	4.12	11.07	0.0	.51	72859.
237	288.00	21.74	1.80	69.38	95.49	1.09	3.41	0.00	0.00	0.0	6.28	-0. (2)
238	285.34	6.51	1.87	27.83	5.27	42.52	52.22	9.85	9.03	0.0	1.13	71047.
239	288.00	16.45	2.58	46.50	92.37	4.23	3.40	0.00	0.00	0.0	2.00	-0. (2)
240	288.00	11.10	.78	41.67	93.59	4.19	2.21	0.00	0.00	0.0	2.44	-0. (2)
241	286.82	7.73	2.15	6.41	2.03	72.29	25.68	7.54	-3.49	0.0	.13	65433.
242	313.56	13.27	4.01	18.14	1.91	46.93	51.16	10.35	22.57	0.0	0.00	57978.
243	288.00	13.59	.55	52.87	95.44	3.54	1.02	0.00	0.00	0.0	3.05	-0. (2)
AVERAGE	288.23	11.53	3.05	36.78	50.94	23.64	25.43	46.57	13.13	659.5	1.92	
SD.	79.39	6.84	2.02	16.16	36.50	20.18	21.34	20.77	10.59	1222.2	3.84	
NUMBER	243	243	243	243	243	243	243	227	227	149	243	

(1) THE DATA FOR POPULATION IN CENTRAL CITY AND CHANGE FROM 1960 ARE NOT AVAILABLE FOR THE S.M.S.A. s SO DEFINED.
(2) THE POPULATION TOTAL WAS NOT AVAILABLE FOR THOSE S.M.S.A. s. THE AVERAGE VALUE OF 288 WAS USED FOR THE POPULATION PER RESIDENCE. MOST OF THESE S.M.S.A. s ARE PART OF METROPOLITAN STATE ECON MIC AREAS DEFINED ONLY IN NEW ENGLAND.
(3) THE AREA DATA WAS NOT FOUND FOR S.M.S.A. s NOT IN THE LARGEST 150.

Table B-1e. SMSA Housing Characteristics Data (cont.)

STATE NO.	POP/RESS	PCS*UNITS	PCMOBHM	PCPRE1939	PCWTASMT	PC*TCCSL	PCLTHERF	PC4FL+	POPULATION
1	308.70	2.24	6.27	33.59	9.72	18.05	72.23	.03	1688464.
2	316.30	6.11	12.64	24.42	7.63	47.99	44.38	.05	453293.
3	283.12	2.83	4.47	35.13	7.17	20.46	72.42	.09	1514670.
4	282.53	6.96	5.74	26.79	.48	30.01	69.51	.16	2351671.
5	279.42	6.92	7.32	48.20	46.72	18.61	34.67	.43	625520.
6	312.99	6.78	1.92	45.15	89.04	5.58	5.38	.49	1011711.
7	313.22	11.41	5.14	32.86	64.41	16.66	18.93	1.44	548104.
8	271.74	50.95	.09	46.97	83.75	13.16	3.09	28.71	756510.
9	265.50	7.01	10.88	16.50	2.74	53.38	43.88	.68	2132450.
10	315.28	3.56	7.24	34.68	10.46	20.65	68.92	.17	2715663.
11	204.69	5.31	6.72	44.34	56.39	13.68	29.93	.31	600778.
12	286.58	3.77	4.59	59.09	62.25	12.93	24.82	.39	2577334.
13	207.41	3.94	5.42	54.08	56.85	13.50	29.65	.42	2337743.
14	290.45	4.16	2.52	70.96	86.51	3.71	9.79	.31	1673375.
15	283.49	5.32	3.27	55.51	58.81	13.42	27.77	.24	1704397.
16	303.88	6.01	4.20	43.55	41.54	16.82	41.64	.46	2965502.
17	327.80	1.44	5.14	28.64	1.96	21.49	76.64	.02	1646983.
18	372.67	5.26	5.79	64.08	79.05	2.58	18.38	.31	993663.
19	318.16	23.84	2.14	25.00	68.17	16.22	15.61	8.34	1851729.
20	424.18	13.00	1.13	57.11	91.51	4.49	4.00	3.32	2591170.
21	286.46	3.07	4.86	50.21	65.53	12.63	20.84	.24	2186593.
22	310.99	3.97	3.59	58.56	85.04	4.32	10.64	.34	1641968.
23	315.35	2.28	4.39	35.44	5.27	19.39	75.34	.05	1823424.
24	260.91	8.15	3.89	51.47	50.46	12.47	37.07	1.66	2074538.
25	279.98	5.80	7.12	54.07	64.78	6.80	28.42	.39	444327.
26	275.82	3.37	3.81	68.25	72.85	9.54	17.62	.30	774711.
27	274.81	7.04	16.47	35.09	22.11	26.46	57.43	1.77	94362.
28	384.08	7.39	6.10	57.24	83.37	3.71	12.92	.70	737681.
29	321.25	10.87	1.20	34.84	71.45	16.76	11.77	1.42	2743282.
30	312.90	4.84	6.71	26.45	9.73	44.44	45.83	.03	700226.
31	308.80	6.76	5.22	62.73	85.10	4.54	10.36	.75	2783530.
32	314.06	1.79	6.69	36.00	20.67	16.81	62.52	.07	3185636.
33	308.16	7.87	4.81	56.04	84.08	4.59	11.33	.43	617761.
34	302.19	7.75	3.75	55.81	74.09	8.61	17.29	1.81	3599672.
35	262.73	3.07	3.43	47.27	11.15	22.94	65.90	.20	1333275.
36	278.63	6.22	7.89	38.06	19.96	22.27	57.77	.37	682340.
37	363.94	10.55	2.29	58.85	87.85	6.39	5.76	3.22	6799049.
38	415.06	9.30	7.52	51.47	59.35	15.76	24.87	.33	38723.
39	320.58	1.64	6.20	34.28	9.08	14.94	73.98	.09	1668582.
40	208.50	5.05	5.51	61.89	74.77	7.61	17.62	.41	571048.
41	236.46	2.95	4.85	35.93	28.23	17.20	54.50	.14	2213565.
42	271.42	2.66	3.16	34.78	3.85	26.72	69.43	.06	3030898.
43	318.56	4.20	6.21	47.98	57.46	16.54	25.96	.06	237584.
44	206.95	7.02	6.25	64.44	85.31	2.84	11.85	.69	444752.
45	335.31	13.18	3.63	32.36	50.87	18.83	30.29	3.76	3423452.
46	271.99	7.39	5.81	34.47	22.44	21.82	55.74	.69	941723.
47	294.99	3.64	4.99	54.58	49.08	10.09	40.63	.47	1332010.
48	302.10	1.99	3.34	61.01	85.52	4.19	10.29	.02	1655083.
49	290.14	6.10	8.95	42.82	58.67	13.12	28.21	.26	332416.
50	341.23	22.75	11.42	11.82	44.33	10.98	45.58	1.56	302173.
51	336.74	5.00	.18	43.63	15.54	24.79	59.67	.15	149737.

Table B-2. State Non-SMSA Housing Characteristics

Appendix C

COMPUTATION OF HOUSING PRODUCT

Due to the absence of the product of homes, a product was calculated. The value of output for the household sector is determined by estimating the expenditures for rent (of that amount spent in lieu of rent, for home occupancy), and output by home-based industries. The median costs of home ownership with and without a mortgage and the median contract rent can be found in the Annual Housing Survey taken in 1974 [U.S. Bureau of the Census, 1976]. The median cost of home ownership with a mortgage is $209, and without a mortgage, the median home ownership cost is $72. To derive "rents" paid by home owners, the ratio of contract rent to gross renter's costs was calculated as 0.874 and both sets of homeowners' costs were multiplied by this ratio to estimate the amount paid as rent by homeowners. Multiplying the median cost by the number of housing units in each category (assuming the median is the mean), a total payment is computed (see below). Also added is the household industry output for 1970. Each value listed is given in terms of billions of 1970$ for 1970, using the commodity price index for home ownership costs [Bureau of Economic Analysis; 1976].

Homeownership	47.529
Renters	30.025
Household Industry Output	5.050
Total Output Associated with Residences	82.604

The estimated value of residential structures in 1970 was 1,106.7 billion 1970$, and the ratio of residential output to structure value is .075, as is listed in Table 5-6.

Appendix D

GRAPHIC REPRESENTATION OF DISCOUNTED BUILDING LOSSES AND SAVINGS

This appendix provides a graphical representation of the effect of different discount rates on the aggregate building losses due to six of the natural hazards examined. The figures provide the cumulative annual national losses from 1970 to 2000 and the cumualtive annual savings resulting from the most effective mitigation to losses. Table 4-3 in Chapter Four is a summary of the total values given in these figures.

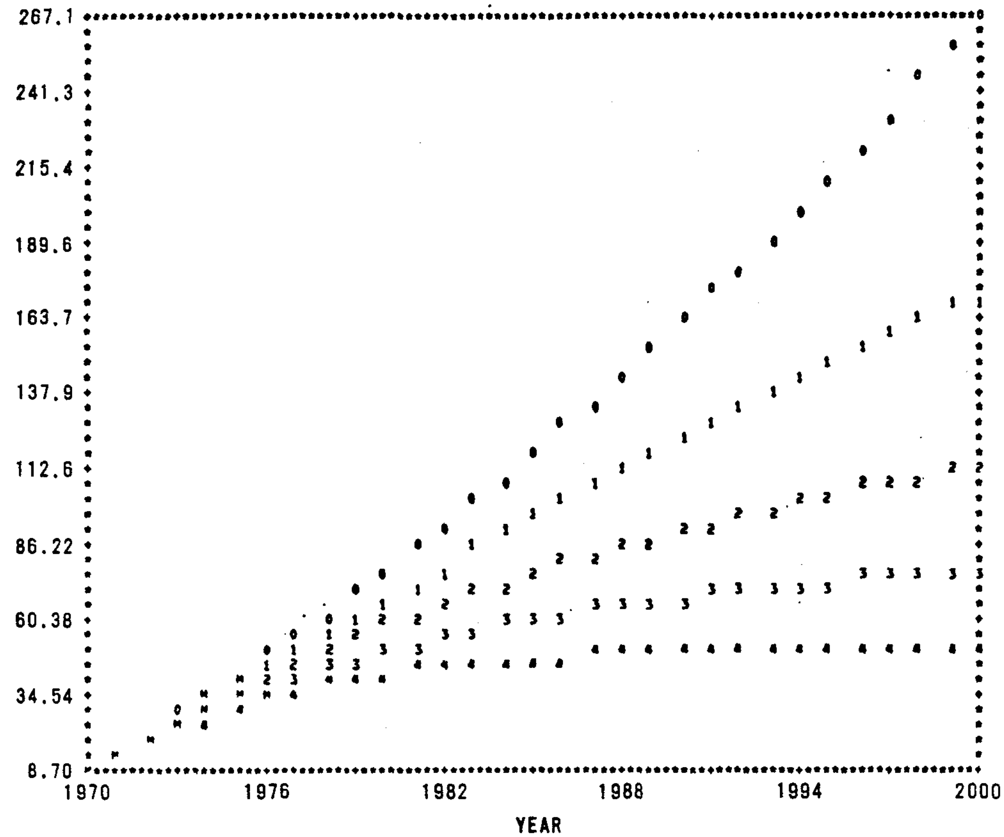

Figure D-1. Aggregate Estimated Losses Due to Tsunami (10^6 1970$)

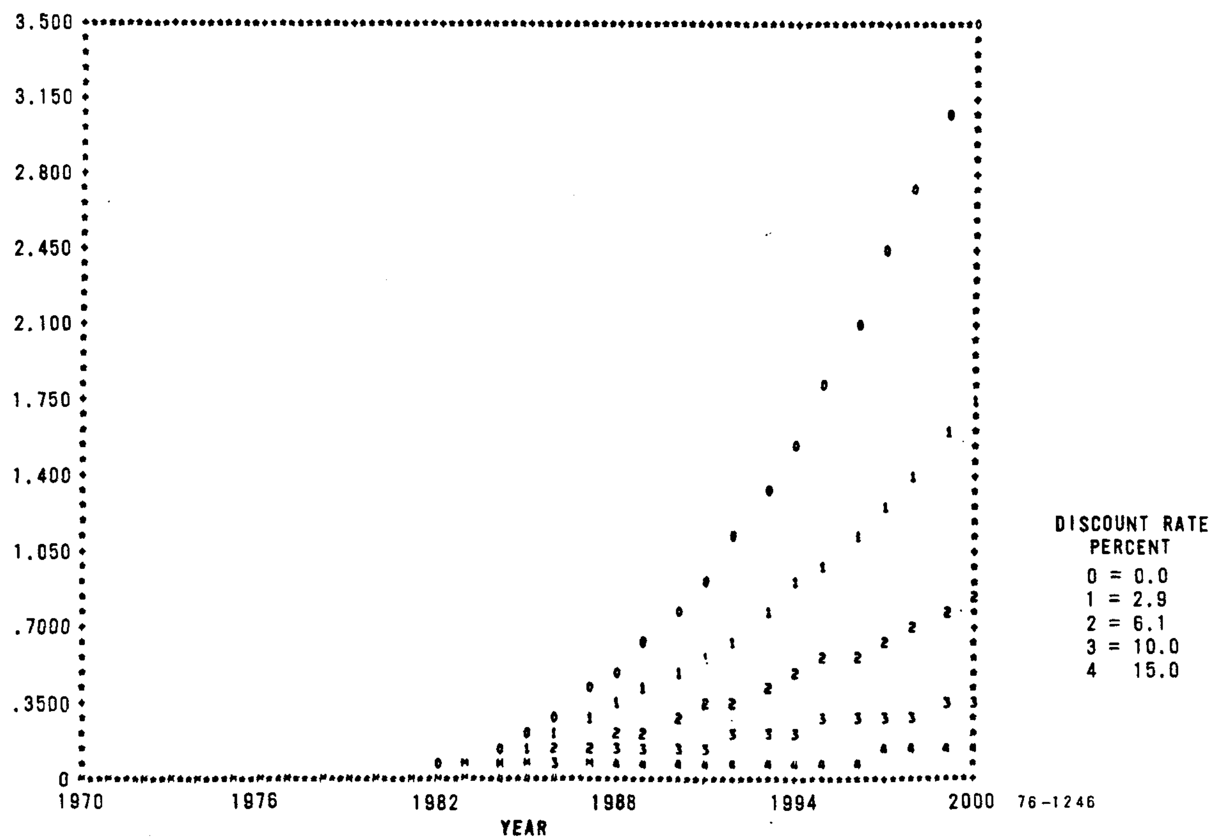

Figure D-2. Aggregate Estimated Savings Due to the Land-Use Restriction (10^6 1970$) in the 100-year Floodplain D-2

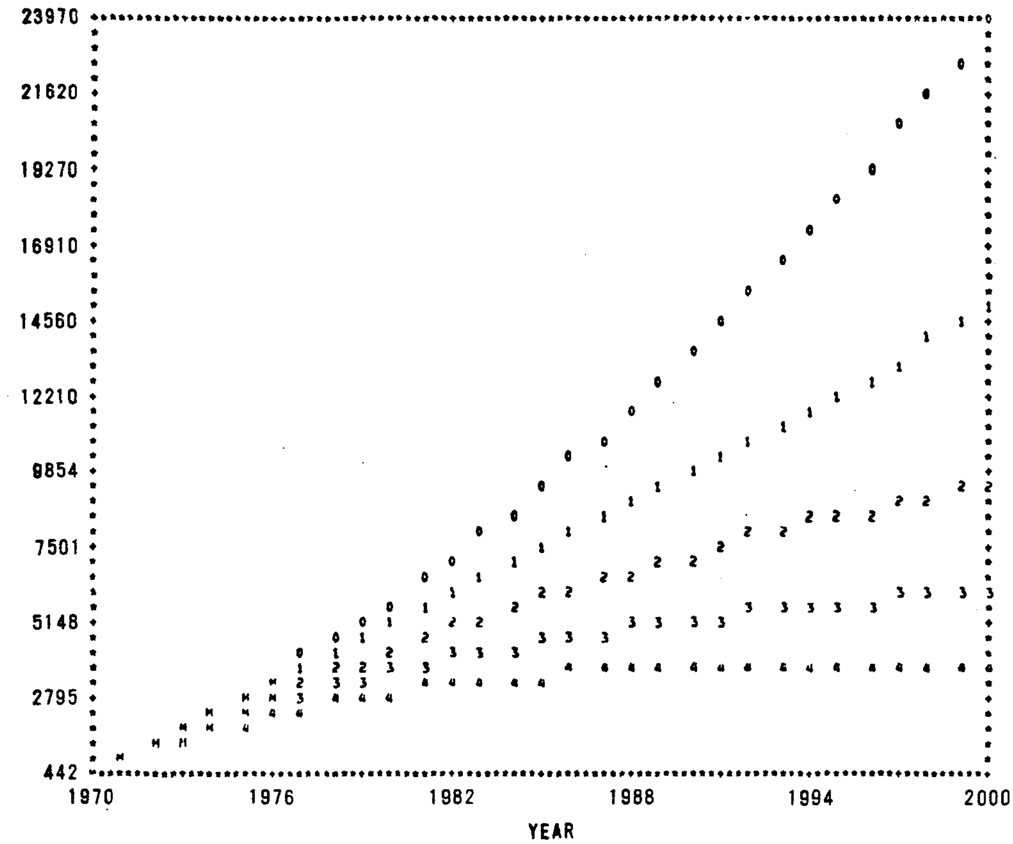

Figure D-3. Aggregate Estimated Losses Due to Storm Surge (10^6 1970$)

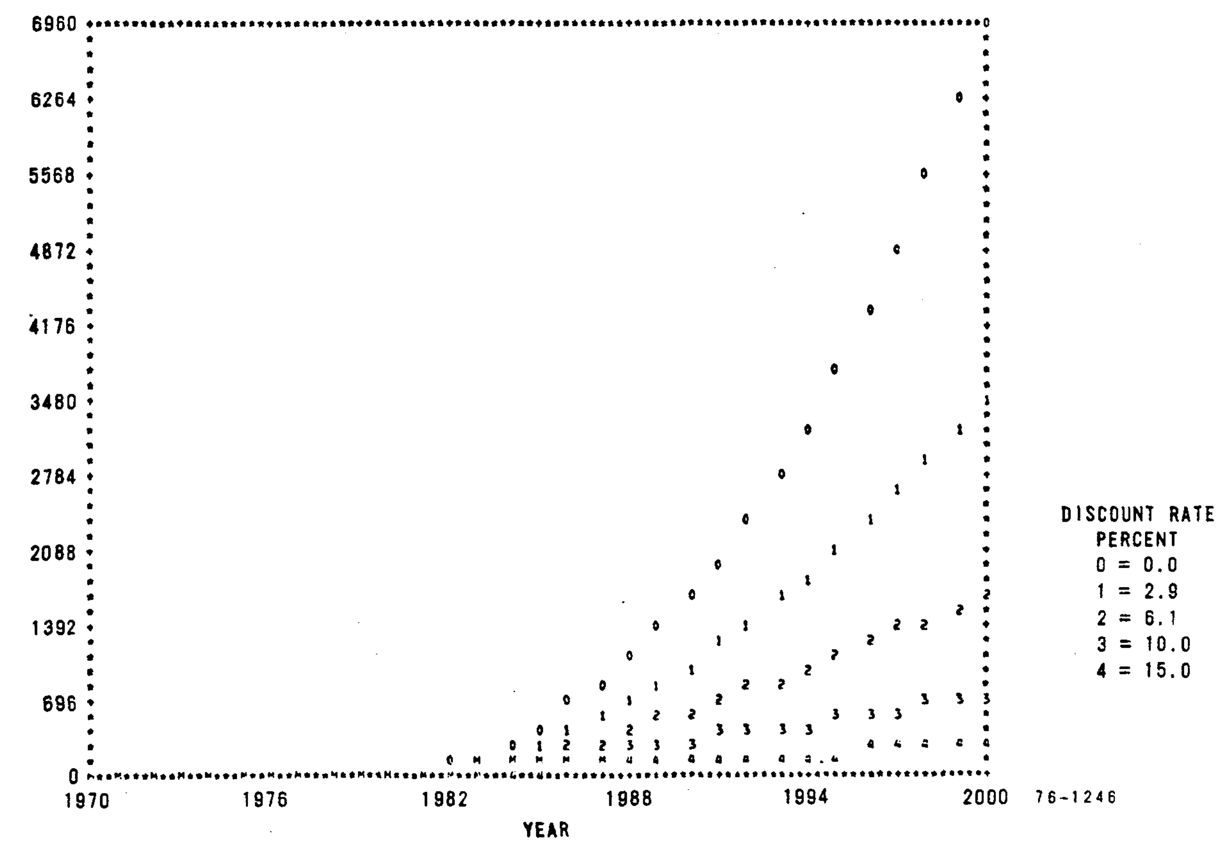

Figure D-4. Aggregate Estimated Savings Due to 50-year Flood Plain Land-Use Controls.

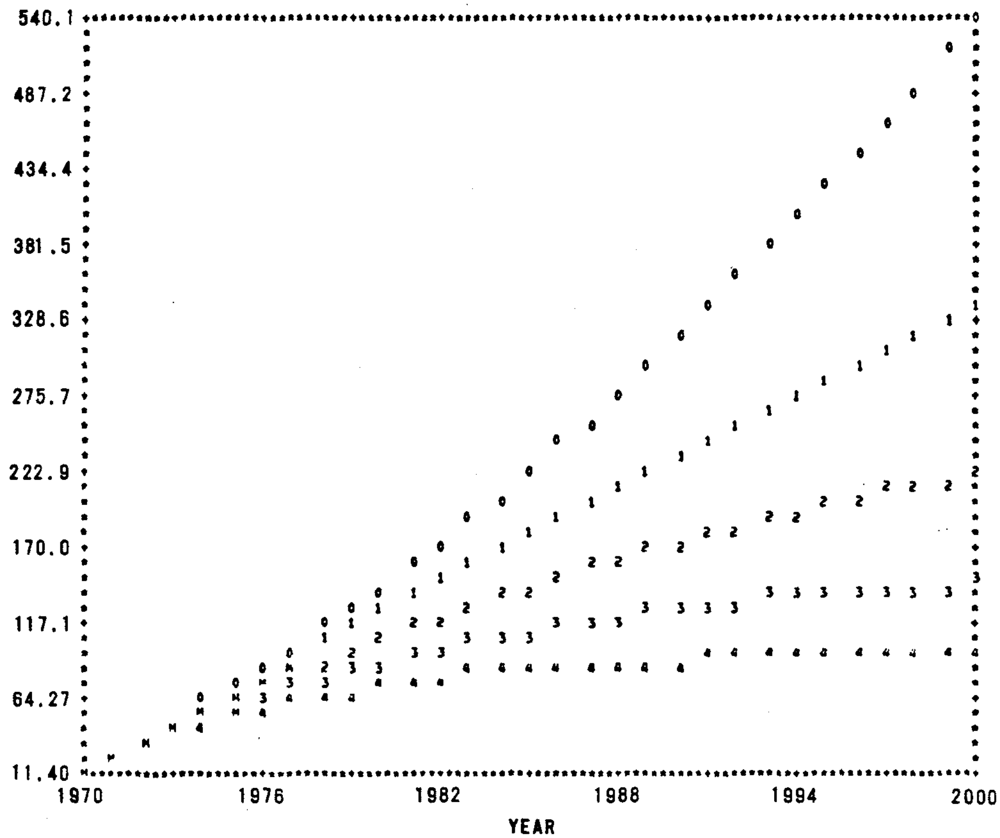

Figure D-5. Aggregate Estimated Losses Due to Severe Wind (10^6 1970$)

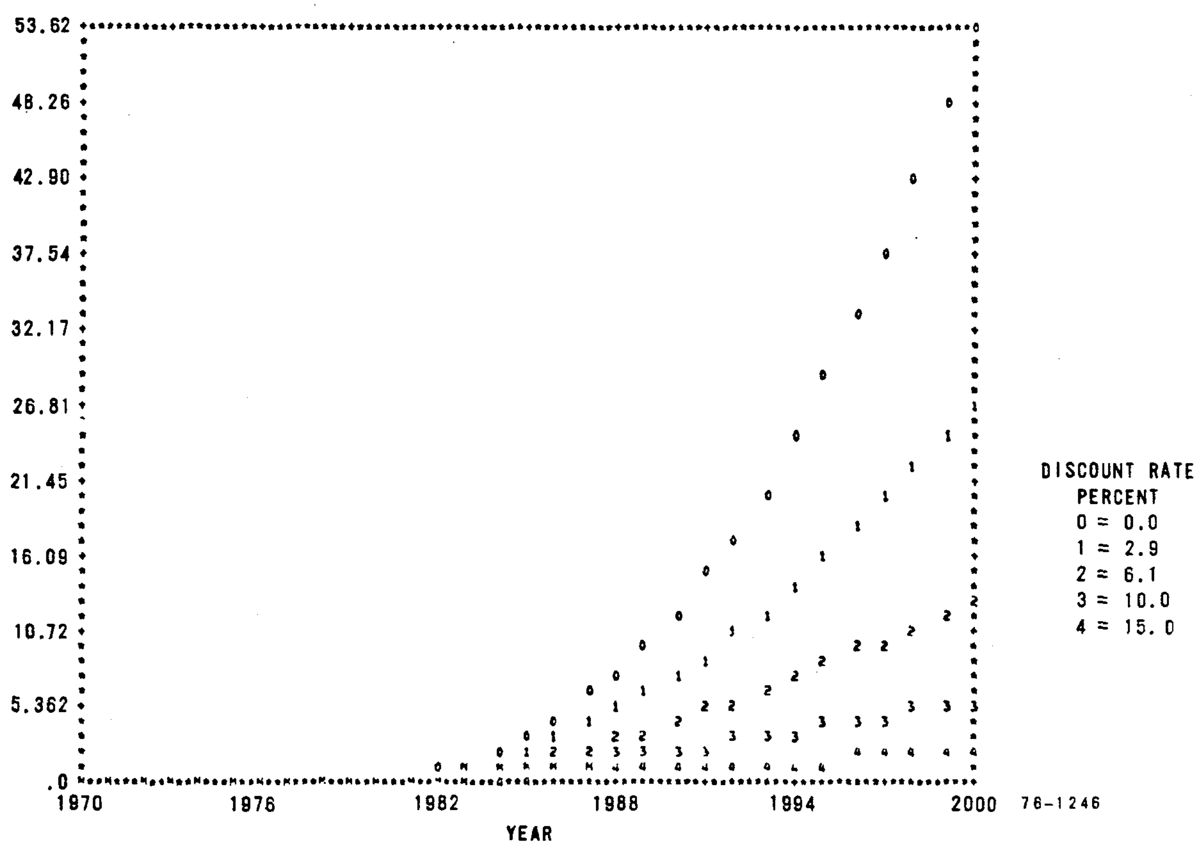

Figure D-6. Aggregated Estimated Savings Due to UBC Zone 3 Building Code (10^6 1970$)

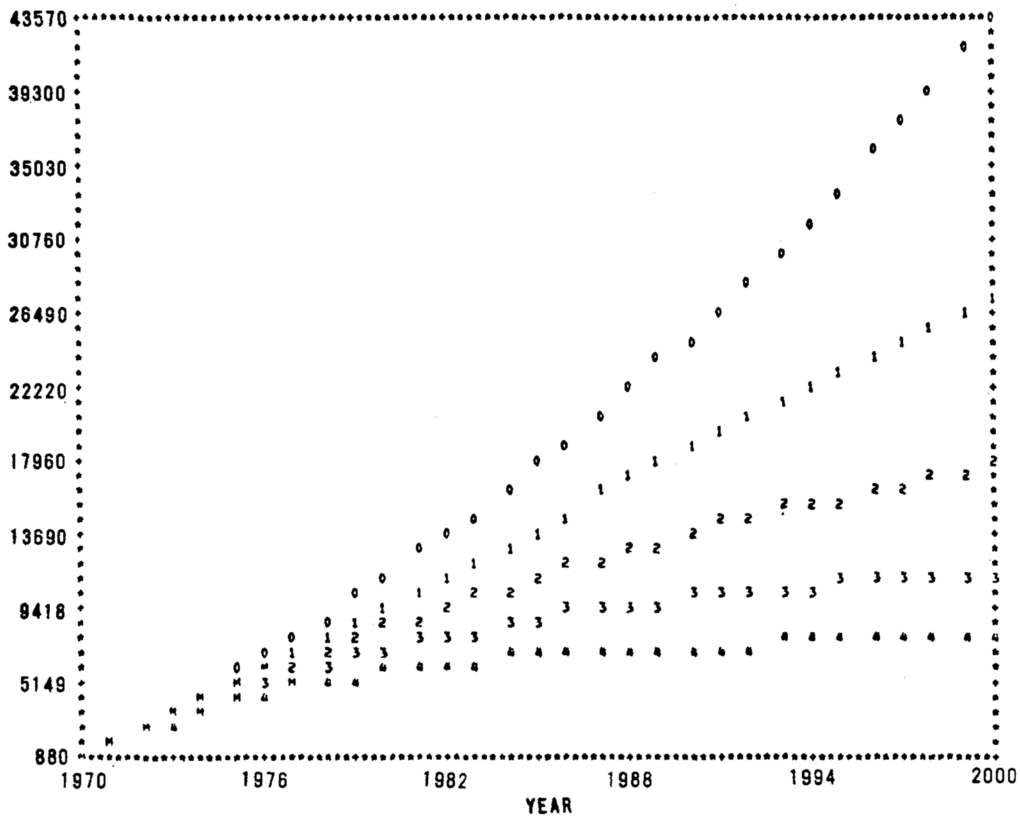

Figure D-7. Aggregate Estimated Losses Due to Tornado (10^6 1970$)

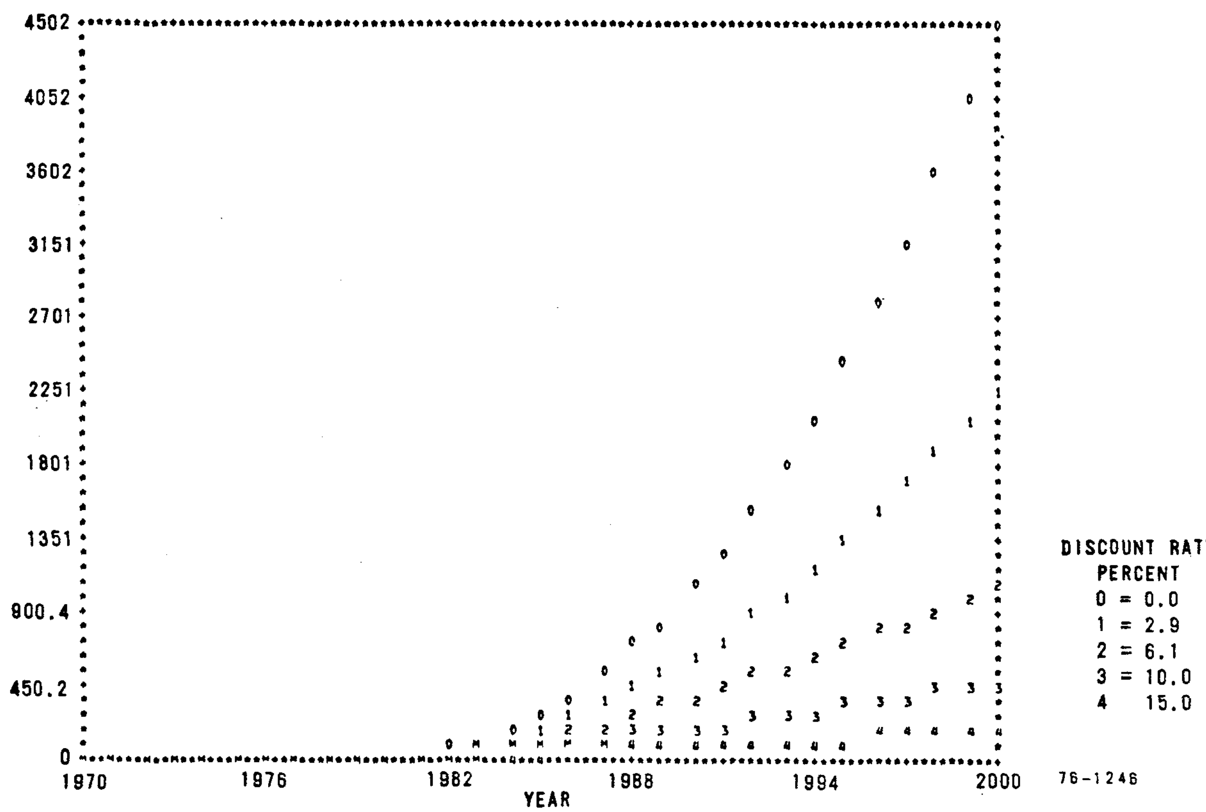

Figure D-8. Aggregate Estimated Savings Due to UBC Zone 3 Building Code (10^6 1970$)

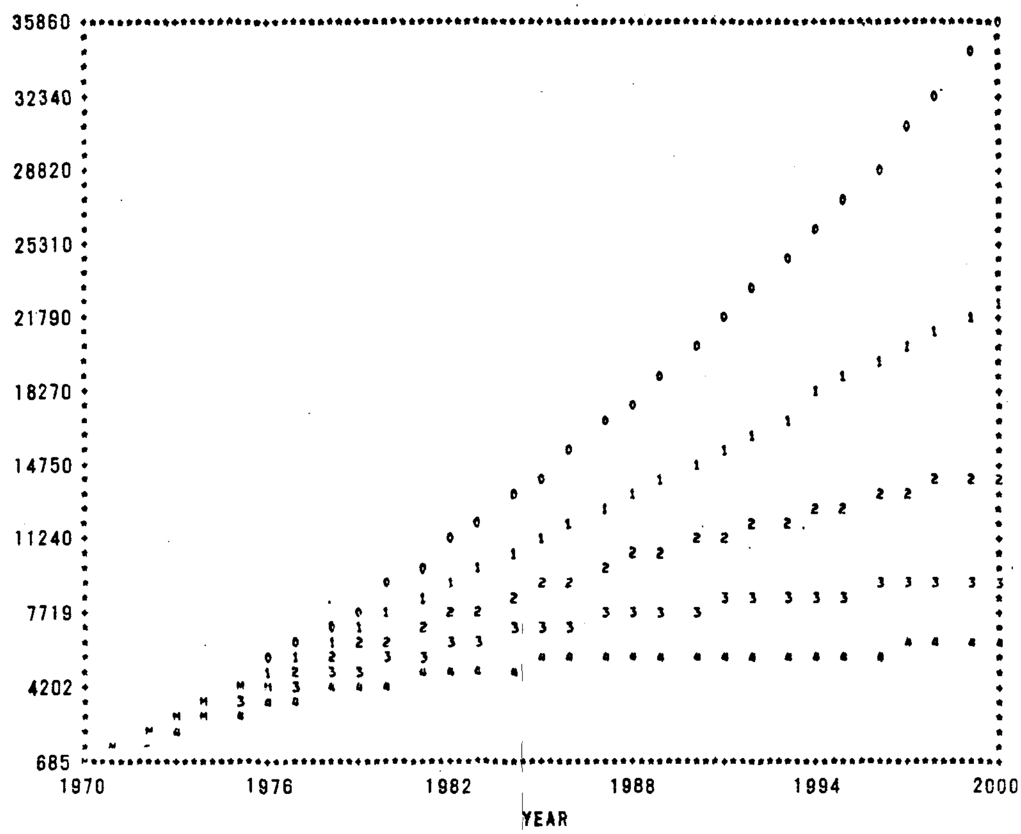

Figure D-9. Aggregate Estimated Losses Due to Hurricane (10^6 1970$)

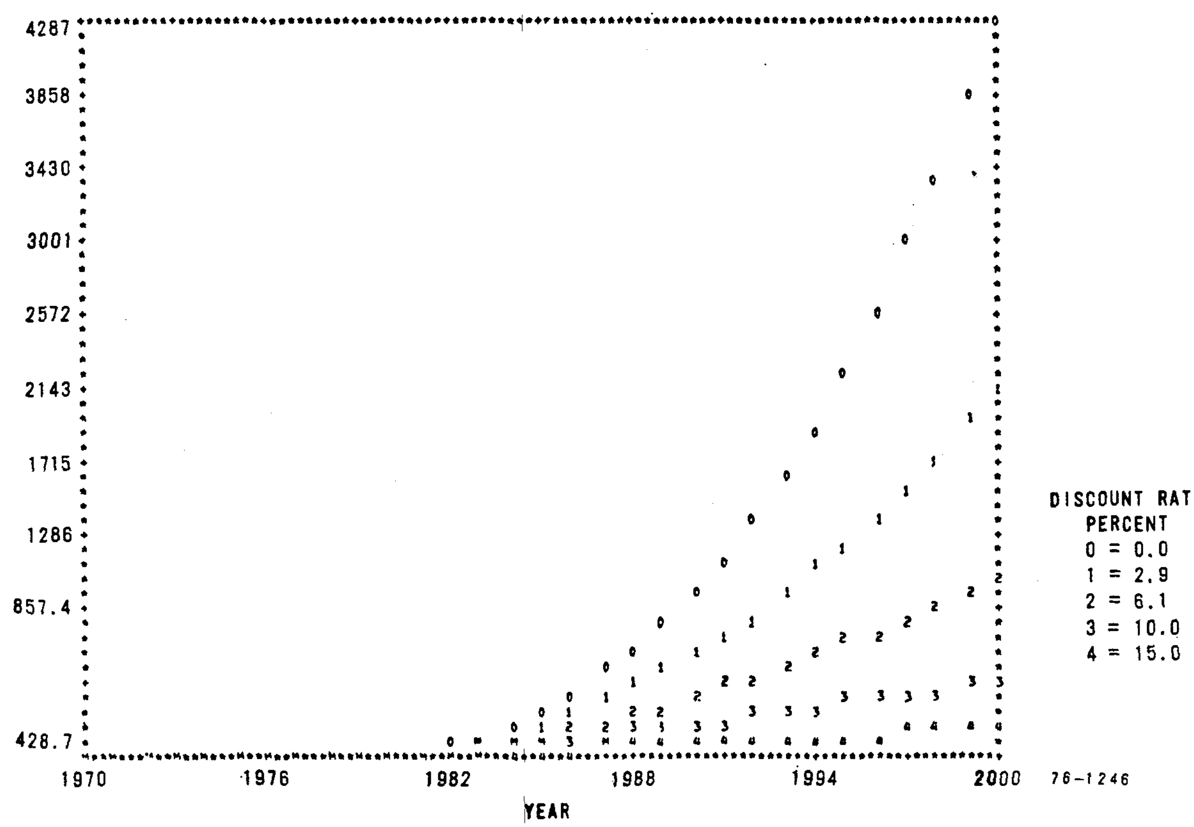

Figure D-10. Aggregate Estimated Savings Due to UBC Zone 3 Building Code (10^6 1970$)

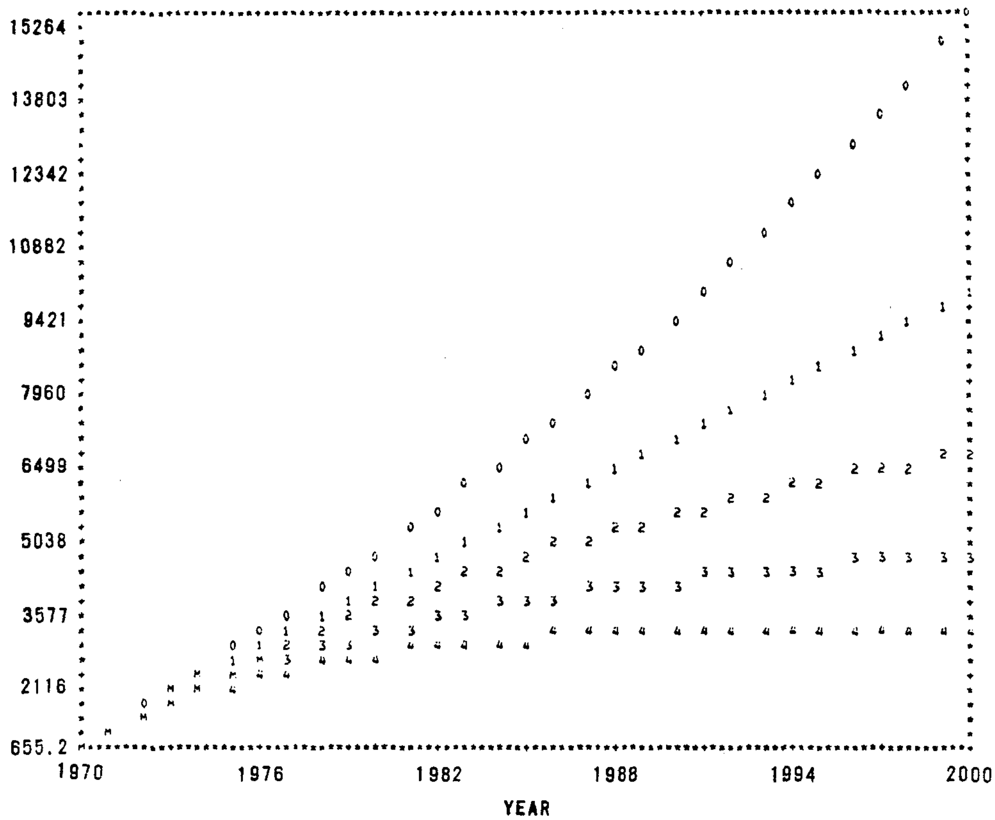

Figure D-11. Aggregate Estimated Losses Due to Earthquake (10^6 1970$)

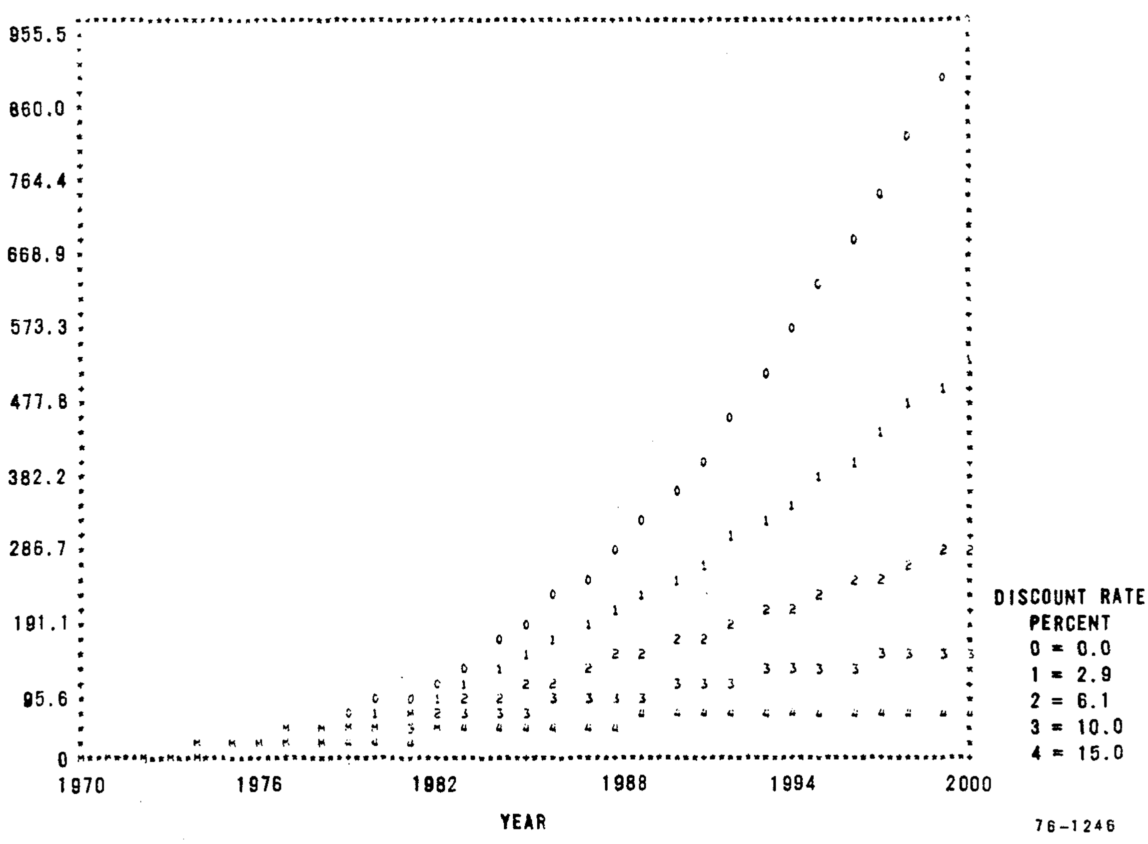

Figure D-12. Aggregate Estimated Savings Due to UBC Zone 3 Building Code (10^6 1970$)

APPENDIX E

SURVIVAL CURVES

The survival curves used in estimating the national wealth stock were taken from Winfrey's [1935] original curves. A survival curve gives the proportion of the original quantity of any item that is still in use at a point in time relative to its production. Thus, a survival curve predicts what proportion of items still in existence at 50% of the average life of the item, at 100% of the average life of the item, and at other proportions of the average item's life. Figure E-1 shows the two survival patterns referred to in this study: L-2 and S-3. L-2 is skewed in the direction of longer life after the average life while S-3 is symmetrical about the average life. L-2 was used by Shavell [1971] because he felt that consumers tend to hold on to items longer and their discard patterns are more widely distributed about the average life than a businessman's behavior. The S-3 curve was used in the estimates by the B.E.A. [1974] because it was felt that it best describes the behavior of the firm.

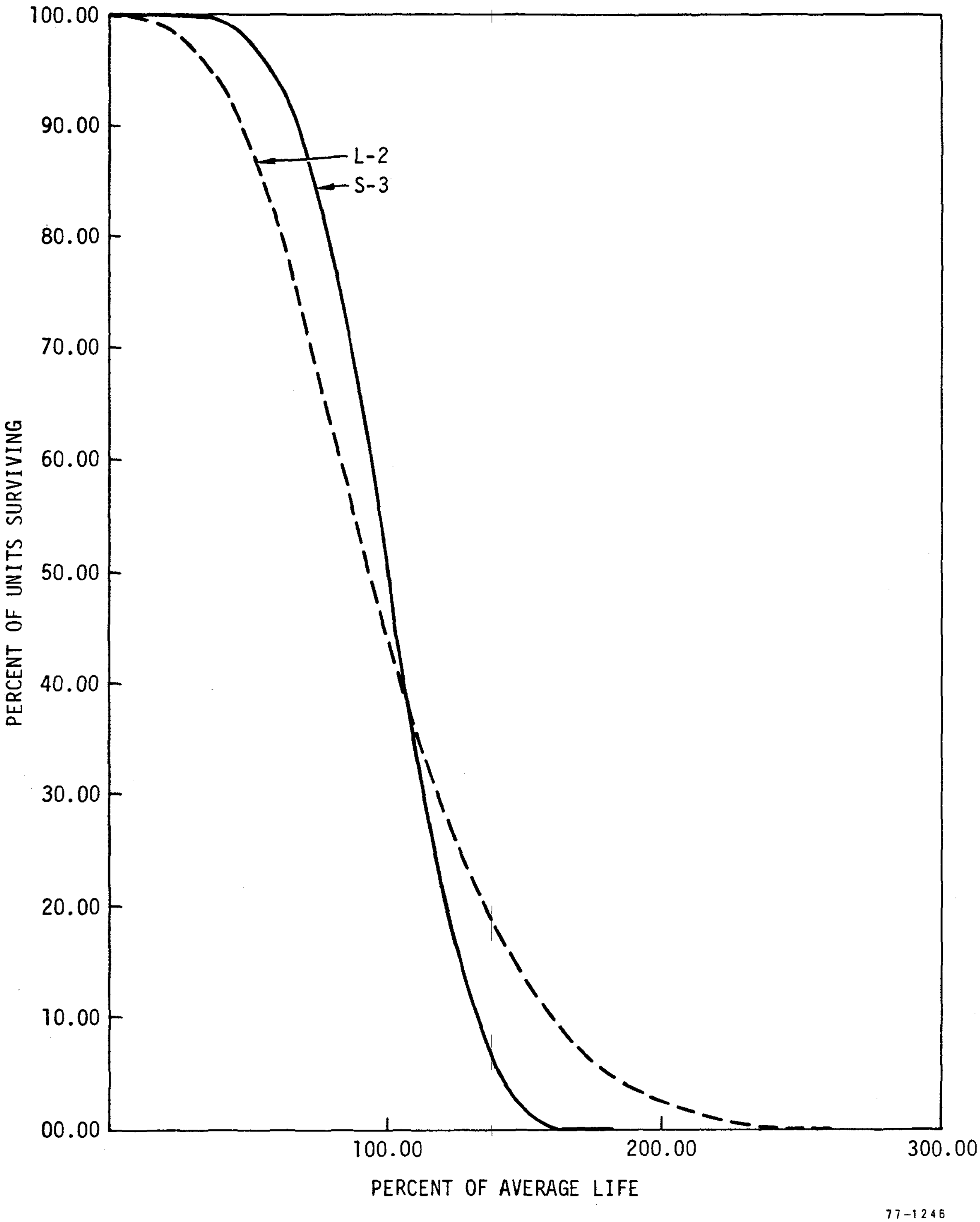

Figure E-1. Survival Curves Used in Wealth Estimates
Source: Winfrey, 1935

Appendix F

COMPUTER PRINTED RESULTS OF BUILDING LOSS DATA

This appendix provides the building loss estimates as they were produced by the computer program that simulated the model discussed in this report. The tables furnish the distribution of building losses by census region, economic sector* and by occurrence in either urban or rural counties. The results are given for: tsunami in 1970 and 2000, severe wind (this appears on the output as "STRONG WINDS") in 1970 and 2000, hurricane wind in 1970 and 2000, tornado in 1970 and 2000, storm surge in 1970 and 2000, earthquake in 1970 and 2000, and landslide in 1970.

Key:

	Census Region
NE	Northeast
NC	North Central
SO	South
WT	West
US	National Total

	Value Categories
UR VL	SMSA Value of Structure at risk in 10^6 1970$
RR VL	Non-SMSA Value of Structures At-risk in 10^6 1970$
UR DR	[Damage/Value of Structure]*100.SMSA
RR DR	[Damage/Value of Structure]*100.NONSMASA
TOT VL	Regional Total Value of Structure At-risk 10^6 1970$
TOT DM	Regional Total Damage Estimate 1970$
TOT DR	Regional [Damage Total/Value of Structure Total]*100.

*The data in the POPULATION column is in number of people exposed and lives lost.

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO STRM SURGE IN 1970 VALUED IN MILLIONS OF 1970 $ MGT= -0 -0 -0 -0 -0

REGIONAL AND NATIONAL TOTALS

REGIONS		HOUSING STRUCTURES	FARM+MINES STRUCTURES	CONSTRUCT STRUCTURES	MANUFACTOR STRUCTURES	TRAN+UTILY STRUCTURES	W+R TRADE STRUCTURES	FINANCE STRUCTURES	SERVICES STRUCTURES	FED GOV STRUCTURES	ST+LOC GOV STRUCTURES	POPULATION NUMBER	TOTAL
NE	UR VL	141021,54	227,98	3082,79	12003,66	35800,11	11108,43	21636,76	15550,16	10143,10	19394,71	20614408,	269969,26
	UR DR	4,164E-02	1,952E-02	2,018E-02	1,986E-02	1,900E-02	2,005E-02	1,982E-02	2,000E-02	1,900E-02	2,030E-02	3,577E-05	,311E-01
	RR VL	5986,24	54,58	174,49	532,00	646,84	431,32	350,56	409,24	861,87	727,87	1108775,	10175,01
	RR DR	8,151E-02	2,303E-02	3,454E-02	2,310E-02	4,512E-02	9,283E-02	8,130E-02	9,818E-02	6,440E-02	4,582E-02	5,809E-05	,722E-01
	TOT VL	147007,78	282,56	3257,28	12535,65	36446,95	11539,75	21987,35	15959,40	11004,96	20122,58	21723183,	280144,27
	TOT DM	6,360E+07	5,707E+04	6,824E+05	2,506E+06	7,095E+06	2,628E+06	4,574E+06	3,512E+06	2,483E+06	4,271E+06	8,	9,141E+07
	TOT DR	4,326E-02	2,020E-02	2,095E-02	1,999E-02	1,947E-02	2,277E-02	2,080E-02	2,201E-02	2,256E-02	2,123E-02	3,691E-05	,326E-01
SO	UR VL	67732,40	1786,35	2079,57	5175,95	17499,58	5666,83	6971,51	5842,64	10934,46	8089,51	12835896,	131778,79
	UR DR	,299	6,915E-02	8,229E-02	5,957E-02	,103	8,350E-02	8,920E-02	8,991E-02	6,750E-02	7,924E-02	1,752E-04	,195E+00
	RR VL	15728,99	820,14	379,45	1218,93	2452,23	1065,66	898,12	842,06	1173,74	2191,59	3828168,	26810,91
	RR DR	,424	,226	,134	,134	,155	,517	,517	,503	,149	,134	2,149E-04	,350E+00
	TOT VL	83461,39	2606,49	2459,02	6394,88	19951,81	6732,46	7869,62	6724,70	12108,20	10281,10	16664064,	158589,70
	TOT DM	2,691E+08	3,086E+06	2,220E+06	4,715E+06	2,176E+07	1,024E+07	1,086E+07	9,693E+06	9,134E+06	9,342E+06	31,	3,502E+08
	TOT DR	,322	,118	9,029E-02	7,373E-02	,109	,152	,138	,144	7,543E-02	9,086E-02	1,843E-04	,221E+00
US	UR VL	208753,94	2014,33	5162,37	17179,61	53299,69	16775,25	28608,29	21392,80	21077,56	27484,22	33450304,	401748,05
	UR DR	,125	6,354E-02	4,520E-02	3,182E-02	4,646E-02	4,148E-02	3,673E-02	3,909E-02	4,416E-02	3,765E-02	8,928E-05	,847E-01
	RR VL	21715,23	874,72	553,94	1750,93	3099,08	1496,98	1248,68	1291,30	2035,60	2919,47	4936943,	36985,92
	RR DR	,330	,213	,103	,100	,132	,395	,395	,375	,113	,112	1,797E-04	,273E+00
	TOT VL	230469,17	2889,05	5716,31	18930,54	56398,76	18272,23	29856,97	22684,10	23113,16	30403,69	38387247,	438733,97
	TOT DM	3,327E+08	3,143E+06	2,903E+06	7,222E+06	2,886E+07	1,287E+07	1,543E+07	1,321E+07	1,162E+07	1,361E+07	39,	4,416E+08
	TOT DR	,144	,109	5,078E-02	3,815E-02	5,116E-02	7,043E-02	5,169E-02	5,821E-02	5,026E-02	4,477E-02	1,009E-04	,101E+00

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO STRM SURGE IN 2000 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

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BASE LINE STORM SURGE

REGIONAL AND NATIONAL TOTALS

REGIONS		HOUSEHOLD STRUCTURES	FARM+MINES STRUCTURES	CONSTRUCT STRUCTURES	MANUFACTOR STRUCTURES	TRAN+UTILY STRUCTURES	W+RTRADE STRUCTURES	FINANCE STRUCTURES	SERVICES STRUCTURES	FEDGOV STRUCTURES	ST+LOCGOV STRUCTURES	POPULATION IN NUMBER	TOTAL
NE	UR VL	283151,20	907,13	5844,58	34384,04	108611,19	20431,77	57947,47	36716,07	21033,74	43116,00	26398274,	612143,19
	UR DR	4,150E-02	2,010E-02	2,012E-02	1,987E-02	1,897E-02	2,000E-02	1,976E-02	1,995E-02	1,889E-02	2,026E-02	6,043E-05	,297E-01
	RR VL	12886,63	209,15	352,22	1593,64	2107,91	851,77	1009,81	1036,83	2017,41	1750,11	1429044,	23815,49
	RR DR	8,909E-02	2,939E-02	3,777E-02	2,504E-02	5,015E-02	,104	8,983E-02	,110	7,268E-02	5,078E-02	1,130E-04	,773E-01
	TOT VL	296037,83	1116,28	6196,80	35977,68	110719,10	21283,54	58957,29	37752,90	23051,15	44866,11	27827318,	635958,68
	TOT DM	1,290E+08	2,438E+05	1,309E+06	7,230E+06	2,166E+07	4,968E+06	1,235E+07	8,463E+06	5,440E+06	9,622E+06	18,	2,003E+08
	TOT DR	4,357E-02	2,184E-02	2,112E-02	2,010E-02	1,956E-02	2,334E-02	2,096E-02	2,242E-02	2,360E-02	2,145E-02	6,313E-05	,315E-01
SO	UR VL	166957,97	6240,60	4893,98	17219,55	66741,56	12775,59	23487,80	17121,14	25127,74	21750,73	18954052,	362316,65
	UR DR	,343	6,734E-02	9,512E-02	6,711E-02	,117	9,448E-02	,102	,103	7,385E-02	9,119E-02	3,535E-04	,211E+00
	RR VL	33580,36	3018,23	771,75	3615,00	7900,27	2096,65	2677,69	2248,81	2604,90	5183,01	4547437,	63696,68
	RR DR	,424	,204	,136	,132	,153	,517	,532	,507	,149	,134	4,125E-04	,336E+00
	TOT VL	200538,33	9258,83	5665,72	20834,56	74641,83	14872,24	26165,49	19369,95	27732,64	26933,74	23501489,	426013,33
	TOT DM	7,159E+08	1,035E+07	5,702E+06	1,634E+07	9,009E+07	2,292E+07	3,810E+07	2,899E+07	2,244E+07	2,680E+07	86,	9,776E+08
	TOT DR	,357	,112	,101	7,842E-02	,121	,154	,146	,150	8,092E-02	9,950E-02	3,649E-04	,229E+00
US	UR VL	450109,17	7147,72	10738,56	51603,59	175352,75	33207,36	81435,27	53837,21	46161,48	64866,73	45352326,	974459,84
	UR DR	,154	6,135E-02	5,430E-02	3,563E-02	5,624E-02	4,865E-02	4,334E-02	4,627E-02	4,881E-02	4,404E-02	1,829E-04	,970E-01
	RR VL	46466,99	3227,39	1123,97	5208,65	10008,18	2948,43	3687,50	3285,63	4622,32	6933,12	5976481,	87512,17
	RR DR	,331	,192	,105	9,950E-02	,131	,398	,411	,382	,116	,113	3,409E-04	,265E+00
	TOT VL	496576,16	10375,11	11862,53	56812,24	185360,93	36155,78	85122,77	57122,85	50783,79	71799,85	51328807,	1061972,01
	TOT DM	8,449E+08	1,059E+07	7,011E+06	2,357E+07	1,117E+08	2,788E+07	5,045E+07	3,745E+07	2,788E+07	3,642E+07	103,	1,178E+09
	TOT DR	,170	,102	5,910E-02	4,149E-02	6,029E-02	7,712E-02	5,927E-02	6,556E-02	5,490E-02	5,073E-02	2,013E-04	,111E+00

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO EARTHQUAKE IN 1970 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

BASE LINE EARTHQUAKE

REGIONAL AND NATIONAL TOTALS

REGIONS		HOUSEHOLD STRUCTURES	FARM+MINES STRUCTURES	CONSTRUCT STRUCTURES	MANUFACTOR STRUCTURES	TRAN+UTILY STRUCTURES	W+R TRADE STRUCTURES	FINANCE STRUCTURES	SERVICES STRUCTURES	FEDGOV STRUCTURES	ST+LOC GOV STRUCTURES	POPULATION IN NUMBER	TOTAL
NE	UR VL	228551,36	468,32	5278,49	22464,01	53078,07	17741,22	30683,94	23566,02	17566,51	30778,81	35106566,	430176,75
	UR DR	7,662E-03	3,409E-03	3,883E-03	3,436E-03	4,776E-03	4,337E-03	5,202E-03	4,505E-03	3,906E-03	4,491E-03	4,886E-05	,617E-02
	RR VL	21294,99	288,74	548,44	1951,15	2929,42	1397,26	1142,81	1420,27	2151,25	3303,01	4187136,	36427,35
	RR DR	9,417E-04	2,680E-04	4,553E-04	3,489E-04	4,190E-04	4,645E-04	4,362E-04	4,637E-04	9,875E-04	4,591E-04	1,040E-05	,761E-03
	TOT VL	249846,35	757,06	5826,93	24415,16	56007,50	19138,48	31826,75	24986,29	19717,76	34081,82	39293702,	466604,10
	TOT DM	1,771E+07	1,674E+04	2,075E+05	7,787E+05	2,548E+06	7,760E+05	1,601E+06	1,068E+06	7,074E+05	1,398E+06	18,	2,681E+07
	TOT DR	7,090E-03	2,211E-03	3,561E-03	3,190E-03	4,549E-03	4,055E-03	5,030E-03	4,275E-03	3,588E-03	4,100E-03	4,476E-05	,575E-02
NC	UR VL	106421,57	555,24	2660,36	15143,03	22521,87	8436,87	9335,63	8739,03	9584,17	13013,69	18014973,	196411,45
	UR DR	1,850E-03	9,506E-04	8,375E-04	8,548E-04	8,815E-04	8,504E-04	8,249E-04	8,300E-04	9,245E-04	7,711E-04	1,446E-05	,139E-02
	RR VL	43192,39	2125,95	872,44	4112,88	6598,27	2864,80	1974,51	2421,47	2606,47	6417,70	9128126,	73186,88
	RR DR	2,533E-02	1,899E-02	1,657E-02	1,651E-02	1,631E-02	2,012E-02	1,899E-02	1,719E-02	1,862E-02	1,517E-02	1,187E-04	,220E-01
	TOT VL	149613,96	2681,19	3532,80	19255,91	29120,14	11301,67	11310,14	11160,50	12190,64	19431,39	27143099,	269598,33
	TOT DM	1,291E+07	4,090E+05	1,669E+05	8,084E+05	1,274E+06	6,482E+05	4,519E+05	4,888E+05	5,740E+05	1,074E+06	13,	1,881E+07
	TOT DR	8,629E-03	1,525E-02	4,723E-03	4,198E-03	4,376E-03	5,735E-03	3,996E-03	4,379E-03	4,708E-03	5,526E-03	4,951E-05	,698E-02
SO	UR VL	128885,78	3351,07	3752,45	9554,31	31947,21	10965,72	13846,60	11886,20	33234,97	16458,56	24066946,	263882,86
	UR DR	9,973E-03	1,563E-03	6,689E-03	6,953E-03	6,028E-03	7,664E-03	6,449E-03	6,263E-03	4,524E-03	6,977E-03	5,033E-05	,791E-02
	RR VL	76397,19	4378,69	1596,78	7818,63	11558,19	4798,99	3696,54	4238,11	6134,37	10520,25	19253767,	131137,74
	RR DR	6,101E-03	3,238E-03	3,468E-03	4,120E-03	3,350E-03	4,029E-03	3,681E-03	3,492E-03	3,367E-03	3,292E-03	3,931E-05	,503E-02
	TOT VL	205282,97	7729,75	5349,23	17372,94	43505,40	15764,71	17543,14	16124,31	39369,33	26978,82	43320713,	395020,61
	TOT DM	1,751E+07	1,942E+05	3,064E+05	9,864E+05	2,313E+06	1,034E+06	1,029E+06	8,924E+05	1,710E+06	1,495E+06	20,	2,747E+07
	TOT DR	8,532E-03	2,512E-03	5,727E-03	5,678E-03	5,317E-03	6,558E-03	5,866E-03	5,534E-03	4,344E-03	5,540E-03	4,543E-05	,696E-02
WT	UR VL	158864,45	1769,48	3785,74	12597,72	36253,09	12829,38	16558,85	15068,76	21176,17	24501,35	26752876,	303404,98
	UR DR	,181	,254	,162	,172	,192	,176	,183	,172	,191	,172	7,465E-04	,181E+00
	RR VL	31249,07	2363,49	789,29	1619,07	5945,17	2081,66	1551,42	2078,57	5166,56	6821,25	6659105,	59665,54
	RR DR	6,008E-02	2,555E-02	4,369E-02	3,937E-02	3,734E-02	4,392E-02	4,239E-02	3,758E-02	5,870E-02	5,187E-02	3,455E-04	,528E-01
	TOT VL	190113,51	4132,97	4575,04	14216,78	42198,27	14911,04	18110,26	17147,33	26342,73	31322,59	33411981,	363070,52
	TOT DM	3,061E+08	5,093E+06	6,481E+06	2,227E+07	7,177E+07	2,350E+07	3,103E+07	2,666E+07	4,351E+07	4,574E+07	223,	5,821E+08
	TOT DR	,161	,123	,142	,157	,170	,158	,171	,156	,165	,146	6,666E-04	,160E+00
US	UR VL	622723,16	6144,10	15477,04	59759,06	143800,24	49973,19	70425,02	59260,00	81561,82	84752,41	103941361,	1193876,04
	UR DR	5,133E-02	7,427E-02	4,274E-02	3,881E-02	5,161E-02	4,857E-02	4,677E-02	4,685E-02	5,242E-02	5,289E-02	2,228E-04	,503E-01
	RR VL	172133,63	9156,87	3806,96	15501,74	27031,06	11142,71	8365,27	10158,43	16058,64	27062,21	39228134,	300417,53
	RR DR	2,009E-02	1,256E-02	1,438E-02	1,061E-02	1,367E-02	1,517E-02	1,403E-02	1,331E-02	2,333E-02	1,801E-02	1,067E-04	,181E-01
	TOT VL	794856,79	15300,98	19284,01	75260,80	170831,30	61115,90	78790,29	69418,43	97620,46	111814,62	143169495,	1494293,56
	TOT DM	3,542E+08	5,713E+06	7,162E+06	2,484E+07	7,790E+07	2,596E+07	3,411E+07	2,911E+07	4,650E+07	4,970E+07	273,	6,552E+08
	TOT DR	4,456E-02	3,734E-02	3,714E-02	3,301E-02	4,560E-02	4,248E-02	4,330E-02	4,194E-02	4,764E-02	4,445E-02	1,910E-04	,438E-01

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO EARTHQUAKE IN 2000 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

BASE LINE EARTHQUAKE

REGIONAL AND NATIONAL TOTALS

REGIONS		HOUSEHOLD STRUCTURES	FARM+MINE STRUCTURES	CONSTRUCT STRUCTURES	MANUFACTOR STRUCTURES	TRAN+UTIL STRUCTURES	W+R TRADE STRUCTURES	FINANCE STRUCTURES	SERVICE STRUCTURES	FED GOV STRUCTURES	ST+LOC GOV STRUCTURES	POPULATION IN NUMBER	TOTAL
NE	UR VL	467269,78	1986,00	10179,44	65615,89	163793,18	33223,75	83383,09	56553,34	36882,05	69894,71	45017130,	988781,23
	UR DR	6,501E-03	2,450E-03	2,948E-03	2,607E-03	3,643E-03	3,296E-03	3,962E-03	3,419E-03	2,980E-03	3,403E-03	5,618E-05	,488E-02
	RR VL	42744,95	1103,23	1041,27	5498,22	8842,65	2584,55	3092,99	3355,82	4667,40	7287,61	4919801,	80218,69
	RR DR	8,978E-04	2,529E-04	3,923E-04	2,961E-04	3,663E-04	4,014E-04	3,744E-04	4,029E-04	8,636E-04	4,013E-04	1,362E-05	,679E-03
	TOT VL	510014,73	3089,23	11220,71	71114,11	172635,83	35808,30	86476,07	59909,16	41549,45	77182,32	49936931,	1068999,92
	TOT DM	3,076E+07	5,145E+04	3,042E+05	1,727E+06	5,999E+06	1,105E+06	3,315E+06	1,947E+06	1,139E+06	2,408E+06	26,	4,876E+07
	TOT DR	6,031E-03	1,665E-03	2,711E-03	2,429E-03	3,475E-03	3,087E-03	3,833E-03	3,250E-03	2,742E-03	3,119E-03	5,198E-05	,456E-02
NC	UR VL	214891,93	2034,03	5058,83	43300,13	69074,02	15610,81	25477,62	20754,71	20115,15	29788,88	22085015,	446106,12
	UR DR	1,590E-03	8,158E-04	6,495E-04	6,676E-04	6,842E-04	6,613E-04	6,353E-04	6,436E-04	7,125E-04	5,921E-04	1,736E-05	,111E-02
	RR VL	80460,63	7975,52	1534,58	11267,24	18591,01	4865,56	4903,44	5283,55	4909,56	13286,12	9777941,	153077,21
	RR DR	2,304E-02	2,173E-02	1,411E-02	1,367E-02	1,408E-02	1,736E-02	1,640E-02	1,478E-02	1,631E-02	1,299E-02	1,627E-04	,193E-01
	TOT VL	295352,56	10009,55	6593,41	54567,37	87665,03	20476,37	30381,06	26038,26	25024,71	43075,01	31862956,	599183,33
	TOT DM	2,195E+07	1,750E+06	2,494E+05	1,830E+06	3,090E+06	9,478E+05	9,660E+05	9,144E+05	9,442E+05	1,902E+06	20,	3,455E+07
	TOT DR	7,433E-03	1,748E-02	3,783E-03	3,353E-03	3,525E-03	4,629E-03	3,180E-03	3,512E-03	3,773E-03	4,416E-03	6,198E-05	,577E-02
SO	UR VL	326374,84	11470,40	8994,71	32326,83	122836,81	25211,02	47609,45	36036,54	93102,13	46281,03	36236200,	750243,76
	UR DR	8,220E-03	1,649E-03	5,112E-03	5,676E-03	4,651E-03	5,982E-03	4,935E-03	4,742E-03	3,197E-03	5,387E-03	5,694E-05	,614E-02
	RR VL	154108,69	15263,60	3059,78	22657,78	35353,80	8897,37	10099,14	10092,25	13008,85	23641,80	21411254,	296183,06
	RR DR	5,315E-03	3,420E-03	2,789E-03	3,325E-03	2,715E-03	3,259E-03	2,964E-03	2,818E-03	2,699E-03	2,659E-03	5,287E-05	,417E-02
	TOT VL	480483,54	26734,00	12054,49	54984,61	158190,61	34108,39	57708,60	46128,79	106110,99	69922,83	57647454,	1046426,82
	TOT DM	3,502E+07	7,111E+05	5,452E+05	2,588E+06	6,673E+06	1,798E+06	2,649E+06	1,993E+06	3,327E+06	3,122E+06	32,	5,843E+07
	TOT DR	7,288E-03	2,660E-03	4,523E-03	4,707E-03	4,218E-03	5,271E-03	4,590E-03	4,321E-03	3,136E-03	4,465E-03	5,543E-05	,558E-02
WT	UR VL	344449,19	7068,10	7793,55	38691,75	118683,34	25424,84	47955,36	38479,54	47668,00	59079,71	35748630,	735293,38
	UR DR	,128	,188	,121	,130	,145	,133	,138	,129	,144	,130	8,173E-04	,133E+00
	RR VL	59034,81	8111,63	1418,45	4327,55	17039,06	3594,78	3949,11	4760,17	10422,19	14454,87	7295894,	127112,61
	RR DR	5,239E-02	2,811E-02	3,681E-02	3,324E-02	3,137E-02	3,600E-02	3,526E-02	3,096E-02	4,876E-02	4,270E-02	4,551E-04	,440E-01
	TOT VL	403484,00	15179,72	9212,00	43019,30	135722,40	29019,62	51904,48	43239,71	58090,18	73534,58	43044524,	862405,99
	TOT DM	4,706E+08	1,555E+07	9,980E+06	5,164E+07	1,773E+08	3,515E+07	6,761E+07	5,108E+07	7,354E+07	8,281E+07	325,	1,035E+09
	TOT DR	,117	,102	,108	,120	,131	,121	,130	,118	,127	,113	7,559E-04	,120E+00
US	UR VL	1352985,75	22558,53	32026,54	179934,60	474387,35	99470,42	204425,52	151824,12	197767,33	205044,33	139086975,	2920424,50
	UR DR	3,698E-02	5,997E-02	3,201E-02	3,003E-02	3,881E-02	3,675E-02	3,524E-02	3,516E-02	3,675E-02	3,984E-02	2,458E-04	,369E-01
	RR VL	336349,07	32453,98	7054,08	43750,79	79826,52	19942,25	22044,69	23491,79	33008,00	58670,41	43404890,	656591,57
	RR DR	1,726E-02	1,398E-02	1,174E-02	8,569E-03	1,122E-02	1,223E-02	1,137E-02	1,087E-02	1,901E-02	1,458E-02	1,408E-04	,150E-01
	TOT VL	1689334,82	55012,50	39080,61	223685,39	554213,87	119412,68	226470,21	175315,91	230775,33	263714,74	182491865,	3577016,07
	TOT DM	5,584E+08	1,807E+07	1,108E+07	5,778E+07	1,931E+08	3,900E+07	7,454E+07	5,593E+07	7,895E+07	9,024E+07	403,	1,177E+09
	TOT DR	3,305E-02	3,284E-02	2,835E-02	2,583E-02	3,484E-02	3,266E-02	3,291E-02	3,190E-02	3,421E-02	3,422E-02	2,209E-04	,329E-01

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO TORNADO IN 1970 VALUED IN MILLIONS OF 1970 $ MGT= -0 -0 -0 -0 -0

REGIONAL AND NATIONAL TOTALS

REGIONS		HOUSING STRUCTURES	FARM+MINES STRUCTURES	CONSTRUCT STRUCTURES	MANUFACTOR STRUCTURES	TRAN+UTILY STRUCTURES	W+R TRADES STRUCTURES	FINANCE STRUCTURES	SERVICES STRUCTURES	FED GOV STRUCTURES	ST+LOC GOV STRUCTURES	POPULATION IN NUMBER	TOTAL
NE	UR VL	184128.10	898.63	4566.64	21012.57	39732.12	13958.16	19313.40	17575.70	14585.16	22917.67	30521471.	338688.15
	UR DR	3.012E-02	1.278E-02	2.015E-02	1.955E-02	2.030E-02	3.084E-02	3.030E-02	3.174E-02	2.088E-02	2.008E-02	1.352E-04	.272E-01
	RR VL	36177.78	833.48	848.38	3522.65	5460.76	2317.29	1873.99	2413.56	3075.69	5602.83	7272949.	62126.42
	RR DR	1.915E-02	1.140E-02	1.435E-02	1.409E-02	1.235E-02	2.365E-02	2.445E-02	2.363E-02	1.333E-02	1.240E-02	6.778E-05	.177E-01
	TOT VL	220305.88	1732.11	5415.02	24535.22	45192.88	16275.45	21187.39	19989.26	17660.85	28520.50	37794420.	400814.57
	TOT DM	6.239E+07	2.098E+05	1.042E+06	4.605E+06	8.739E+06	4.853E+06	6.310E+06	6.148E+06	3.455E+06	5.296E+06	46.	1.031E+08
	TOT DR	2.832E-02	1.211E-02	1.925E-02	1.877E-02	1.934E-02	2.982E-02	2.978E-02	3.076E-02	1.956E-02	1.857E-02	1.222E-04	.257E-01
NC	UR VL	224952.14	1380.31	5915.36	30585.94	50285.26	18335.57	21314.47	18735.84	18396.63	27989.56	37542643.	417891.08
	UR DR	8.724E-02	4.980E-02	5.076E-02	5.625E-02	6.340E-02	.107	.109	.107	6.546E-02	5.783E-02	4.069E-04	.815E-01
	RR VL	88209.49	3472.82	1796.32	8405.24	13058.84	5870.62	4066.39	4930.09	5383.43	13336.91	18798180.	148530.15
	RR DR	7.187E-02	4.906E-02	5.161E-02	5.101E-02	5.164E-02	.111	.111	.110	5.128E-02	5.170E-02	2.461E-04	.695E-01
	TOT VL	313161.64	4853.13	7711.68	38991.18	63344.09	24206.19	25380.87	23665.93	23780.05	41326.47	56340823.	566421.23
	TOT DM	2.596E+08	2.391E+06	4.521E+06	2.149E+07	3.863E+07	2.622E+07	2.773E+07	2.539E+07	1.480E+07	2.308E+07	199.	4.439E+08
	TOT DR	8.291E-02	4.927E-02	5.862E-02	5.512E-02	6.098E-02	.108	.109	.107	6.225E-02	5.585E-02	3.532E-04	.784E-01
SO	UR VL	181103.72	3723.05	5145.24	14489.12	44585.76	15616.72	19773.99	16357.73	43367.58	23045.30	34249246.	367208.21
	UR DR	6.177E-02	6.431E-02	4.339E-02	4.352E-02	4.397E-02	9.322E-02	9.228E-02	8.942E-02	3.386E-02	4.150E-02	2.802E-04	.583E-01
	RR VL	108836.18	5851.41	2252.30	11061.27	15888.26	6791.58	5336.89	6001.77	9475.38	15071.96	27671865.	186567.01
	RR DR	4.696E-02	3.302E-02	3.284E-02	3.152E-02	3.496E-02	9.664E-02	9.798E-02	9.608E-02	3.298E-02	3.452E-02	1.437E-04	.475E-01
	TOT VL	289939.90	9574.46	7397.54	25550.39	60474.02	22408.30	25110.88	22359.49	52842.97	38117.26	61921111.	553775.21
	TOT DM	1.630E+08	4.327E+06	2.972E+06	9.792E+06	2.516E+07	2.112E+07	2.348E+07	2.039E+07	1.781E+07	1.477E+07	136.	3.028E+08
	TOT DR	5.621E-02	4.519E-02	4.018E-02	3.833E-02	4.160E-02	9.425E-02	9.349E-02	9.121E-02	3.371E-02	3.874E-02	2.192E-04	.547E-01
WT	UR VL	123140.78	1531.72	2966.33	10245.89	26300.74	9981.22	12469.74	11880.25	15843.58	18817.77	21074116.	233178.02
	UR DR	1.189E-02	9.154E-03	8.792E-03	7.967E-03	8.438E-03	1.465E-02	1.453E-02	1.374E-02	8.135E-03	7.605E-03	5.469E-05	.110E-01
	RR VL	18480.76	1696.01	442.74	888.41	3279.84	1243.63	919.05	1190.92	2895.69	3763.06	4068279.	34800.11
	RR DR	1.352E-02	1.036E-02	8.808E-03	8.130E-03	9.297E-03	2.045E-02	2.061E-02	1.932E-02	7.331E-03	9.526E-03	4.777E-05	.125E-01
	TOT VL	141621.54	3227.73	3409.07	11134.30	29580.58	11224.85	13388.78	13071.17	18739.27	22580.83	25142395.	267978.13
	TOT DM	1.714E+07	3.158E+05	2.998E+05	8.885E+05	2.524E+06	1.717E+06	2.001E+06	1.863E+06	1.501E+06	1.790E+06	13.	3.004E+07
	TOT DR	1.211E-02	9.786E-03	8.794E-03	7.980E-03	8.533E-03	1.529E-02	1.495E-02	1.425E-02	8.011E-03	7.925E-03	5.357E-05	.112E-01
US	UR VL	713324.74	7533.71	18593.57	76333.51	160903.87	57891.68	72871.60	64549.51	92192.95	92770.30	123387476.	1356965.46
	UR DR	5.302E-02	4.429E-02	3.769E-02	3.725E-02	3.839E-02	6.910E-02	6.743E-02	6.475E-02	3.369E-02	3.426E-02	2.444E-04	.496E-01
	RR VL	251704.22	11853.71	5339.74	23877.58	37687.70	16223.12	12196.32	14536.34	20830.19	37774.76	57811273.	432023.68
	RR DR	4.924E-02	3.296E-02	3.422E-02	3.494E-02	3.523E-02	8.572E-02	8.512E-02	8.256E-02	3.124E-02	3.482E-02	1.607E-04	.480E-01
	TOT VL	965028.96	19387.43	23933.31	100211.09	198591.57	74114.80	85067.92	79085.86	113023.14	130545.06	181198749.	1788989.15
	TOT DM	5.022E+08	7.243E+06	8.835E+06	3.679E+07	7.505E+07	5.391E+07	5.952E+07	5.380E+07	3.757E+07	4.494E+07	394.	8.798E+08
	TOT DR	5.204E-02	3.736E-02	3.691E-02	3.670E-02	3.779E-02	7.274E-02	6.997E-02	6.802E-02	3.324E-02	3.442E-02	2.177E-04	.492E-01

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO TORNADO IN 2000 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

BASE LINE TORNADO

REGIONAL AND NATIONAL TOTALS

REGIONS		HOUSEHOLD STRUCTURES	FARM+MINES STRUCTURES	CONSTRUCT STRUCTURES	MANUFACTOR STRUCTURES	TRAN+UTILY STRUCTURES	W+R TRADE STRUCTURES	FINANCE STRUCTURES	SERVICES STRUCTURES	FED GOV STRUCTURES	ST+LOC GOV STRUCTURES	POPULATION IN NUMBER	TOTAL
NE	UR VL	376769,14	3033,04	8788,68	60752,13	123041,63	26221,78	53234,09	42452,89	30680,03	52265,58	38176315,	777238,98
	UR DR	3,075E-02	1,447E-02	2,059E-02	1,994E-02	2,075E-02	3,000E-02	2,945E-02	3,088E-02	2,131E-02	2,050E-02	2,462E-04	,270E-01
	RR VL	71177,27	2746,50	1582,35	9706,46	16186,27	4198,10	4986,52	5609,83	6500,02	12213,08	8280923,	134906,40
	RR DR	1,952E-02	1,154E-02	1,464E-02	1,440E-02	1,256E-02	2,290E-02	2,371E-02	2,284E-02	1,348E-02	1,260E-02	1,284E-04	,176E-01
	TOT VL	447946,40	5779,54	10371,03	70458,59	139227,90	30419,88	58220,60	48062,72	37180,04	64478,67	46457238,	912145,38
	TOT DM	1,298E+08	7,560E+05	2,041E+06	1,351E+07	2,756E+07	8,827E+06	1,686E+07	1,439E+07	7,416E+06	1,225E+07	105,	2,334E+08
	TOT DR	2,897E-02	1,308E-02	1,968E-02	1,918E-02	1,980E-02	2,902E-02	2,895E-02	2,994E-02	1,995E-02	1,900E-02	2,252E-04	,256E-01
NC	UR VL	462642,59	4851,35	11462,00	88784,81	157691,47	34615,63	59363,21	45312,76	39317,74	65272,28	46999781,	969313,83
	UR DR	8,712E-02	5,309E-02	6,068E-02	5,618E-02	6,351E-02	,101	,102	,100	6,510E-02	5,745E-02	7,312E-04	,791E-01
	RR VL	166342,33	14332,99	3199,18	23105,64	37291,17	10103,58	10244,95	10891,17	10370,22	28002,71	20336844,	313883,94
	RR DR	7,152E-02	5,144E-02	5,142E-02	5,088E-02	5,130E-02	,105	,104	,104	5,122E-02	5,150E-02	4,655E-04	,673E-01
	TOT VL	628984,93	19184,34	14661,18	111890,44	194982,64	44719,21	69608,16	56203,93	49687,95	93275,00	67336625,	1283197,78
	TOT DM	5,220E+08	9,948E+06	8,600E+06	6,164E+07	1,193E+08	4,550E+07	7,131E+07	5,663E+07	3,091E+07	5,192E+07	438,	9,778E+08
	TOT DR	8,300E-02	5,186E-02	5,866E-02	5,509E-02	6,118E-02	,102	,102	,101	6,220E-02	5,566E-02	6,510E-04	,762E-01
SO	UR VL	454004,49	12986,48	12205,31	49302,85	170968,61	35783,10	67366,74	49042,86	118372,41	64082,79	50921828,	1034115,64
	UR DR	6,159E-02	6,418E-02	4,342E-02	4,404E-02	4,353E-02	8,599E-02	8,500E-02	8,161E-02	3,205E-02	4,124E-02	5,122E-04	,563E-01
	RR VL	222949,40	21147,54	4390,07	32261,79	49245,36	12790,54	14925,03	14520,62	20403,17	34352,62	31145598,	426986,14
	RR DR	4,557E-02	3,398E-02	3,199E-02	3,087E-02	3,380E-02	8,664E-02	8,755E-02	8,601E-02	3,195E-02	3,365E-02	2,757E-04	,449E-01
	TOT VL	676953,88	34134,02	16595,38	81564,64	220213,97	48573,64	82291,78	63563,48	138775,58	98435,41	82067426,	1461101,78
	TOT DM	3,812E+08	1,552E+07	6,704E+06	3,167E+07	9,107E+07	4,185E+07	7,033E+07	5,251E+07	4,446E+07	3,799E+07	347,	7,733E+08
	TOT DR	5,631E-02	4,547E-02	4,040E-02	3,883E-02	4,135E-02	8,616E-02	8,546E-02	8,262E-02	3,204E-02	3,859E-02	4,224E-04	,529E-01
WT	UR VL	270037,05	5970,95	6193,17	31778,84	87208,37	19990,06	36557,42	30662,81	36222,10	45889,75	28465706,	570510,53
	UR DR	1,208E-02	8,754E-03	8,934E-03	8,100E-03	8,618E-03	1,410E-02	1,400E-02	1,313E-02	8,247E-03	7,718E-03	9,807E-05	,109E-01
	RR VL	34486,91	5877,42	786,55	2352,60	9219,97	2120,27	2316,63	2653,77	5898,50	7823,13	4393503,	73535,76
	RR DR	1,337E-02	1,044E-02	8,866E-03	8,224E-03	9,169E-03	1,913E-02	1,925E-02	1,779E-02	7,163E-03	9,608E-03	9,012E-05	,120E-01
	TOT VL	304523,97	11848,37	6979,72	34131,44	96428,34	22110,33	38874,04	33316,58	42120,60	53712,89	32859208,	644046,29
	TOT DM	3,722E+07	1,136E+06	6,231E+05	2,767E+06	8,361E+06	3,225E+06	5,565E+06	4,499E+06	3,410E+06	4,293E+06	32,	7,110E+07
	TOT DR	1,222E-02	9,591E-03	8,927E-03	8,108E-03	8,671E-03	1,458E-02	1,432E-02	1,351E-02	8,095E-03	7,993E-03	9,701E-05	,110E-01
US	UR VL	1563453,27	26841,82	38649,16	230618,63	538910,08	116610,57	216521,46	167471,33	224592,27	227510,41	164563630,	3351178,99
	UR DR	5,316E-02	4,423E-02	3,782E-02	3,741E-02	3,853E-02	6,549E-02	6,406E-02	6,120E-02	3,253E-02	3,436E-02	4,414E-04	,484E-01
	RR VL	494955,91	44104,46	9958,15	67426,49	111942,77	29212,49	32473,13	33675,39	43171,90	82391,55	64156868,	949312,24
	RR DR	4,830E-02	3,512E-02	3,365E-02	3,457E-02	3,453E-02	7,888E-02	7,808E-02	7,584E-02	3,041E-02	3,432E-02	3,041E-04	,458E-01
	TOT VL	2058409,18	70946,28	48607,31	298045,12	650852,85	145823,06	248994,58	201146,72	267764,18	309901,96	228720498,	4300491,23
	TOT DM	1,070E+09	2,736E+07	1,797E+07	1,096E+08	2,463E+08	9,941E+07	1,641E+08	1,280E+08	8,619E+07	1,065E+08	922,	2,056E+09
	TOT DR	5,199E-02	3,857E-02	3,697E-02	3,677E-02	3,784E-02	6,817E-02	6,589E-02	6,365E-02	3,219E-02	3,435E-02	4,029E-04	,478E-01

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO HURRICANE IN 1970 VALUED IN MILLIONS OF 1970 $ MGT= -0 -0 -0 -0 -0

REGIONAL AND NATIONAL TOTALS

REGIONS		HOUSING STRUCTURES	FARM+MINES STRUCTURES	CONSTRUCT STRUCTURES	MANUFACTOR STRUCTURES	TRAN+UTILY STRUCTURES	W+R TRADES STRUCTURES	FINANCE STRUCTURES	SERVICES STRUCTURES	FLD GOV STRUCTURES	ST+LOC GOV STRUCTURES	POPULATION IN NUMBER	TOTAL
NE	UR VL	209819.41	404.98	4844.91	20181.04	48428.73	16324.77	28406.12	21878.46	16075.02	27466.11	32201643.	393829.55
	UR DR	9.617E-02	3.358E-02	3.687E-02	3.574E-02	3.405E-02	5.893E-02	6.250E-02	5.993E-02	3.379E-02	3.613E-02	7.715E-05	.719E-01
	RR VL	16943.84	134.48	474.99	1480.55	2203.82	1142.71	992.39	1202.85	1773.92	2452.67	3250056.	28802.22
	RR DR	6.207E-02	2.227E-02	2.686E-02	2.644E-02	3.063E-02	5.235E-02	4.933E-02	5.213E-02	3.468E-02	2.982E-02	3.995E-05	.514E-01
	TOT VL	226763.25	539.46	5319.90	21661.59	50632.55	17467.49	29398.51	23081.31	17848.94	29918.77	35451699.	422631.77
	TOT DM	2.123E+08	1.659E+05	1.914E+06	7.603E+06	1.716E+07	1.022E+07	1.824E+07	1.374E+07	6.047E+06	1.065E+07	26.	2.980E+08
	TOT DR	9.362E-02	3.076E-02	3.597E-02	3.510E-02	3.390E-02	5.850E-02	6.206E-02	5.952E-02	3.388E-02	3.561E-02	7.374E-05	.705E-01
SO	UR VL	95376.23	1964.31	2841.46	6504.36	22639.53	7744.43	9863.72	8697.85	25492.77	12518.69	17549125.	193643.34
	UR DR	.183	8.820E-02	9.307E-02	7.884E-02	.105	.215	.219	.212	4.785E-02	8.047E-02	1.434E-04	.148E+00
	RR VL	38959.28	1543.17	854.40	3621.93	5568.56	2562.71	2164.58	2188.01	3162.39	5578.90	9740440.	66203.94
	RR DR	.165	9.518E-02	8.974E-02	8.985E-02	8.967E-02	.266	.269	.263	8.430E-02	8.642E-02	9.055E-05	.152E+00
	TOT VL	134335.51	3507.48	3695.85	10126.29	28208.09	10307.15	12028.30	10885.85	28655.16	18097.59	27289565.	259847.28
	TOT DM	2.389E+08	3.201E+06	3.411E+06	8.382E+06	2.871E+07	2.343E+07	2.742E+07	2.417E+07	1.486E+07	1.490E+07	34.	3.874E+08
	TOT DR.	.178	9.127E-02	9.230E-02	8.277E-02	.102	.227	.228	.222	5.187E-02	8.231E-02	1.245E-04	.149E+00
US	UR VL	305195.63	2369.29	7686.37	26685.40	71068.26	24069.21	38269.84	30576.31	41567.79	39984.79	49750768.	587472.89
	UR DR	.123	7.887E-02	5.764E-02	4.624E-02	5.657E-02	.109	.103	.103	4.241E-02	5.001E-02	1.005E-04	.970E-01
	RR VL	55903.13	1677.66	1329.39	5102.48	7772.38	3705.43	3156.97	3390.85	4936.30	8031.57	12990496.	95006.16
	RR DR	.134	8.934E-02	6.728E-02	7.145E-02	7.293E-02	.200	.200	.188	6.647E-02	6.914E-02	7.789E-05	.121E+00
	TOT VL	361098.76	4046.95	9015.76	31787.88	78840.64	27774.64	41426.81	33967.16	46504.09	48016.36	62741264.	682479.05
	TOT DM	4.512E+08	3.367E+06	5.325E+06	1.599E+07	4.587E+07	3.364E+07	4.566E+07	3.791E+07	2.091E+07	2.555E+07	60.	6.855E+06
	TOT DR	.125	8.321E-02	5.906E-02	5.029E-02	5.819E-02	.121	.110	.112	4.497E-02	5.321E-02	9.583E-05	.100E+00

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO HURRICANE IN 2000 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

BASE LINE HURRICANE

REGIONAL AND NATIONAL TOTALS

REGIONS		HOUSEHOLD STRUCTURES	FARM+MINES STRUCTURES	CONSTRUCT STRUCTURES	MANUFACTOR STRUCTURES	TRAN+UTILY STRUCTURES	W+R TRADES STRUCTURES	FINANCE STRUCTURES	SERVICES STRUCTURES	FED GOV STRUCTURES	ST+LOC GOV STRUCTURES	POPULATION IN NUMBER	TOTAL
NE	UR VL	427658,56	1653,89	9314,10	58583,59	149199,71	30502,08	77100,14	52412,76	33640,63	62128,16	41201959,	902193,62
	UR DR	9,587E-02	3,549E-02	3,688E-02	3,579E-02	3,415E-02	5,547E-02	5,891E-02	5,642E-02	3,395E-02	3,609E-02	1,302E-04	,678E-01
	RR VL	34700,83	561,61	914,96	4260,10	6780,11	2154,02	2734,28	2895,52	3901,51	5544,84	3927929,	64447,77
	RR DR	6,263E-02	2,521E-02	2,679E-02	2,605E-02	3,055E-02	4,962E-02	4,654E-02	4,950E-02	3,551E-02	2,990E-02	7,173E-05	,498E-01
	TOT VL	462359,39	2215,49	10229,06	62843,69	155979,82	32656,10	79834,42	55308,28	37542,14	67673,00	45129888,	966641,39
	TOT DM	4,317E+08	7,286E+05	3,681E+06	2,208E+07	5,302E+07	1,799E+07	4,669E+07	3,100E+07	1,281E+07	2,408E+07	56,	6,438E+08
	TOT DR	9,338E-02	3,289E-02	3,598E-02	3,513E-02	3,399E-02	5,509E-02	5,849E-02	5,605E-02	3,411E-02	3,559E-02	1,251E-04	,666E-01
SO	UR VL	245948,70	7162,96	6932,39	22058,01	88920,80	18136,82	34414,70	26907,02	71392,86	35680,22	27081329,	557554,48
	UR DR	,201	9,198E-02	,101	8,524E-02	,115	,214	,220	,209	4,479E-02	8,604E-02	2,797E-04	,155E+00
	RR VL	82535,72	6263,30	1727,11	10681,32	17870,41	5000,39	6370,46	5503,34	6974,57	13122,52	11404025,	156049,13
	RR DR	,169	9,618E-02	9,209E-02	8,968E-02	9,102E-02	,248	,253	,246	8,617E-02	8,789E-02	1,786E-04	,149E+00
	TOT VL	328484,42	13426,26	8659,50	32739,33	106791,21	23137,22	40785,16	32410,36	78367,42	48802,74	38485354,	713603,61
	TOT DM	6,346E+08	1,261E+07	8,614E+06	2,838E+07	1,183E+08	5,123E+07	9,186E+07	6,981E+07	3,799E+07	4,223E+07	96,	1,096E+09
	TOT DR	,193	9,394E-02	9,948E-02	8,669E-02	,111	,221	,225	,215	4,847E-02	8,654E-02	2,497E-04	,154E+00
US	UR VL	673607,26	8816,85	16246,49	80641,60	238120,51	48638,91	111514,83	79319,78	105033,49	97808,38	68283288,	1459748,10
	UR DR	,134	8,138E-02	6,438E-02	4,932E-02	6,426E-02	,115	,109	,108	4,132E-02	5,431E-02	1,895E-04	,101E+00
	RR VL	117236,55	6824,91	2642,07	14941,42	24650,52	7154,41	9104,74	8398,85	10876,08	18667,36	15331954,	220496,90
	RR DR	,137	9,034E-02	6,947E-02	7,154E-02	7,439E-02	,188	,191	,178	6,800E-02	7,067E-02	1,512E-04	,120E+00
	TOT VL	790843,81	15641,75	18868,56	95583,02	262771,03	55793,32	120619,58	87718,64	115909,56	116475,74	83615242,	1680245,00
	TOT DM	1,066E+09	1,334E+07	1,229E+07	5,046E+07	1,714E+08	6,922E+07	1,386E+08	1,008E+08	5,079E+07	6,632E+07	153,	1,739E+09
	TOT DR	,135	8,529E-02	6,509E-02	5,279E-02	6,521E-02	,124	,115	,115	4,382E-02	5,694E-02	1,825E-04	,104E+00

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO TSUNAMI IN 1970 VALUED IN MILLIONS OF 1970 $ MGT= -0 -0 -0 -0 -0

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REGIONAL AND NATIONAL TOTALS

REGIONS		HOUSING STRUCTURES	FARM+MINES STRUCTURES	CONSTRUCT STRUCTURES	MANUFACTOR STRUCTURES	TRAN+UTILY STRUCTURES	W+R TRADES STRUCTURES	FINANCE STRUCTURES	SERVICES STRUCTURES	FED GOV STRUCTURES	ST+LOC GOV STRUCTURES	POPULATION IN NUMBER	TOTAL
WT	UR VL	106853.83	654.61	2417.49	8871.11	25529.38	8575.48	11888.05	10288.95	13069.51	15919.73	16870566.	204068.14
	UR DR	6.265E-03	4.917E-04	6.864E-04	3.856E-04	9.372E-03	5.569E-04	5.887E-04	5.852E-04	9.784E-04	6.283E-04	1.263E-04	.468E-02
	RR VL	6802.45	157.02	193.73	471.47	1521.69	433.21	333.39	439.65	1175.55	1731.11	1330285.	13259.26
	RR DR	5.793E-02	0.	0.	0.	4.642E-02	5.581E-02	6.083E-02	7.957E-02	0.	0.	9.126E-04	.410E-01
	TOT VL	113656.27	811.63	2611.22	9342.58	27051.07	9008.69	12221.43	10728.59	14245.06	17650.84	18200851.	217327.40
	TOT DM	1.063E+07	3.219E+03	1.659E+04	3.421E+04	3.099E+06	2.895E+05	2.728E+05	4.101E+05	1.279E+05	1.000E+05	33.	1.499E+07
	TOT DR	9.357E-03	3.966E-04	6.355E-04	3.661E-04	1.146E-02	3.214E-03	2.232E-03	3.822E-03	8.976E-04	5.667E-04	1.837E-04	.690E-02
US	UR VL	106853.83	654.61	2417.49	8871.11	25529.38	8575.48	11888.05	10288.95	13069.51	15919.73	16870566.	204068.14
	UR DR	6.265E-03	4.917E-04	6.864E-04	3.856E-04	9.372E-03	5.569E-04	5.887E-04	5.852E-04	9.784E-04	6.283E-04	1.263E-04	.468E-02
	RR VL	6802.45	157.02	193.73	471.47	1521.69	433.21	333.39	439.65	1175.55	1731.11	1330285.	13259.26
	RR DR	5.793E-02	0.	0.	0.	4.642E-02	5.581E-02	6.083E-02	7.957E-02	0.	0.	9.126E-04	.410E-01
	TOT VL	113656.27	811.63	2611.22	9342.58	27051.07	9008.69	12221.43	10728.59	14245.06	17650.84	18200851.	217327.40
	TOT DM	1.063E+07	3.219E+03	1.659E+04	3.421E+04	3.099E+06	2.895E+05	2.728E+05	4.101E+05	1.279E+05	1.000E+05	33.	1.499E+07
	TOT DR	9.357E-03	3.966E-04	6.355E-04	3.661E-04	1.146E-02	3.214E-03	2.232E-03	3.822E-03	8.976E-04	5.667E-04	1.837E-04	.690E-02

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO TSUNAMI IN 2000 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

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BASE LINE RUN FOR TSUNAMI

REGIONAL AND NATIONAL TOTALS

REGIONS		HOUSEHOLD STRUCTURES	FARM+MINES STRUCTURES	CONSTRUCT STRUCTURES	MANUFACTUR STRUCTURES	TRAN+UTILY STRUCTURES	W+RTRADE STRUCTURES	FINANCE STRUCTURES	SERVICES STRUCTURES	FEDGOV STRUCTURES	ST+LOCGOV STRUCTURES	POPULATION NUMBER	TOTAL
WT	UR VL	224702,72	2555,36	4803,35	26152,00	81313,65	16451,86	33368,19	25323,80	28970,68	37286,13	22131550,	480927,73
	UR DR	2,693E-03	6,600E-04	8,491E-04	4,712E-04	7,996E-03	6,891E-04	7,309E-04	7,227E-04	1,201E-03	7,753E-04	1,402E-04	,289E-02
	RR VL	12824,36	562,26	344,42	1228,82	4386,33	746,51	845,42	962,11	2324,75	3699,52	1475232,	27924,48
	RR DR	2,586E-02	0,	0,	0,	4,120E-02	2,451E-02	2,635E-02	3,284E-02	0,	0,	8,840E-04	,209E-01
	TOT VL	237527,07	3117,61	5147,77	27380,81	85699,97	17198,37	34213,61	26285,91	31295,43	40985,64	23606782,	508852,20
	TOT DM	9,367E+06	1,686E+04	4,079E+04	1,232E+05	8,309E+06	2,963E+05	4,667E+05	4,990E+05	3,480E+05	2,891E+05	44,	1,976E+07
	TOT DR	3,944E-03	5,409E-04	7,923E-04	4,500E-04	9,695E-03	1,723E-03	1,364E-03	1,898E-03	1,112E-03	7,053E-04	1,867E-04	,388E-02
US	UR VL	224702,72	2555,36	4803,35	26152,00	81313,65	16451,86	33368,19	25323,80	28970,68	37286,13	22131550,	480927,73
	UR DR	2,693E-03	6,600E-04	8,491E-04	4,712E-04	7,996E-03	6,891E-04	7,309E-04	7,227E-04	1,201E-03	7,753E-04	1,402E-04	,289E-02
	RR VL	12824,36	562,26	344,42	1228,82	4386,33	746,51	845,42	962,11	2324,75	3699,52	1475232,	27924,48
	RR DR	2,586E-02	0,	0,	0,	4,120E-02	2,451E-02	2,635E-02	3,284E-02	0,	0,	8,840E-04	,209E-01
	TOT VL	237527,07	3117,61	5147,77	27380,81	85699,97	17198,37	34213,61	26285,91	31295,43	40985,64	23606782,	508852,20
	TOT DM	9,367E+06	1,686E+04	4,079E+04	1,232E+05	8,309E+06	2,963E+05	4,667E+05	4,990E+05	3,480E+05	2,891E+05	44,	1,976E+07
	TOT DR	3,944E-03	5,409E-04	7,923E-04	4,500E-04	9,695E-03	1,723E-03	1,364E-03	1,898E-03	1,112E-03	7,053E-04	1,867E-04	,388E-02

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO STRG WINDS IN 1970 VALUED IN MILLIONS OF 1970 $ MGT= -0 -0 -0 -0 -0

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REGIONAL AND NATIONAL TOTALS

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R       HS      FS      CS      MS      TS      WS      FS      SS      FS      SS      P
 E       UT      AT      OT      AT      RT      +T      IT      IT      ET      TT      OI
  G       UR      RR      NR      NR      AP      RR      NR      RR      DR      +R      PN        T
   I       SU      MU      SU      UU      NU       U      AU      VU       U      LU       U        O
    O       IC      +C      TC      FC      +C      TC      NC      IC      GC      OC      LN        T
     N       NT      MT      RT      AT      UT      RT      CT      CT      OT      CT      AU        A
      S       GU      IU      UU      CU      TU      AU      EU      EU      VU       U      TM        L
               R.      NR      CR      TR      IR      DR       R      SR       R      GR      IB
                E      EF      TF      OE      LF      EE       E       E       E      OE      OE
                 S      SS       S      RS      YS       S       S       S       S      VS      NR
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NE	UR VL	262360.77	1041.61	6134.00	26712.18	60232.82	20167.66	33312.45	26397.13	19792.49	34931.83	41389376.	491082.93
	UR DR	9.243E-04	1.516E-04	3.459E-04	3.338E-04	3.124E-04	6.527E-04	6.376E-04	6.744E-04	3.599E-04	3.178E-04	3.714E-06	.698E-03
	RR VL	38083.51	873.47	890.05	3717.15	5764.74	2434.53	1963.44	2534.00	3211.02	5922.60	7668641.	65394.51
	RR DR	4.235E-04	7.354E-05	2.248E-04	1.585E-04	1.272E-04	4.435E-04	4.541E-04	4.137E-04	2.813E-04	1.486E-04	1.316E-06	.344E-03
	TOT VL	300444.28	1915.08	7024.04	30429.32	65997.56	22602.19	35275.89	28931.13	23003.51	40854.43	49058017.	556477.44
	TOT DM	2.586E+06	2.221E+03	2.322E+04	9.506E+04	1.955E+05	1.424E+05	2.213E+05	1.885E+05	8.027E+04	1.198E+05	2.	3.655E+06
	TOT DR	8.608E-04	1.160E-04	3.305E-04	3.124E-04	2.962E-04	6.301E-04	6.274E-04	6.516E-04	3.489E-04	2.932E-04	3.340E-06	.657E-03
NC	UR VL	224952.14	1380.31	5915.36	30585.94	50285.26	18335.57	21314.47	18735.84	18396.63	27989.56	37542643.	417891.08
	UR DR	5.628E-04	4.986E-04	2.427E-04	2.073E-04	2.417E-04	5.605E-04	5.836E-04	5.551E-04	2.758E-04	2.424E-04	2.295E-06	.460E-03
	RR VL	89354.86	3555.17	1821.33	8508.21	13221.70	5943.91	4113.18	4993.31	5484.83	13563.53	19057741.	150560.04
	RR DR	9.911E-04	4.878E-04	4.394E-04	3.424E-04	4.652E-04	1.362E-03	1.313E-03	1.345E-03	5.379E-04	4.685E-04	3.050E-06	.861E-03
	TOT VL	314307.01	4935.48	7736.69	39094.15	63506.96	24279.48	25427.65	23729.15	23881.45	41553.09	56600384.	568451.12
	TOT DM	2.152E+06	2.422E+04	2.236E+04	9.254E+04	1.830E+05	1.837E+05	1.784E+05	1.711E+05	8.023E+04	1.314E+05	1.	3.219E+06
	TOT DR	6.845E-04	4.908E-04	2.890E-04	2.367E-04	2.882E-04	7.567E-04	7.015E-04	7.212E-04	3.360E-04	3.162E-04	2.549E-06	.566E-03
SO	UR VL	184261.07	3842.69	5222.90	14730.30	45690.69	15906.62	20035.32	16593.95	43850.48	23503.32	34978420.	373547.36
	UR DR	5.000E-04	3.270E-04	1.925E-04	1.671E-04	1.966E-04	6.413E-04	6.010E-04	6.083E-04	2.593E-04	2.105E-04	1.980E-06	.414E-03
	RR VL	109419.88	5975.59	2267.49	11114.24	15998.34	6824.94	5359.87	6033.02	9511.97	15169.29	27830810.	187674.64
	RR DR	4.546E-04	2.902E-04	1.905E-04	1.389E-04	2.295E-04	8.742E-04	8.304E-04	6.728E-04	1.919E-04	2.127E-04	1.254E-06	.415E-03
	TOT VL	293680.95	9818.28	7490.39	25844.54	61599.03	22731.56	25395.19	22626.97	53362.46	38672.62	62809230.	561221.99
	TOT DM	1.419E+06	2.990E+04	1.437E+04	4.006E+04	1.264E+05	1.617E+05	1.649E+05	1.536E+05	1.320E+05	8.175E+04	1.	2.323E+06
	TOT DR	4.831E-04	3.046E-04	1.919E-04	1.550E-04	2.052E-04	7.112E-04	6.494E-04	6.788E-04	2.473E-04	2.114E-04	1.658E-06	.414E-03
WT	UR VL	162864.57	1774.73	3928.74	12688.98	37414.46	13134.29	17078.70	15439.92	22640.04	25174.04	27383404.	312138.28
	UR DR	6.413E-04	2.887E-04	2.762E-04	2.336E-04	2.803E-04	6.178E-04	6.080E-04	5.955E-04	2.937E-04	2.505E-04	2.622E-06	.513E-03
	RR VL	34776.55	2582.99	878.19	1840.38	6591.35	2329.33	1733.99	2312.75	5673.55	7499.60	7409496.	66218.67
	RR DR	1.035E-03	5.614E-04	4.532E-04	3.896E-04	4.843E-04	1.309E-03	1.340E-03	1.316E-03	4.425E-04	4.203E-04	3.379E-06	.843E-03
	TOT VL	197640.92	4357.72	4806.93	14529.36	44005.81	15463.62	18812.69	17752.67	28313.59	32673.64	34792900.	378356.95
	TOT DM	1.405E+06	1.962E+04	1.383E+04	3.682E+04	1.368E+05	1.116E+05	1.271E+05	1.224E+05	9.159E+04	9.459E+04	1.	2.160E+06
	TOT DR	7.107E-04	4.503E-04	3.085E-04	2.534E-04	3.109E-04	7.218E-04	6.755E-04	6.894E-04	3.235E-04	2.895E-04	2.783E-06	.571E-03
US	UR VL	834438.36	8039.34	21201.00	84717.39	193533.23	67544.14	91740.94	77166.84	104679.64	111598.76	141293843.	1594659.65
	UR DR	6.779E-04	3.253E-04	2.664E-04	2.442E-04	2.606E-04	6.182E-04	6.115E-04	6.154E-04	2.886E-04	2.611E-04	2.696E-06	.533E-03
	RR VL	271634.80	12987.21	5857.06	25179.98	41576.13	17532.71	13170.46	15873.09	23881.37	42155.03	61966688.	469847.86
	RR DR	7.011E-04	3.836E-04	3.125E-04	2.269E-04	3.306E-04	1.037E-03	9.920E-04	1.013E-03	3.429E-04	3.229E-04	2.068E-06	.608E-03
	TOT VL	1106073.16	21026.56	27058.05	109897.37	235109.36	85076.85	104911.43	93039.93	128561.01	153753.79	203260531.	2064507.51
	TOT DM	7.561E+06	7.597E+04	7.478E+04	2.645E+05	6.417E+05	5.994E+05	6.917E+05	6.356E+05	3.840E+05	4.275E+05	5.	1.136E+07
	TOT DR	6.836E-04	3.613E-04	2.764E-04	2.407E-04	2.729E-04	7.046E-04	6.593E-04	6.832E-04	2.987E-04	2.781E-04	2.505E-06	.550E-03

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO STRG WINDS IN 2000 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

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BASE LINE SEVERE WIND

REGIONAL AND NATIONAL TOTALS

REGIONS		HOUSEHOLDS STRUCTURES	FARM+MINES STRUCTURES	CONSTRUCT STRUCTURES	MANUFACTURERS STRUCTURES	TRAN+UTILY STRUCTURES	W+R TRADE STRUCTURES	FINANCE STRUCTURES	SERVICES STRUCTURES	FEDGOV STRUCTURES	ST+LOCGOV STRUCTURES	POPULATION NUMBER	TOTAL
NE	UR VL	531632,34	3588,53	11709,72	77091,03	184436,20	37456,94	90078,46	62856,93	41196,92	78699,67	52067090,	1118746,75
	UR DR	9,369E-04	1,921E-04	3,513E-04	3,390E-04	3,187E-04	6,160E-04	6,004E-04	6,374E-04	3,647E-04	3,227E-04	6,418E-06	,666E-03
	RR VL	74826,73	2884,97	1657,59	10230,26	17072,86	4404,44	5217,06	5881,06	6768,86	12893,90	8718411,	141837,72
	RR DR	4,655E-04	8,375E-05	2,440E-04	1,736E-04	1,408E-04	4,548E-04	4,613E-04	4,235E-04	3,151E-04	1,636E-04	2,612E-06	,358E-03
	TOT VL	606459,06	6473,50	13367,30	87321,29	201509,06	41861,39	95295,52	68737,99	47965,78	91593,58	60785501,	1260584,47
	TOT DM	5,329E+06	9,311E+03	4,518E+04	2,791E+05	6,118E+05	2,508E+05	5,649E+05	4,255E+05	1,716E+05	2,751E+05	4,	7,962E+06
	TOT DR	8,787E-04	1,438E-04	3,380E-04	3,197E-04	3,036E-04	5,991E-04	5,928E-04	6,191E-04	3,577E-04	3,003E-04	5,872E-06	,632E-03
NC	UR VL	462642,59	4851,35	11462,00	88784,81	157691,47	34615,63	59363,21	45312,76	39317,74	65272,28	46999781,	969313,83
	UR DR	5,661E-04	4,494E-04	2,432E-04	2,085E-04	2,417E-04	5,173E-04	5,404E-04	5,127E-04	2,743E-04	2,419E-04	4,037E-06	,437E-03
	RR VL	168522,79	14583,91	3244,06	23380,73	37760,42	10231,29	10364,13	11032,11	10571,27	28488,43	20617245,	318179,13
	RR DR	9,464E-04	5,183E-04	4,216E-04	3,328E-04	4,403E-04	1,215E-03	1,166E-03	1,198E-03	5,089E-04	4,490E-04	5,408E-06	,782E-03
	TOT VL	631165,38	19435,26	14706,06	112165,53	195451,88	44846,92	69727,34	56344,88	49889,00	93760,71	67617025,	1287492,96
	TOT DM	4,214E+06	9,738E+04	4,156E+04	2,630E+05	5,474E+05	3,034E+05	4,417E+05	3,645E+05	1,616E+05	2,858E+05	3,	6,720E+06
	TOT DR	6,676E-04	5,011E-04	2,826E-04	2,344E-04	2,801E-04	6,764E-04	6,334E-04	6,469E-04	3,240E-04	3,049E-04	4,455E-06	,522E-03
SO	UR VL	459729,51	13319,60	12336,65	49917,89	173748,63	36265,16	68001,39	49544,31	119297,01	65003,57	51672588,	1047163,71
	UR DR	4,585E-04	2,981E-04	1,766E-04	1,581E-04	1,806E-04	5,281E-04	5,002E-04	4,956E-04	2,201E-04	1,900E-04	3,232E-06	,356E-03
	RR VL	224050,68	21481,72	4416,96	32403,57	49561,31	12848,34	14983,37	14589,96	20474,65	34556,87	31305113,	429367,42
	RR DR	4,186E-04	2,757E-04	1,771E-04	1,317E-04	2,089E-04	7,353E-04	6,924E-04	7,327E-04	1,748E-04	1,971E-04	2,234E-06	,363E-03
	TOT VL	683780,19	34801,32	16753,61	82321,46	223309,94	49113,50	82984,76	64134,27	139771,66	99560,44	82977701,	1476531,14
	TOT DM	3,046E+06	9,893E+04	2,960E+04	1,216E+05	4,174E+05	2,860E+05	4,439E+05	3,524E+05	2,983E+05	1,916E+05	2,	5,285E+06
	TOT DR	4,454E-04	2,843E-04	1,767E-04	1,477E-04	1,869E-04	5,823E-04	5,349E-04	5,495E-04	2,134E-04	1,924E-04	2,855E-06	,358E-03
WT	UR VL	354307,27	7114,82	8124,36	39010,50	123046,66	26113,89	49675,24	39553,79	51379,55	60924,16	36731987,	759250,24
	UR DR	6,540E-04	2,751E-04	2,804E-04	2,394E-04	2,851E-04	5,811E-04	5,693E-04	5,616E-04	2,977E-04	2,545E-04	4,599E-06	,496E-03
	RR VL	65297,24	8870,59	1567,19	4886,67	18776,65	3999,37	4389,20	5251,70	11392,32	15785,29	8066945,	140216,23
	RR DR	1,009E-03	5,326E-04	4,421E-04	3,843E-04	4,665E-04	1,179E-03	1,201E-03	1,177E-03	4,316E-04	4,123E-04	6,085E-06	,781E-03
	TOT VL	419604,51	15985,41	9691,55	43897,18	141823,31	30113,26	54064,44	44805,49	62771,87	76709,44	44798932,	899466,46
	TOT DM	2,976E+06	6,682E+04	2,971E+04	1,122E+05	4,384E+05	1,989E+05	3,355E+05	2,839E+05	2,021E+05	2,201E+05	2,	4,863E+06
	TOT DR	7,091E-04	4,180E-04	3,066E-04	2,556E-04	3,091E-04	6,606E-04	6,206E-04	6,337E-04	3,220E-04	2,869E-04	4,867E-06	,541E-03
US	UR VL	1808311,71	28874,30	43632,73	254804,22	638922,96	134451,62	267118,30	197267,79	251191,22	269899,69	187471446,	3894474,54
	UR DR	6,649E-04	3,047E-04	2,603E-04	2,429E-04	2,557E-04	5,601E-04	5,558E-04	5,579E-04	2,682E-04	2,558E-04	4,587E-06	,493E-03
	RR VL	532697,43	47821,18	10885,80	70901,24	123171,23	31483,44	34953,76	36754,84	49207,09	91724,49	68707714,	1029600,50
	RR DR	6,645E-04	3,857E-04	2,983E-04	2,215E-04	3,097E-04	9,082E-04	8,623E-04	8,864E-04	3,253E-04	3,077E-04	3,687E-06	,549E-03
	TOT VL	2341009,14	76695,48	54518,52	325705,46	762094,19	165935,06	302072,05	234022,63	300398,32	361624,18	256179160,	4924075,04
	TOT DM	1,556E+07	2,724E+05	1,460E+05	7,759E+05	2,015E+06	1,039E+06	1,786E+06	1,426E+06	8,337E+05	9,726E+05	11,	2,483E+07
	TOT DR	6,648E-04	3,552E-04	2,679E-04	2,382E-04	2,644E-04	6,262E-04	5,913E-04	6,095E-04	2,775E-04	2,690E-04	4,345E-06	,504E-03

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO LANDSLIDE IN 1970 VALUED IN MILLIONS OF 1970 $ MGT= 0 -0 -0 -0 -0

REGIONAL AND NATIONAL TOTALS

REGIONS		HOUSING STRUCTURES	FARM+MINE STRUCTURES	CONSTRUCT STRUCTURES	MANUFACTUR STRUCTURES	TRAN+UTILY STRUCTURES	W+R TRADE STRUCTURES	FINANCE STRUCTURES	SERVICE STRUCTURES	FED GOV STRUCTURES	ST+LOC GOV STRUCTURES	POPULATION IN NUMBER	TOTAL
NE	UR VL	262360,77	1041,61	6134,00	26712,18	60232,82	20167,66	33312,45	26397,13	19792,49	34931,83	41389376,	491082,93
	UR DR	8,134E-03	1,922E-02	8,286E-03	8,533E-03	8,238E-03	8,048E-03	7,504E-03	7,968E-03	7,856E-03	7,799E-03	2,636E-05	,810E-02
	RR VL	38083,51	873,47	890,05	3717,15	5764,74	2434,53	1963,44	2534,00	3211,02	5922,60	7668641,	65394,51
	RR DR	1,119E-02	1,865E-02	1,020E-02	1,235E-02	1,209E-02	1,094E-02	1,043E-02	1,058E-02	9,355E-03	1,069E-02	5,547E-05	,112E-01
	TOT VL	300444,28	1915,08	7024,04	30429,32	65997,56	22602,19	35275,89	28931,13	23003,51	40854,43	49058017,	556477,44
	TOT DM	,256E+08	,363E+06	,599E+06	,274E+07	,566E+07	,189E+07	,270E+07	,237E+07	,186E+07	,336E+07	15,	,471E+08
	TOT DR	8,522E-03	1,896E-02	8,528E-03	9,000E-03	8,574E-03	8,360E-03	7,667E-03	8,197E-03	8,065E-03	8,218E-03	3,091E-05	,847E-02
NC	UR VL	224952,14	1380,31	5915,36	30585,94	50285,26	18335,57	21314,47	18735,84	18396,63	27989,56	37542643,	417891,08
	UR DR	1,042E-02	1,161E-02	1,055E-02	9,982E-03	1,101E-02	1,058E-02	1,058E-02	1,052E-02	1,104E-02	9,931E-03	6,090E-05	,105E-01
	RR VL	89354,86	3555,17	1821,33	8508,21	13221,70	5943,91	4113,18	4993,31	5484,83	13563,53	19057741,	150560,04
	RR DR	9,859E-03	1,234E-02	9,901E-03	9,405E-03	1,002E-02	9,870E-03	9,930E-03	9,992E-03	1,013E-02	9,972E-03	3,805E-05	,993E-02
	TOT VL	314307,01	4935,48	7736,69	39094,15	63506,96	24279,48	25427,65	23729,15	23881,45	41553,09	56600384,	568451,12
	TOT DM	,322E+08	,599E+06	,804E+06	,385E+07	,686E+07	,253E+07	,266E+07	,247E+07	,259E+07	,413E+07	30,	,587E+08
	TOT DR	1,026E-02	1,214E-02	1,040E-02	9,857E-03	1,080E-02	1,040E-02	1,048E-02	1,041E-02	1,083E-02	9,945E-03	5,320E-05	,103E-01
SO	UR VL	184261,07	3842,69	5222,90	14730,30	45600,69	15906,62	20035,32	16593,95	43850,48	23503,32	34978420,	373547,36
	UR DR	1,011E-02	9,654E-03	9,957E-03	1,068E-02	1,020E-02	9,865E-03	9,763E-03	1,004E-02	1,054E-02	1,018E-02	5,374E-05	,102E-01
	RR VL	109419,88	5975,59	2267,49	11114,24	15998,34	6824,94	5359,87	6033,02	9511,97	15169,29	27830810,	187674,64
	RR DR	1,015E-02	1,530E-02	1,043E-02	1,009E-02	1,084E-02	9,963E-03	9,554E-03	1,012E-02	1,024E-02	1,032E-02	3,647E-05	,104E-01
	TOT VL	293680,95	9818,28	7490,39	25844,54	61599,03	22731,56	25395,19	22626,97	53362,46	38672,62	62809230,	561221,99
	TOT DM	,297E+08	,129E+07	,757E+06	,269E+07	,639E+07	,225E+07	,247E+07	,228E+07	,559E+07	,396E+07	29,	,574E+08
	TOT DR	1,012E-02	1,309E-02	1,010E-02	1,043E-02	1,037E-02	9,895E-03	9,719E-03	1,006E-02	1,048E-02	1,023E-02	4,609E-05	,102E-01
WT	UR VL	158864,45	1769,48	3785,74	12597,72	36253,09	12829,38	16558,85	15068,76	21176,17	24501,35	26752876,	303404,98
	UR DR	1,344E-02	1,281E-02	1,354E-02	1,292E-02	1,503E-02	1,322E-02	1,378E-02	1,315E-02	1,558E-02	1,341E-02	1,146E-04	,138E-01
	RR VL	32365,91	2436,05	798,00	1721,57	5812,80	2200,18	1623,18	2141,39	5152,06	6806,27	6996647,	61057,39
	RR DR	1,478E-02	1,128E-02	1,492E-02	1,653E-02	1,581E-02	1,519E-02	1,477E-02	1,470E-02	1,238E-02	1,511E-02	1,042E-04	,146E-01
	TOT VL	191230,36	4205,53	4583,74	14319,28	42065,89	15029,56	18182,02	17210,14	26328,22	31307,61	33749523,	364462,37
	TOT DM	,261E+08	,502E+06	,632E+06	,191E+07	,637E+07	,203E+07	,252E+07	,230E+07	,394E+07	,432E+07	38,	,507E+08
	TOT DR	1,367E-02	1,193E-02	1,378E-02	1,336E-02	1,514E-02	1,351E-02	1,387E-02	1,334E-02	1,495E-02	1,378E-02	1,125E-04	,139E-01
US	UR VL	830438,43	8034,10	21058,00	84626,13	192371,86	67239,24	91221,08	76795,68	103215,76	110926,06	140663315,	1585926,35
	UR DR	1,021E-02	1,193E-02	1,028E-02	1,008E-02	1,071E-02	1,016E-02	9,859E-03	1,006E-02	1,115E-02	1,008E-02	5,917E-05	,103E-01
	RR VL	269224,17	12840,28	5776,86	25061,17	40797,58	17403,56	13059,67	15701,73	23359,87	41461,70	61553839,	464686,58
	RR DR	1,076E-02	1,395E-02	1,085E-02	1,064E-02	1,146E-02	1,073E-02	1,045E-02	1,078E-02	1,057E-02	1,104E-02	4,703E-05	,109E-01
	TOT VL	1099662,60	20874,37	26834,86	109687,30	233169,44	84642,79	104280,75	92497,41	126575,64	152387,76	202217154,	2050612,92
	TOT DM	,114E+09	,275E+07	,279E+07	,112E+08	,253E+08	,870E+07	,104E+08	,941E+07	,140E+08	,158E+08	112,	,214E+09
	TOT DR	1,034E-02	1,317E-02	1,040E-02	1,021E-02	1,084E-02	1,027E-02	9,934E-03	1,018E-02	1,104E-02	1,034E-02	5,547E-05	,104E-01

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THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO EXPAN SOIL IN 1970 VALUED IN MILLIONS OF 1970 $ MGT= 0 =0 =0 =0 =0

REGIONAL AND NATIONAL TOTALS

REGIONS		HOUSING STRUCTURES	FARM+MINES STRUCTURES	CONSTRUCT STRUCTURES	MANUFACTOR STRUCTURES	TRAN+UTILY STRUCTURES	W+R TRADE STRUCTURES	FINANCE STRUCTURES	SERVICES STRUCTURES	FED GOV STRUCTURES	ST+LOC GOV STRUCTURES	POPULATION NUMBER	TOTAL
NE	UR VL	262360,77	1041,61	6134,00	26712,18	60232,82	20167,66	33312,45	26397,13	19792,49	34931,83	41389376,	491082,93
	UR DR	2,149E-02	2,303E-02	2,192E-02	2,198E-02	2,108E-02	2,153E-02	2,239E-02	2,118E-02	2,110E-02	2,124E-02	0,	,215E-01
	RR VL	38083,51	873,47	890,05	3717,15	5764,74	2434,53	1963,44	2534,00	3211,02	5922,60	7668641,	65394,51
	RR DR	2,302E-02	2,604E-02	2,298E-02	2,349E-02	2,352E-02	2,289E-02	2,259E-02	2,283E-02	2,238E-02	2,298E-02	0,	,231E-01
	TOT VL	300444,28	1915,08	7024,04	30429,32	65997,56	22602,19	35275,89	28931,13	23003,51	40854,43	49058017,	556477,44
	TOT DM	,651E+08	,467E+06	,155E+07	,674E+07	,141E+08	,490E+07	,790E+07	,617E+07	,489E+07	,878E+07	0,	,121E+09
	TOT DR	2,168E-02	2,440E-02	2,205E-02	2,216E-02	2,129E-02	2,167E-02	2,240E-02	2,132E-02	2,128E-02	2,149E-02	0,	,217E-01
NC	UR VL	224952,14	1380,31	5915,36	30585,94	50285,26	18335,57	21314,47	18735,84	18396,63	27989,56	37542643,	417891,08
	UR DR	5,282E-02	5,775E-02	5,252E-02	4,889E-02	5,859E-02	5,325E-02	5,757E-02	5,294E-02	6,052E-02	5,322E-02	0,	,539E-01
	RR VL	89354,86	3555,17	1821,33	8508,21	13221,70	5943,91	4113,18	4993,31	5484,83	13563,53	19057741,	150560,04
	RR DR	5,379E-02	6,124E-02	5,310E-02	4,343E-02	5,536E-02	5,488E-02	5,440E-02	5,406E-02	5,977E-02	5,516E-02	0,	,539E-01
	TOT VL	314307,01	4935,48	7736,69	39094,15	63506,96	24279,48	25427,65	23729,15	23881,45	41553,09	56600384,	568451,12
	TOT DM	,167E+09	,297E+07	,407E+07	,186E+08	,368E+08	,130E+08	,145E+08	,126E+08	,144E+08	,224E+08	0,	,306E+09
	TOT DR	5,309E-02	6,026E-02	5,266E-02	4,770E-02	5,792E-02	5,365E-02	5,706E-02	5,317E-02	6,035E-02	5,385E-02	0,	,539E-01
SO	UR VL	184261,07	3842,69	5222,90	14730,30	45600,69	15906,62	20035,32	16593,95	43850,48	23503,32	34978420,	373547,36
	UR DR	7,982E-02	,130	8,157E-02	8,684E-02	8,541E-02	8,617E-02	8,518E-02	8,026E-02	5,105E-02	7,719E-02	0,	,784E-01
	RR VL	109419,88	5975,59	2267,49	11114,24	15998,34	6824,94	5359,87	6033,02	9511,97	15169,29	27830810,	187674,64
	RR DR	5,700E-02	6,065E-02	5,599E-02	5,466E-02	5,859E-02	5,731E-02	5,571E-02	5,665E-02	4,746E-02	5,678E-02	0,	,566E-01
	TOT VL	293680,95	9818,28	7490,39	25844,54	61599,03	22731,56	25395,19	22626,97	53362,46	38672,62	62809230,	561221,99
	TOT DM	,209E+09	,861E+07	,553E+07	,189E+08	,483E+08	,176E+08	,201E+08	,167E+08	,269E+08	,268E+08	0,	,399E+09
	TOT DR	7,132E-02	8,773E-02	7,383E-02	7,300E-02	7,844E-02	7,751E-02	7,896E-02	7,397E-02	5,041E-02	6,918E-02	0,	,711E-01
WT	UR VL	158864,45	1769,48	3785,74	12597,72	36253,09	12829,38	16558,85	15068,76	21176,17	24501,35	26752876,	303404,98
	UR DR	9,126E-02	9,906E-02	9,150E-02	9,141E-02	8,726E-02	8,871E-02	8,693E-02	8,877E-02	9,542E-02	8,975E-02	0,	,905E-01
	RR VL	32365,91	2436,05	798,00	1721,57	5812,80	2200,18	1623,18	2141,39	5152,06	6806,27	6996647,	61057,39
	RR DR	5,265E-02	4,652E-02	4,912E-02	5,040E-02	5,438E-02	5,325E-02	5,205E-02	5,069E-02	4,584E-02	5,418E-02	0,	,520E-01
	TOT VL	191230,36	4205,53	4583,74	14319,28	42065,89	15029,56	18182,02	17210,14	26328,22	31307,61	33749523,	364462,37
	TOT DM	,162E+09	,289E+07	,386E+07	,124E+08	,348E+08	,126E+08	,152E+08	,145E+08	,226E+08	,257E+08	0,	,306E+09
	TOT DR	8,473E-02	6,863E-02	8,412E-02	8,648E-02	8,272E-02	8,352E-02	8,382E-02	8,403E-02	8,572E-02	8,202E-02	0,	,841E-01
US	UR VL	830438,43	8034,10	21058,00	84626,13	192371,86	67239,24	91221,08	76795,68	103215,76	110926,06	140663315,	1585926,35
	UR DR	5,626E-02	9,683E-02	5,782E-02	5,333E-02	5,861E-02	5,829E-02	5,612E-02	5,496E-02	5,610E-02	5,630E-02	0,	,566E-01
	RR VL	269224,17	12840,28	5776,86	25061,17	40797,58	17403,56	13059,67	15701,73	23359,87	41461,70	61553839,	464686,58
	RR DR	5,060E-02	5,578E-02	4,904E-02	4,593E-02	5,199E-02	5,115E-02	4,986E-02	4,956E-02	4,655E-02	5,100E-02	0,	,504E-01
	TOT VL	1099662,60	20874,37	26834,86	109687,30	233169,44	84642,79	104280,75	92497,41	126575,64	152387,76	202217154,	2050612,92
	TOT DM	,603E+09	,149E+08	,150E+08	,566E+08	,134E+09	,481E+08	,577E+08	,500E+08	,688E+08	,836E+08	0,	,113E+10
	TOT DR	5,488E-02	7,158E-02	5,593E-02	5,164E-02	5,745E-02	5,682E-02	5,533E-02	5,404E-02	5,434E-02	5,485E-02	0,	,552E-01

APPENDIX G

NATIONAL TOTALS, LOSSES AND SAVINGS DUE TO MITIGATIONS

This appendix provides the national totals for all the economic and social losses for all hazards except landslide, expansive soil, and riverine flood. Values are also furnished for the aggregate saving from some selected mitigations as described in Chapter Nine.

NATIONAL ESTIMATED ANNUAL LOSSES AND SAVINGS	LOSSES		SAVINGS IN 2000		NATIONAL VALUES AT RISK	
	1970	2000	50 YR. F.P. MITIGATION	100 YR.F.P. MITIGATION	1970	2000
ECONOMIC FACTORS						
BUILDING VALUE 1970$ 10^6	(8.7) (2) 8.0	(19.8) 20.0	(.1) 0	(.3) 0	217,327.0	508,852.0
CONTENT VALUE 1970$ 10^6	(5.5) 6.0	(19.1) 19.0	(.1) 0	(.3) 0	117,907.0	608,870.0
INCOME 1970$ 10^3	727.0	1,479.0	26.0	46.0	1.065E+08	2.687E+08
SUPPLIER COSTS 1970$	12,425.0	27,339.0	662.0	992.0	---	---
TOTAL OF ECONOMIC FACTORS 1970$ 10^6	(14.9) 14.7	(40.4) 40.5	(0.3) 0.0	(0.7) 0.0	---	---
SOCIAL FACTORS						
LIVES	(20) 20	(44) 44	(0) 0	(1) 1	18,200,851	23,606,782
HOMES (HOUSING UNITS)	234.0	335.0	2.0	6.0	6,340,000.0	9,410,000.0
HOME USE (PERSON YEARS)	345.0	389.0	9.0	13.0	---	---
EMPLOYMENT (PERSON YEARS)	98.0	196.0	3.0	6.0	2.078E+07 (1)	5.244E+07 (1)

THE AGGREGATED ANNUAL TOTAL ECONOMIC LOSSES AND SAVINGS FROM 1970 TO 2000					
DISCOUNT RATES	AGGREGATED ECONOMIC LOSS FROM 1970-2000	AGGREGATED ECONOMIC SAVINGS FROM (50 YR.F.P.)	PERCENT SAVINGS OF AGGREGATED LOSS FROM (50 YR.F.P.)	AGGREGATED ECONOMIC SAVINGS FROM (100 YR.F.P.)	PERCENT SAVINGS OF AGGREGATED LOSS FROM (100 YR.F.P.)
0.0%	562.	3.15	0.6	7.35	1.3
2.9%	338.	1.60	0.5	3.74	1.1
6.1%	211.	.77	0.4	1.81	0.9
10.0%	137.	.33	0.2	.78	0.6
15.0%	92.	.12	0.1	.28	.3

1. The estimates for employment tend to overestimate the actual employment level because of the use of the employment-per-product by sector computed for 1963 used in estimates for 1970 and 2000.

2. Because of the round off errors in calculations of tsunami damage to the nearest million dollars of loss, the national total computed from the county totals is given in parenthesis.

Table G-1. National Totals for Tsunami

NATIONAL ESTIMATED ANNUAL LOSSES AND SAVINGS	LOSSES		SAVINGS IN 2000		NATIONAL VALUES AT RISK	
	1970	2000	50 YEAR FLOOD PLANE MITIGATION	FLOOD PROOFING MITIGATION 4FT	1970	2000
ECONOMIC FACTORS						
BUILDING VALUE 1970$ 10^6	442.0	1,176.0	265.0	697.0	438,733.0	1,061,972.0
CONTENT VALUE 1970$ 10^6	197.0	1,160.0	255.0	681.0	238,241.0	1,275,127.0
INCOME 1970$ 10^3	2,367.0	6,407.0	1,290.0	3,747.0	2.227E+08	5.813E+08
SUPPLIER COSTS 1970$	28,483.0	77,382.0	0.0	28,002.0	---	---
TOTAL OF ECONOMIC FACTORS 1970$ 10^6	641.4	2,342.5	521.3	1,381.8	---	---
SOCIAL FACTORS						
LIVES	37	103	23	61	38,387,247	51,328,807
HOMES (HOUSING UNITS)	24,521.0	43,757.0	10,397.0	26,882.0	12,890,000.0	19,890,000.0
HOME USE (PERSON YEARS)	7,290.0	10,330.0	2,235.0	6,341.0	---	---
EMPLOYMENT (PERSON YEARS)	370.0	1,018.0	172.0	507.0	4.406E+07 (1)	1.153E+08 (1)

THE AGGREGATED ANNUAL TOTAL ECONOMIC LOSSES AND SAVINGS FROM 1970 TO 2000					
DISCOUNT RATES	AGGREGATED ECONOMIC LOSS FROM 1970-2000	AGGREGATED ECONOMIC SAVINGS FROM A 50 YEAR FLOOD PLANE MITIGATION	PERCENT SAVINGS OF AGGREGATED LOSS FROM 50 YEAR FLOOD PLANE MITIGATION	AGGREGATED ECONOMIC SAVINGS FROM 4FT FLOOD PROOFING MITIGATION	PERCENT SAVINGS OF AGGREGATED LOSS FROM 4FT FLOOD PROOFING MITIGATION
0.0%	33,422.	5,474.	16.4	14,509.	43.4
2.9%	19,811.	2,783.	14.0	7,378.	37.2
6.1%	12,075.	1,346.	11.1	3,568.	29.5
10.0%	7,512.	582.	7.7	1,542.	20.5
15.0%	4,831.	209.	4.3	555.	11.5

1. The estimates for employment tend to overestimate the actual employment level because of the use of the employment per product by sector computed for 1963 used in estimates for 1970 and 2000.

Table G-2. Storm Surge National Results

NATIONAL ESTIMATED ANNUAL LOSSES AND SAVINGS	LOSSES		SAVINGS IN 2000		NATIONAL VALUES AT RISK	
	1970	2000	(1.5 UBC)	(3.0 UBC)	1970	2000
ECONOMIC FACTORS						
BUILDING VALUE 1970$ 10^6	(11.4)[2] 6.0	(24.8) 22.0	(3.6) 0.0	(5.7) 2.0	2,064,507.	4,924,075.
CONTENT VALUE 1970$ 10^6	(4.5) 4.0	(23.8) 22.0	(1.8) 0.0	(2.9) 1.0	1,207,498.	6,252,952.
INCOME 1970$	2,090.0	4,696.0	678.0	1,087.0	1.053 E+12[1]	2.753 E+12
SUPPLIER COSTS 1970$	21,800.0	50,705.0	10,581.0	16,867.0	---	---
TOTAL OF ECONOMIC FACTORS 1970$	(18.0) 12.1	(53.1) 48.7	(6.1) 0.7	(9.2) 4.1	---	---
SOCIAL FACTORS						
LIVES	(5) 0	(11) 6	(1) 0	(2) 0	203,260,531	256,179,160
HOMES (HOUSING UNITS)	547.0	748.0	108.0	176.0	67,560,000.	97,770,000.
HOME USE (PERSON YEARS)	852.0	1,014.0	149.0	240.0	---	---
EMPLOYMENT (PERSON YEARS)	373.0	851.0	124.0	193.0	2.115 E+08[1]	5.523 E+08[1]

THE AGGREGATED ANNUAL TOTAL ECONOMIC LOSSES AND SAVINGS FROM 1970 TO 2000					
DISCOUNT RATES	AGGREGATED ECONOMIC LOSS FROM 1970-2000	AGGREGATED ECONOMIC SAVINGS FROM (1.5 UBC)	PERCENT SAVINGS OF AGGREGATED LOSS FROM (1.5 UBC)	AGGREGATED ECONOMIC SAVINGS FROM (3.0 UBC)	PERCENT SAVINGS OF AGGREGATED LOSS FROM (3.0 UBC)
0.0%	700.	64.	9.1	97.	13.9
2.9%	413.	33.	8.0	49.	11.9
6.1%	250.	16.	6.4	24.	9.6
10.0%	154.	7.	4.5	10.	6.5
15.0%	97.	2.	2.1	4.	4.1

1. The estimates for employment tend to overestimate the actual employment level because of the use of the employment per product by sector computed for 1963 used in estimates for 1970 and 2000.

2. Because of the round off errors in calculations of severe wind damage to the nearest million dollars of loss the national total computed from the county totals is given in parenthesis.

Table G-3. Severe Wind National Exposure

NATIONAL ESTIMATED ANNUAL LOSSES AND SAVINGS	LOSSES		SAVINGS IN 2000		NATIONAL VALUES AT RISK	
	1970	2000	1.5 UBC	3.0 UBC	1970	2000
ECONOMIC FACTORS						
BUILDING VALUE 1970$ 10^6	875.0	2,058.0	312.0	494.0	1,788,989.0	4,300,491.0
CONTENT VALUE 1970$ 10^6	470.0	2,401.0	358.0	573.0	1,065,396.0	5,539,277.0
INCOME 1970$ 10^3	303.0	751.0	114.0	182.0	9.172 E+08	2.421 E+09
SUPPLIER COSTS 1970$	3,909.0	9,042.0	2,093.0	3,292.0	---	---
TOTAL OF ECONOMIC FACTORS 1970$ 10^6	1,651.5	5,219.0	786.1	1,252.3	---	---
SOCIAL FACTORS						
LIVES	392	920	139	226	181,198,749	228,720,498
HOMES (HOUSING UNITS)	36,212.0	52,119.0	8,039.0	12,816.0	60,010,000.0	86,990,000.0
HOME USE (PERSON YEARS)	86,122.0	107,650.0	16,529.9	26,108.0	---	---
EMPLOYMENT (PERSON YEARS)	57,541.0	146,569.0	21,959.0	35,795.0	1.823 E+08 (1)	4.863 E+08 (1)

THE AGGREGATED ANNUAL TOTAL ECONOMIC LOSSES AND SAVINGS FROM 1970 TO 2000					
DISCOUNT RATES	AGGREGATED ECONOMIC LOSS FROM 1970-2000	AGGREGATED ECONOMIC SAVINGS FROM A 1.5 UBC MITIGATION	PERCENT SAVINGS OF AGGREGATED LOSS FROM A 1.5 UBC MITIGATION	AGGREGATED ECONOMIC SAVINGS FROM A 3.0 UBC MITIGATION	PERCENT SAVINGS OF AGGREGATED LOSS FROM A 3.0 UBC MITIGATION
0.0%	73,463.	8,254.	11.2	13,149.	17.9
2.9%	43,869.	4,197.	9.6	6,686.	15.2
6.1%	27,068.	2,030.	7.5	3,234.	11.9
10.0%	17,155.	877.	5.1	1,397.	8.1
15.0%	11,307.	316.	2.8	503.	4.4

1. The estimates for employment tend to overestimate the actual employment level because of the use of the employment per product by sector computed for 1963 used in estimates for 1970 and 2000.

Table G-4. Tornado National Results

NATIONAL ESTIMATED ANNUAL LOSSES AND SAVINGS	LOSSES		SAVINGS IN 2000		NATIONAL VALUES AT RISK	
	1970	2000	1.5 UBC	3.0 UBC	1970	2000
ECONOMIC FACTORS						
BUILDING VALUE 1970$ 10^6	686.0	1,742.0	289.0	462.0	682,479.0	1,680,245.0
CONTENT VALUE 1970$ 10^6	268.0	1,505.0	249.0	400.0	379,800.0	2,038,041.0
INCOME 1970$ 10^3	102.0	276.0	47.0	75.0	3.434 E+08	9.130 E+08
SUPPLIER COSTS 1970$	1,092.0	3,095.0	729.0	1,163.0	---	---
TOTAL OF ECONOMIC FACTORS 1970$ 10^6	1,057.1	3,526.1	585.7	938.2	---	---
SOCIAL FACTORS						
LIVES	62	153	26	41	62,741,264	83,615,242
HOMES (HOUSING UNITS)	31,885.0	52,237.0	9,107.0	14,524.0	20,720,000.0	31,890,000.0
HOME USE (PERSON YEARS)	34,505.0	48,271.0	8,414.0	13,411.0	---	---
EMPLOYMENT (PERSON YEARS)	21,004.0	58,224.0	9,385.0	14,982.0	6.749 E+07 (1)	1.802 E+08 (1)

THE AGGREGATED ANNUAL TOTAL ECONOMIC LOSSES AND SAVINGS FROM 1970 TO 2000					
DISCOUNT RATES	AGGREGATED ECONOMIC LOSS FROM 1970-2000	AGGREGATED ECONOMIC SAVINGS FROM 1.5 UBC MITIGATION	PERCENT SAVINGS OF AGGREGATED LOSS FROM 3.0 UBC MITIGATION	AGGREGATED ECONOMIC SAVINGS FROM 1.5 UBC MITIGATION	PERCENT SAVINGS OF AGGREGATED LOSS FROM 3.0 UBC MITIGATION
0.0%	49,898.	9,851.	19.7	6,150.	12.3
2.9%	29,710.	5,009.	16.9	3,127.	10.5
6.1%	18,245.	2,423.	13.3	1,152.	6.3
10.0%	11,480.	1,047.	9.1	653.	5.7
15.0%	7,496.	377.	5.0	235.	3.1

1. The estimates for employment tend to overestimate the actual employment level because of the use of the employment per product by sector computed for 1963 used in estimates for 1970 and 2000.

Table G-5. Hurricane National Results

NATIONAL ESTIMATED ANNUAL LOSSES AND SAVINGS	LOSSES		SAVINGS IN 2000		NATIONAL VALUES AT RISK	
	1970	2000	UBC ZONE 3 MITIGATION		1970	2000
ECONOMIC FACTORS						
BUILDING VALUE 1970$ 10^6	653.0	1,175.0	91.0	---	1,494,293.0	3,577,016.0
CONTENT VALUE 1970$ 10^6	123.0	373.0	32.0	---	858,053.0	4,466,392.0
INCOME 1970$ 10^3	2,651.0	3,906.0	283.0	---	1.513 E+05	3.992 E+05
SUPPLIER COSTS 1970$	30,304.0	48,260.0	5,487.0	---	---	---
TOTAL OF ECONOMIC FACTORS 1970$ 10^6	778.7	1,552.0	123.3	---	---	---
SOCIAL FACTORS						
LIVES	272	400	30	---	143,169,495	182,491,865
HOMES (HOUSING UNITS)	20,485.0	22,888.0	2,303.0	---	47,790,000.0	69,960,000.0
HOME USE (PERSON YEARS)	736.0	648.0	51.0	---	---	---
EMPLOYMENT (PERSON YEARS)	414.0	635.0	50.0	---	1.513 E+08 [1]	3.992 E+08 [1]

THE AGGREGATED ANNUAL TOTAL ECONOMIC LOSSES AND SAVINGS FROM 1970 TO 2000					
DISCOUNT RATES	AGGREGATED ECONOMIC LOSS FROM 1970-2000	AGGREGATED ECONOMIC SAVINGS FROM A UBC ZONE 3 MITIGATION	PERCENT SAVINGS OF AGGREGATED LOSS FROM A UBC ZONE 3 MITIGATION	AGGREGATED ECONOMIC SAVINGS FROM	PERCENT SAVINGS OF AGGREGATED LOSS FROM
0.0%	20,553.	1,295.	6.3	---	---
2.9%	12,696.	658.	5.2	---	---
6.1%	8,263.	318.	3.8	---	---
10.0%	5,642.	138.	2.4	---	---
15.0%	4,064.	50.	1.2	---	---

1. The estimates for employment tend to overestimate the actual employment level because of the use of the employment per product by sector computed for 1963 used in estimates for 1970 and 2000.

Table G-6. Earthquake National Results

Appendix H

SOCIAL AND ECONOMIC LOSSES BY STATE, AND THE SAVINGS IN 2000 DUE TO SELECTED MITIGATIONS

These tables provide the annual losses for 1970 and 2000, and the savings in 2000 by state. For expansive soil and landslide the only losses given are annual building losses in 1970, along with the damage rates by state. The building losses for Riverine Flooding are also provided for 1970 and 2000, but no rates were calculated because these losses were calculated by apportioning the regional flood loss totals by the values-at-risk in the state included in these regions. The following is a set of notes that detail the assumptions used in the creation of this data set.

General Notes Concerning the Following Tables

1. The Building Loss rate was computed from the division of the estimated Building Losses by the estimated Building Replacement Value-at-risk to each hazard in each state.

2. The Contents Loss rates were calculated from the estimated contents value-at-risk by state.

3. The Income Loss rates were calculated from the estimated income at-risk by state.

4. The Supplier Loss rates were calculated using the estimated income at-risk by state.

5. The Life Loss rates use the population at-risk for the value-at-risk.

6. Homes Lost rate is based on the number of housing units estimated in each state.

7. The Homelessness rate is based on the population as the value-at-risk.

8. The Unemployment rate is based on the estimate of the work force at-risk.

9. Note, when the loss is zero, the rate will also be zero.

10. Some of these tables were compiled from national data because the state level results were not printed at the time.

EARTHQUAKE TABLES

H - 1 Annual Losses in 1970

H - 2 Annual Loss rates in 1970

H - 3 Annual Losses in 2000

H - 4 Annual Loss rates in 2000

H - 5 The savings due to a mitigation of a building code of UBC Zone 3 (see chapter 9 for details in 2000).

H - 6 The percentage savings due to the mitigation of a building code of UBC Zone 3 in 2000

Table H-1. Estimated Annual Earthquake Losses in 1970

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESSNESS PERSON YEARS	UNEMPLOYMENT PERSON YEARS
ALABAMA	0.	0.01	2.	0.	0.	1.	0.	0.0
ARIZONA	1.	0.08	1569.	16.	1.	30.	1.	0.3
ARKANSAS	3.	0.40	6458.	75.	3.	191.	4.	1.4
CALIFORNIA	440.	86.21	1862000.	20690.	154.	12093.	480.	284.0
COLORADO	20.	4.87	152400.	1812.	10.	682.	28.	27.0
CONNECTICUT	1.	0.00	78.	1.	1.	24.	0.	0.0
DELAWARE	0.	0.00	4.	0.	0.	3.	0.	0.0
DIST. OF COLUMBIA	0.	0.00	0.	0.	0.	2.	0.	0.0
FLORIDA	1.	0.08	1515.	15.	1.	39.	1.	0.2
GEORGIA	0.	0.04	723.	9.	1.	21.	0.	0.1
IDAHO	2.	0.31	6341.	69.	1.	59.	2.	1.2
ILLINOIS	1.	0.16	3536.	46.	1.	49.	1.	0.6
INDIANA	0.	0.00	27.	0.	0.	7.	0.	0.0
IOWA	0.	0.00	2.	0.	0.	2.	0.	0.0
KANSAS	0.	0.01	86.	1.	0.	7.	0.	0.0
KENTUCKY	1.	0.28	4981.	55.	1.	75.	2.	1.0
LOUISIANA	2.	0.35	6951.	106.	2.	80.	3.	1.3
MAINE	0.	0.00	0.	0.	0.	1.	0.	0.0
MARYLAND	0.	0.00	10.	0.	0.	5.	0.	0.0
MASSACHUSETTS	2.	0.09	1660.	18.	1.	55.	1.	0.2
MICHIGAN	1.	0.05	1375.	25.	1.	39.	0.	0.3
MINNESOTA	0.	0.00	0.	0.	0.	0.	0.	0.0
MISSISSIPPI	0.	0.03	618.	6.	1.	23.	0.	0.1
MISSOURI	15.	4.54	110100.	1363.	9.	1003.	40.	23.1
MONTANA	1.	0.30	6986.	87.	1.	63.	2.	1.3
NEBRASKA	0.	0.01	167.	2.	0.	9.	0.	0.0
NEVADA	3.	0.08	1917.	18.	2.	101.	1.	0.3
NEW HAMPSHIRE	0.	0.00	16.	0.	0.	8.	0.	0.0
NEW JERSEY	3.	0.00	437.	7.	3.	111.	0.	0.1
NEW MEXICO	1.	0.14	3194.	26.	1.	54.	2.	0.6
NEW YORK	20.	0.00	1624.	19.	12.	643.	0.	0.2
NORTH CAROLINA	0.	0.00	1.	0.	0.	5.	0.	0.0
NORTH DAKOTA	0.	0.00	13.	0.	0.	0.	0.	0.0
OHIO	1.	0.04	681.	10.	1.	43.	0.	0.1
OKLAHOMA	1.	0.02	388.	4.	1.	22.	0.	0.1
OREGON	2.	0.24	4074.	61.	2.	77.	2.	0.6
PENNSYLVANIA	0.	0.02	367.	5.	0.	15.	0.	0.1
RHODE ISLAND	0.	0.00	5.	0.	0.	3.	0.	0.0
SOUTH CAROLINA	2.	0.30	5556.	55.	2.	81.	3.	1.0
SOUTH DAKOTA	0.	0.01	146.	1.	0.	4.	0.	0.0
TENNESSEE	15.	1.76	31530.	341.	7.	629.	16.	5.1
TEXAS	1.	0.07	1344.	17.	1.	34.	1.	0.2
UTAH	12.	2.39	54450.	565.	7.	384.	17.	9.3
VERMONT	0.	0.00	0.	0.	0.	0.	0.	0.0
VIRGINIA	0.	0.01	194.	3.	1.	19.	0.	0.0
WASHINGTON	97.	20.05	372100.	4710.	40.	3575.	127.	53.2
WEST VIRGINIA	0.	0.01	177.	2.	0.	4.	0.	0.0
WISCONSIN	0.	0.00	2.	0.	0.	1.	0.	0.0
WYOMING	0.	0.01	138.	1.	0.	2.	0.	0.0
ALASKA	4.	0.23	4178.	54.	3.	98.	2.	0.4
HAWAII	0.	0.04	729.	9.	0.	9.	0.	0.1
NATIONAL TOTAL	653.	123.23	2650850.	30304.	272.	20485.	736.	413.5

Table H-2. The Estimated Annual Proportion of the Value at Risk Lost to Earthquake in 1970

STATE	① BUILDING DAMAGE	② CONTENTS DAMAGE	③ INCOME LOSS	④ SUPPLIER LOSS	⑤ LIFE LOSS	⑥ HOMES LOST	⑦ HOMELESS-NESS	⑧ UNEMPLOY-MENT
ALABAMA	4.4-06	3.3-06	7.5-10	9.5-12	5.4-08	5.5-06	0.0 00	6.0-10
ARIZONA	4.4-05	9.2-06	1.7-07	1.7-09	3.9-07	5.2-05	5.6-07	1.3-07
ARKANSAS	7.8-04	1.4-04	3.1-06	3.6-08	4.3-06	8.3-04	6.1-06	2.2-06
CALIFORNIA	1.9-03	6.9-04	1.7-05	1.9-07	7.7-06	1.7-03	2.4-05	1.5-05
COLORADO	9.0-04	4.1-04	1.3-05	1.6-07	4.8-06	9.3-04	1.3-05	1.2-05
CONNECTICUT	2.2-05	0.0 00	4.0-09	3.9-11	2.1-07	2.6-05	0.0 00	5.7-09
DELAWARE	1.2-05	0.0 00	1.4-09	2.0-11	1.8-07	1.7-05	0.0 00	1.1-09
DIST. OF COLUMBIA	4.5-06	0.0 00	6.0-11	1.1-12	9.2-08	7.2-06	0.0 00	6.7-12
FLORIDA	2.0-05	3.3-06	6.8-08	6.8-10	1.6-07	2.1-05	1.9-07	4.7-08
GEORGIA	3.1-05	4.4-06	1.0-07	1.2-09	2.9-07	3.4-05	0.0 00	6.9-08
IDAHO	2.7-04	9.3-05	2.2-06	2.4-08	2.1-06	2.7-04	3.0-06	1.7-06
ILLINOIS	3.1-05	8.2-06	2.2-07	2.8-09	3.2-07	5.0-05	3.4-07	2.1-07
INDIANA	1.2-05	0.0 00	4.4-09	5.1-11	1.6-07	1.6-05	0.0 00	2.0-09
IOWA	5.2-06	0.0 00	7.0-10	7.7-12	9.0-08	6.7-06	0.0 00	5.6-10
KANSAS	1.3-05	1.4-06	1.4-08	1.5-10	2.1-07	1.6-05	0.0 00	7.4-09
KENTUCKY	2.3-04	8.2-05	1.5-06	1.6-08	1.5-06	2.7-04	2.4-06	1.1-06
LOUISIANA	6.4-05	2.2-05	4.3-07	6.6-09	5.0-07	7.2-05	8.5-07	3.1-07
MAINE	4.6-06	0.0 00	1.9-11	2.3-13	7.5-08	6.2-06	0.0 00	2.5-12
MARYLAND	4.6-06	0.0 00	7.8-10	1.2-11	9.5-08	7.4-06	0.0 00	3.5-10
MASSACHUSETTS	3.4-05	3.3-06	6.6-08	7.3-10	3.2-07	4.0-05	2.3-07	4.3-08
MICHIGAN	1.4-05	1.1-06	3.7-08	6.7-10	1.5-07	1.9-05	0.0 00	4.6-08
MINNESOTA	4.5-07	0.0 00	1.6-11	2.3-13	1.2-08	6.0-07	0.0 00	1.0-11
MISSISSIPPI	3.6-05	4.2-06	1.1-07	1.1-09	3.4-07	4.4-05	0.0 00	6.8-08
MISSOURI	6.7-04	3.2-04	9.3-06	1.2-07	4.2-06	1.3-03	1.8-05	9.7-06
MONTANA	2.5-04	1.0-04	2.5-06	3.2-08	2.2-06	2.9-04	3.2-06	2.2-06
NEBRASKA	1.2-05	1.3-06	2.5-08	2.8-10	2.2-07	1.7-05	0.0 00	1.9-08
NEVADA	4.7-04	3.0-05	6.7-07	6.3-09	4.1-06	6.0-04	2.1-06	5.1-07
NEW HAMPSHIRE	3.6-05	0.0 00	5.4-09	6.0-11	4.4-07	4.6-05	0.0 00	4.2-09
NEW JERSEY	4.1-05	0.0 00	1.0-08	1.5-10	4.1-07	4.8-05	0.0 00	8.2-09
NEW MEXICO	1.5-04	3.7-05	8.1-07	6.6-09	1.2-06	1.9-04	2.3-06	6.5-07
NEW YORK	9.7-05	0.0 00	1.5-08	1.8-10	7.3-07	1.2-04	0.0 00	1.2-08
NORTH CAROLINA	3.2-06	0.0 00	1.1-10	1.2-12	5.1-08	4.3-06	0.0 00	7.9-11
NORTH DAKOTA	2.6-06	0.0 00	9.0-09	1.2-10	5.5-08	3.3-06	0.0 00	6.6-09
OHIO	1.2-05	6.7-07	1.4-08	2.1-10	1.4-07	1.5-05	0.0 00	9.1-09
OKLAHOMA	2.3-05	1.7-06	3.4-08	3.2-10	2.3-07	2.4-05	0.0 00	2.4-08
OREGON	9.8-05	2.4-05	4.7-07	7.1-09	8.9-07	1.2-04	1.1-06	3.6-07
PENNSYLVANIA	5.7-06	4.8-07	1.1-08	1.4-10	7.3-08	7.1-06	0.0 00	8.3-09
RHODE ISLAND	8.1-06	0.0 00	1.2-09	1.4-11	1.1-07	1.0-05	0.0 00	9.5-10
SOUTH CAROLINA	1.0-04	2.3-05	5.5-07	5.5-09	6.2-07	1.0-04	1.2-06	4.0-07
SOUTH DAKOTA	1.5-05	3.5-06	6.3-08	6.4-10	2.3-07	1.8-05	0.0 00	4.7-08
TENNESSEE	8.3-04	1.5-04	3.2-06	3.5-08	3.1-06	8.0-04	6.7-06	2.1-06
TEXAS	8.7-06	1.4-06	2.8-08	3.7-10	1.1-07	1.1-05	1.1-07	2.1-08
UTAH	1.2-03	4.6-04	1.0-05	1.1-07	6.4-06	1.2-03	1.6-05	8.7-06
VERMONT	2.8-06	0.0 00	0.0 00	0.0 00	6.4-08	4.0-06	0.0 00	0.0 00
VIRGINIA	9.3-06	4.3-07	9.2-09	1.4-10	1.6-07	1.4-05	0.0 00	9.3-09
WASHINGTON	2.8-03	1.1-03	2.2-05	2.8-07	1.2-05	3.0-03	3.8-05	1.8-05
WEST VIRGINIA	7.0-06	1.9-06	3.0-08	4.1-10	9.3-08	9.7-06	0.0 00	2.6-08
WISCONSIN	9.5-06	0.0 00	1.5-09	2.2-11	1.3-07	1.2-05	0.0 00	1.2-09
WYOMING	1.6-05	7.1-06	8.5-08	8.8-10	2.9-07	1.9-05	0.0 00	7.0-08
ALASKA	9.4-04	1.3-04	2.4-06	3.1-08	9.9-06	1.2-03	7.4-06	1.7-06
HAWAII	2.6-04	6.8-05	1.6-06	2.0-08	2.2-06	3.0-04	0.0 00	1.2-06
NATIONAL AVERAGE	4.4-04	1.4-04	3.5-06	4.0-08	1.9-06	4.3-04	5.1-06	2.7-06

Table H-3. Estimated Annual Earthquake Losses in 2000

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESSNESS PERSON YEARS	UNEMPLOYMENT PERSON YEARS
ALABAMA	0.	0.00	3.	0.	0.	2.	0.	0.0
ARIZONA	2.	0.28	2675.	31.	1.	43.	1.	0.5
ARKANSAS	6.	1.21	10470.	127.	4.	213.	3.	2.7
CALIFORNIA	749.	235.52	2505000.	30010.	217.	12041.	386.	396.0
COLORADO	45.	21.00	267100.	3374.	18.	989.	34.	45.8
CONNECTICUT	1.	0.00	113.	1.	1.	32.	0.	0.0
DELAWARE	0.	0.00	8.	0.	0.	4.	0.	0.0
DIST. OF COLUMBIA	0.	0.00	0.	0.	0.	4.	0.	0.0
FLORIDA	2.	0.27	2281.	24.	2.	59.	1.	0.3
GEORGIA	1.	0.12	1021.	13.	1.	24.	0.	0.2
IDAHO	3.	1.18	11530.	133.	2.	73.	2.	2.1
ILLINOIS	2.	0.57	6185.	84.	1.	53.	1.	1.2
INDIANA	0.	0.00	41.	1.	0.	8.	0.	0.0
IOWA	0.	0.00	3.	0.	0.	2.	0.	0.0
KANSAS	0.	0.01	122.	1.	0.	8.	0.	0.0
KENTUCKY	3.	0.99	9522.	110.	2.	86.	2.	2.1
LOUISIANA	4.	1.49	13460.	213.	3.	100.	3.	2.5
MAINE	0.	0.00	0.	0.	0.	2.	0.	0.0
MARYLAND	0.	0.00	15.	0.	0.	8.	0.	0.0
MASSACHUSETTS	3.	0.30	2655.	31.	2.	73.	1.	0.4
MICHIGAN	2.	0.18	2493.	49.	1.	46.	0.	0.6
MINNESOTA	0.	0.00	0.	0.	0.	0.	0.	0.0
MISSISSIPPI	1.	0.12	1035.	11.	1.	25.	0.	0.2
MISSOURI	28.	15.73	225200.	2991.	14.	1067.	35.	55.8
MONTANA	2.	0.81	9877.	137.	2.	61.	2.	1.9
NEBRASKA	0.	0.02	206.	3.	0.	8.	0.	0.0
NEVADA	7.	0.28	3020.	30.	4.	186.	1.	0.4
NEW HAMPSHIRE	0.	0.00	26.	0.	0.	11.	0.	0.0
NEW JERSEY	7.	0.00	716.	12.	4.	146.	0.	0.1
NEW MEXICO	2.	0.55	5504.	46.	2.	66.	2.	1.0
NEW YORK	36.	0.00	2345.	29.	17.	813.	0.	0.3
NORTH CAROLINA	0.	0.00	2.	0.	0.	6.	0.	0.0
NORTH DAKOTA	0.	0.00	12.	0.	0.	0.	0.	0.0
OHIO	2.	0.12	1092.	17.	2.	53.	0.	0.1
OKLAHOMA	1.	0.05	519.	5.	1.	31.	0.	0.1
OREGON	3.	0.84	6926.	111.	2.	94.	2.	1.0
PENNSYLVANIA	1.	0.06	587.	8.	1.	19.	0.	0.1
RHODE ISLAND	0.	0.00	8.	0.	0.	4.	0.	0.0
SOUTH CAROLINA	4.	1.06	9519.	101.	2.	99.	3.	1.8
SOUTH DAKOTA	0.	0.02	159.	2.	0.	3.	0.	0.0
TENNESSEE	34.	6.18	48750.	547.	13.	864.	16.	7.5
TEXAS	1.	0.23	2146.	29.	1.	192.	2.	0.3
UTAH	27.	9.92	108100.	1207.	12.	545.	19.	18.3
VERMONT	0.	0.00	0.	0.	0.	0.	0.	0.0
VIRGINIA	1.	0.03	268.	4.	1.	24.	0.	0.1
WASHINGTON	188.	72.78	637800.	8672.	62.	4560.	130.	90.8
WEST VIRGINIA	0.	0.01	189.	3.	0.	4.	0.	0.0
WISCONSIN	0.	0.00	3.	0.	0.	1.	0.	0.0
WYOMING	0.	0.02	194.	2.	0.	2.	0.	0.0
ALASKA	7.	0.74	6017.	82.	4.	127.	2.	0.6
HAWAII	0.	0.09	704.	9.	0.	7.	0.	0.1
NATIONAL TOTAL	1175.	372.78	3905621.	48260.	400.	22888.	648.	634.9

Table H-4. The Estimated Annual Proportion of the Value at Risk Lost to Earthquake in 2000

STATE	① BUILDING DAMAGE	② CONTENTS DAMAGE	③ INCOME LOSS	④ SUPPLIER LOSS	⑤ LIFE LOSS	⑥ HOMES LOST	⑦ HOMELESS-NESS	⑧ UNEMPLOY-MENT
ALABAMA	3.7-06	0.0 00	4.7-10	6.2-12	7.3-08	5.0-06	0.0 00	3.6-10
ARIZONA	3.3-05	5.0-06	9.3-08	1.1-09	4.1-07	4.1-05	3.6-07	7.4-08
ARKANSAS	7.0-04	9.8-05	1.9-06	2.3-08	6.4-06	7.9-04	4.4-06	1.4-06
CALIFORNIA	1.4-03	3.6-04	8.8-06	1.1-07	8.3-06	1.2-03	1.5-05	8.1-06
COLORADO	8.0-04	3.3-04	8.7-06	1.1-07	6.3-06	9.1-04	1.2-05	7.7-06
CONNECTICUT	1.8-05	0.0 00	2.2-09	2.2-11	2.4-07	2.2-05	0.0 00	3.4-09
DELAWARE	1.0-05	0.0 00	8.8-10	1.4-11	2.1-07	1.5-05	0.0 00	7.4-10
DIST. OF COLUMBIA	3.4-06	0.0 00	1.9-11	3.5-13	9.0-08	5.9-06	0.0 00	2.2-12
FLORIDA	1.4-05	1.6-06	2.9-08	3.1-10	1.7-07	1.6-05	1.1-07	1.8-08
GEORGIA	2.4-05	2.6-06	5.1-08	6.7-10	3.6-07	2.9-05	0.0 00	3.3-08
IDAHO	2.4-04	7.8-05	1.6-06	1.9-08	2.9-06	2.6-04	2.7-06	1.2-06
ILLINOIS	2.5-05	6.1-06	1.6-07	2.1-09	3.9-04	4.1-05	2.9-07	1.6-07
INDIANA	9.2-06	0.0 00	2.3-09	2.9-11	1.8-07	1.4-05	0.0 00	1.2-09
IOWA	4.0-06	0.0 00	3.8-10	4.6-12	1.1-07	5.5-06	0.0 00	3.2-10
KANSAS	1.0-05	3.4-07	8.7-09	9.5-11	2.5-07	1.3-05	0.0 00	5.2-09
KENTUCKY	1.9-04	5.7-05	1.1-06	1.2-08	2.1-06	2.5-04	2.2-06	8.1-07
LOUISIANA	6.0-05	2.0-05	3.4-07	5.4-09	7.2-07	7.3-05	7.9-07	2.5-07
MAINE	3.8-06	0.0 00	6.2-12	7.3-14	9.7-08	5.6-06	0.0 00	8.0-13
MARYLAND	3.5-06	0.0 00	3.5-10	5.7-12	1.0-07	6.1-06	0.0 00	2.0-10
MASSACHUSETTS	2.7-05	2.0-06	4.0-08	4.6-10	3.7-07	3.4-05	1.7-07	2.8-08
MICHIGAN	1.1-05	7.7-07	2.7-08	5.3-10	1.8-07	1.6-05	0.0 00	3.5-08
MINNESOTA	3.5-07	0.0 00	6.0-12	9.0-14	1.6-08	5.2-07	0.0 00	3.7-12
MISSISSIPPI	2.9-05	3.5-06	6.9-08	7.1-10	4.5-07	3.8-05	0.0 00	3.9-08
MISSOURI	5.9-04	2.5-04	8.2-06	1.1-07	5.5-06	1.1-03	1.4-05	9.9-06
MONTANA	2.0-04	6.6-05	1.6-06	2.3-08	2.9-06	2.4-04	3.2-06	1.5-06
NEBRASKA	8.4-06	0.0 00	1.2-08	1.6-10	2.5-07	1.3-05	0.0 00	1.1-08
NEVADA	4.0-04	1.5-05	3.3-07	3.3-09	4.6-06	5.5-04	1.2-06	2.3-07
NEW HAMPSHIRE	2.9-05	0.0 00	3.3-09	3.8-11	5.2-07	4.0-05	0.0 00	2.6-09
NEW JERSEY	3.3-01	0.0 00	6.4-09	1.1-10	4.7-07	4.1-05	0.0 00	5.2-09
NEW MEXICO	1.3-04	3.1-05	5.8-07	4.8-09	1.7-06	1.8-04	2.0-06	4.6-07
NEW YORK	7.7-05	0.0 00	9.1-09	1.1-10	8.5-07	1.0-04	0.0 00	7.5-09
NORTH CAROLINA	2.7-06	0.0 00	5.8-11	6.4-13	6.7-08	3.9-06	0.0 00	4.6-11
NORTH DAKOTA	1.7-06	0.0 00	3.8-09	5.5-11	6.5-08	2.4-06	0.0 00	2.9-09
OHIO	9.6-06	4.1-07	8.9-09	1.4-10	1.8-07	1.3-05	0.0 00	6.4-09
OKLAHOMA	2.2-05	8.2-07	1.7-08	1.7-10	3.2-07	2.5-05	0.0 00	1.3-08
OREGON	8.1-05	1.7-05	3.2-07	5.1-09	1.1-06	1.1-04	9.1-07	2.5-07
PENNSYLVANIA	4.9-06	3.0-07	6.9-09	9.7-11	9.3-08	6.5-06	0.0 00	5.3-09
RHODE ISLAND	6.7-06	0.0 00	7.7-10	9.5-12	1.3-07	9.0-06	0.0 00	6.3-10
SOUTH CAROLINA	8.0-05	1.6-05	3.5-07	3.7-09	7.9-07	8.8-05	9.5-07	2.4-07
SOUTH DAKOTA	1.1-05	1.8-06	2.9-08	3.3-10	2.8-07	1.4-05	0.0 00	2.3-08
TENNESSEE	7.4-04	9.8-05	1.8-06	2.0-08	4.3-06	7.8-04	5.4-06	1.1-06
TEXAS	6.4-06	8.3-07	1.6-08	2.2-10	1.2-07	8.6-06	1.7-07	1.2-08
UTAH	1.0-03	3.5-04	7.3-06	8.2-08	8.3-06	1.2-03	1.4-05	6.2-06
VERMONT	2.4-06	0.0 00	0.0 00	0.0 00	9.0-08	3.8-06	0.0 00	0.0 00
VIRGINIA	6.7-06	2.3-07	4.4-09	7.0-11	1.8-07	1.1-05	0.0 00	4.3-09
WASHINGTON	2.4-03	7.9-04	1.6-05	2.2-07	1.6-05	2.9-03	3.3-05	1.2-05
WEST VIRGINIA	5.5-06	4.0-07	1.4-08	1.9-10	1.3-07	7.9-06	0.0 00	1.2-08
WISCONSIN	7.9-06	0.0 00	9.9-10	1.5-11	1.6-07	1.0-05	0.0 00	8.3-10
WYOMING	1.4-05	3.3-06	5.2-08	5.5-10	3.9-07	1.7-05	0.0 00	4.3-08
ALASKA	8.4-04	8.9-05	1.4-06	2.0-08	1.3-05	1.2-03	6.3-06	9.4-07
HAWAII	2.0-04	4.2-05	7.6-07	1.0-08	2.7-06	2.5-04	0.0 00	5.3-07
NATIONAL AVERAGE	3.3-04	8.3-05	2.0-06	2.4-08	2.8-06	3.3-04	3.6-06	1.6-06

Table H-5. The Estimated Annual Earthquake Loss Save Due to a UBC Zone 3 Mitigation in 2000

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESSNESS PERSON YEARS	UNEMPLOYMENT PERSON YEARS
ALABAMA	0.	0.00	1.	0.	0.	0.	0.	0.0
ARIZONA	0.	0.09	591.	9.	0.	9.	0.	0.0
ARKANSAS	1.	0.35	1277.	24.	0.	34.	0.	0.6
CALIFORNIA	0.	0.00	0.	0.	0.	0.	0.	0.0
COLORADO	12.	5.31	56368.	929.	4.	267.	7.	8.6
CONNECTICUT	0.	0.00	6.	0.	0.	3.	0.	0.0
DELAWARE	0.	0.00	1.	0.	0.	1.	0.	0.0
DIST. OF COLUMBIA	0.	0.00	0.	0.	0.	0.	0.	0.0
FLORIDA	0.	0.10	459.	9.	1.	12.	0.	0.0
GEORGIA	0.	0.03	104.	2.	0.	4.	0.	0.0
IDAHO	1.	0.28	2651.	41.	0.	16.	0.	0.6
ILLINOIS	0.	0.05	464.	8.	0.	6.	0.	0.0
INDIANA	0.	0.00	2.	0.	0.	1.	0.	0.0
IOWA	0.	0.00	0.	0.	0.	0.	0.	0.0
KANSAS	0.	0.00	3.	0.	0.	1.	0.	0.0
KENTUCKY	0.	0.16	1314.	23.	0.	16.	0.	0.6
LOUISIANA	1.	0.49	4562.	120.	1.	29.	1.	0.6
MAINE	0.	0.00	0.	0.	0.	0.	0.	0.0
MARYLAND	0.	0.00	2.	0.	0.	1.	0.	0.0
MASSACHUSETTS	0.	0.00	27.	1.	0.	4.	0.	0.0
MICHIGAN	0.	0.02	289.	4.	0.	5.	0.	0.0
MINNESOTA	0.	0.00	0.	0.	0.	0.	0.	0.0
MISSISSIPPI	0.	0.04	302.	5.	0.	6.	0.	0.0
MISSOURI	4.	2.01	17566.	304.	2.	157.	3.	3.4
MONTANA	0.	0.09	820.	15.	0.	7.	0.	0.0
NEBRASKA	0.	0.00	5.	0.	0.	0.	0.	0.0
NEVADA	2.	0.07	526.	7.	1.	47.	0.	0.0
NEW HAMPSHIRE	0.	0.00	0.	0.	0.	1.	0.	0.0
NEW JERSEY	1.	0.00	52.	1.	0.	11.	0.	0.0
NEW MEXICO	1.	0.15	1448.	18.	1.	16.	1.	0.0
NEW YORK	2.	0.00	40.	1.	1.	55.	0.	0.0
NORTH CAROLINA	0.	0.00	0.	0.	0.	1.	0.	0.0
NORTH DAKOTA	0.	0.00	1.	0.	0.	0.	0.	0.0
OHIO	0.	0.00	19.	1.	0.	5.	0.	0.0
OKLAHOMA	0.	0.00	39.	1.	0.	5.	0.	0.0
OREGON	1.	0.15	1226.	35.	0.	16.	0.	0.0
PENNSYLVANIA	0.	0.01	31.	1.	0.	2.	0.	0.0
RHODE ISLAND	0.	0.00	0.	0.	0.	0.	0.	0.0
SOUTH CAROLINA	1.	0.35	2856.	50.	0.	28.	1.	0.6
SOUTH DAKOTA	0.	0.00	9.	0.	0.	0.	0.	0.0
TENNESSEE	7.	1.99	9116.	158.	2.	168.	2.	2.9
TEXAS	0.	0.07	592.	13.	0.	42.	1.	0.0
UTAH	7.	2.61	28654.	425.	3.	132.	5.	4.6
VERMONT	0.	0.00	0.	0.	0.	0.	0.	0.0
VIRGINIA	0.	0.00	28.	1.	0.	3.	0.	0.0
WASHINGTON	48.	17.03	149887.	3240.	13.	1158.	30.	26.4
WEST VIRGINIA	0.	0.00	8.	0.	0.	0.	0.	0.0
WISCONSIN	0.	0.00	0.	0.	0.	0.	0.	0.0
WYOMING	0.	0.00	16.	0.	0.	0.	0.	0.0
ALASKA	2.	0.33	1793.	40.	1.	33.	0.	0.6
HAWAII	0.	0.02	74.	1.	0.	1.	0.	0.0
NATIONAL TOTAL	91.	31.8	283229.	5487.	30.	2303.	51.	49.5

Table H-6. The Percentage of Estimated Annual Earthquake Loss Saved Due to a UBC Zone 3 Mitigation in 2000

STATE	BUILDING DAMAGE %	CONTENTS DAMAGE %	INCOME LOSS %	SUPPLIER LOSS %	LIFE LOSS %	HOMES LOST %	HOMELESS-NESS %	UNEMPLOY-MENT %
ALABAMA	15.7	0.0	22.5	22.3	0.0	15.7	19.1	26.8
ARIZONA	19.9	31.9	22.1	25.2	0.0	19.9	18.2	24.5
ARKANSAS	16.1	28.7	12.2	12.1	0.0	16.1	7.8	14.8
CALIFORNIA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COLORADO	27.0	25.3	21.1	21.4	22.2	27.0	20.3	22.4
CONNECTICUT	10.4	0.0	5.6	7.1	0.0	10.4	2.6	21.0
DELAWARE	12.5	0.0	17.9	17.7	0.0	12.5	17.1	18.2
DIST. OF COLUMBIA	7.9	0.0	0.0	0.0	0.0	7.9	0.0	0.0
FLORIDA	20.2	37.3	20.1	25.0	50.0	20.2	13.4	24.9
GEORGIA	15.1	21.2	10.2	9.0	0.0	15.1	6.5	14.8
IDAHO	21.5	23.5	23.0	22.8	0.0	21.5	22.9	23.2
ILLINOIS	11.1	8.2	7.5	7.8	0.0	11.1	6.8	8.2
INDIANA	7.5	38.4	4.7	5.4	0.0	7.5	5.9	3.7
IOWA	6.8	0.0	1.9	1.5	0.0	6.8	1.6	2.5
KANSAS	8.1	0.0	2.4	2.4	0.0	8.1	2.8	2.2
KENTUCKY	18.6	16.0	13.8	14.0	0.0	18.6	12.7	15.1
LOUISIANA	28.8	33.0	33.9	34.0	33.3	28.8	34.3	33.1
MAINE	4.9	0.0	0.0	0.0	0.0	4.9	0.0	0.0
MARYLAND	13.0	0.0	14.2	13.5	0.0	13.0	16.7	13.0
MASSACHUSETTS	5.9	0.0	1.0	1.0	0.0	5.9	1.1	1.0
MICHIGAN	11.1	11.1	11.6	11.7	0.0	11.1	11.2	12.0
MINNESOTA	6.3	0.0	0.0	0.0	0.0	6.3	0.0	0.0
MISSISSIPPI	22.4	35.3	29.2	29.7	0.0	22.4	27.7	30.6
MISSOURI	14.7	12.8	7.8	7.8	14.3	14.7	7.2	8.4
MONTANA	11.7	11.7	8.3	8.7	0.0	11.7	7.7	9.3
NEBRASKA	5.8	5.8	2.3	2.4	0.0	5.8	1.6	3.0
NEVADA	25.4	25.4	17.4	18.9	25.0	25.4	14.4	20.1
NEW HAMPSHIRE	5.4	0.0	0.9	1.0	0.0	5.4	0.4	1.3
NEW JERSEY	7.8	0.0	7.3	6.7	0.0	7.8	5.9	8.5
NEW MEXICO	24.3	27.2	26.3	27.4	50.0	24.3	25.6	27.3
NEW YORK	6.8	0.0	1.7	2.1	5.9	6.8	0.8	2.4
NORTH CAROLINA	11.4	0.0	2.9	2.8	0.0	11.4	2.0	3.5
NORTH DAKOTA	10.7	10.7	6.6	8.3	0.0	10.7	4.3	8.6
OHIO	8.5	0.0	1.7	1.7	0.0	8.5	1.9	1.6
OKLAHOMA	17.1	0.0	7.5	7.2	0.0	17.1	8.0	6.9
OREGON	17.3	17.3	17.7	18.0	0.0	17.3	17.4	18.1
PENNSYLVANIA	8.2	18.4	5.3	5.6	0.0	8.2	3.2	7.5
RHODE ISLAND	6.1	0.0	2.9	3.4	0.0	6.1	1.3	3.5
SOUTH CAROLINA	28.3	33.1	30.0	28.8	0.0	28.3	28.9	31.1
SOUTH DAKOTA	9.5	15.2	5.7	6.5	0.0	9.5	4.3	7.3
TENNESSEE	19.5	32.2	18.7	18.4	15.4	19.5	12.3	25.4
TEXAS	21.8	31.0	27.6	27.8	0.0	21.8	27.0	28.2
UTAH	24.3	26.3	26.5	26.6	25.0	24.3	26.5	26.7
VERMONT	8.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0
VIRGINIA	14.4	14.4	10.5	14.7	0.0	14.4	7.9	11.8
WASHINGTON	25.4	23.4	23.5	23.7	21.0	25.4	22.7	24.7
WEST VIRGINIA	8.4	16.0	4.2	5.0	0.0	8.4	2.7	7.9
WISCONSIN	5.7	0.0	1.0	1.1	0.0	5.7	0.5	1.6
WYOMING	13.0	17.2	8.2	9.1	0.0	13.0	6.4	12.3
ALASKA	25.9	44.4	29.8	33.1	25.0	25.9	22.8	40.6
HAWAII	13.2	20.1	10.5	10.0	0.0	13.2	6.4	13.5
NATIONAL AVERAGE	7.7	8.5	7.3	11.4	7.5	10.1	7.9	7.8

TSUNAMI TABLES

H - 7 Annual Losses in 1970

H - 8 Annual Loss Rates in 1970

H - 9 Annual Losses in 2000

H - 10 Annual Loss Rates in 2000

H - 11 The saving due to a 50-year flood plain mitigation (see Chapter 9 for details) in 2000

H - 12 The percentage of losses saved due to the 50-year flood plain mitigation in 2000

H - 13 The savings due to a 100-year flood plain mitigation in 2000

H - 14 The percentage of losses, saved due to a 100-year flood plain mitigation

Table H-7. The Estimated Annual Tsunami Losses in 1970

STATE	BUILDING DAMAGE / 1970$ 10^6	CONTENTS DAMAGE / 1970$ 10^6	INCOME LOSS / 1970$	SUPPLIER LOSS / 1970$	LIFE LOSS / LIVES	HOMES LOST / HOUSING UNITS	HOMELESS-NESS / PERSON YEARS	UNEMPLOY-MENT / PERSON YEARS
CALIFORNIA	3.	2.79	113900.	3318.	8.	48.	15.	16.2
OREGON	0.	0.03	313.	6.	0.	2.	0.	0.0
WASHINGTON	1.	0.61	1124.	31.	2.	10.	0.	0.2
ALASKA	0.	0.16	59140.	700.	1.	12.	27.	6.6
HAWAII	4.	1.95	552700.	8370.	9.	162.	303.	74.5
NATIONAL TOTAL	8.	5.54	727177.	12425.	20.	234.	345.	97.5

Table H-8. The Estimated Annual Proportion of the Value at Risk Lost to Tsunami in 1970

STATE	(1) BUILDING DAMAGE	(2) CONTENTS DAMAGE	(3) INCOME LOSS	(4) SUPPLIER LOSS	(5) LIFE LOSS	(6) HOMES LOST	(7) HOMELESS-NESS	(8) UNEMPLOY-MENT
CALIFORNIA	2.0-05	2.9-05	1.3-06	3.8-08	5.3-07	9.4-06	1.0-06	1.1-06
OREGON	1.5-05	1.3-05	1.8-07	3.2-09	2.6-07	1.7-05	0.0 00	1.5-07
WASHINGTON	3.0-05	4.6-05	9.5-08	2.6-09	7.5-07	1.3-05	0.0 00	7.9-08
ALASKA	1.2-04	1.1-04	4.2-05	5.0-07	3.7-06	2.0-04	1.2-04	3.3-05
HAWAII	4.1-04	4.4-04	1.3-04	1.9-06	1.2-05	7.4-04	3.9-04	8.3-05
NATIONAL AVERAGE	3.7-05	4.7-05	6.8-06	1.2-07	1.1-06	3.7-05	1.9-05	4.7-06

Table H-9. The Estimated Annual Tsunami Losses in 2000

STATE	BUILDING DAMAGE / 1970$ 10^6	CONTENTS DAMAGE / 1970$ 10^6	INCOME LOSS / 1970$	SUPPLIER LOSS / 1970$	LIFE LOSS / LIVES	HOMES LOST / HOUSING UNITS	HOMELESS-NESS / PERSON YEARS	UNEMPLOY-MENT / PERSON YEARS
CALIFORNIA	9.	8.95	324800.	9909.	20.	84.	24.	46.8
OREGON	0.	0.10	626.	12.	0.	3.	0.	0.1
WASHINGTON	2.	1.97	2560.	75.	4.	16.	0.	0.4
ALASKA	1.	1.34	196600.	2353.	3.	35.	52.	22.6
HAWAII	8.	6.74	954600.	14990.	17.	197.	313.	126.0
NATIONAL TOTAL	20.	19.10	1479186.	27339.	44.	335.	389.	195.9

Table H-10. The Estimated Annual Proportion of the Value at Risk Lost to Tsunami in 2000

STATE	(1) BUILDING DAMAGE	(2) CONTENTS DAMAGE	(3) INCOME LOSS	(4) SUPPLIER LOSS	(5) LIFE LOSS	(6) HOMES LOST	(7) HOMELESS-NESS	(8) UNEMPLOY-MENT
CALIFORNIA	2.1-05	1.8-05	1.5-06	4.5-08	1.0-06	1.1-05	0.0 00	1.3-06
OREGON	1.5-05	1.1-05	1.6-07	3.2-09	5.0-07	1.6-05	0.0 00	1.3-07
WASHINGTON	3.4-05	3.0-05	8.8-08	2.6-09	1.6-06	1.4-05	0.0 00	7.4-08
ALASKA	2.0-04	2.0-04	5.8-05	7.0-07	1.2-05	3.8-04	2.0-04	4.7-05
HAWAII	2.9-04	2.7-04	7.9-05	1.2-06	1.5-05	5.5-04	2.8-04	5.1-05
NATIONAL AVERAGE	3.9-05	3.1-05	5.5-06	1.0-07	1.9-06	3.6-05	1.6-05	3.7-06

Table H-11. The Estimated Annual Tsunami Loss Saved Due to a 50 Year Flood Plain Mitigation in 2000

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESS-NESS PERSON YEARS	UNEMPLOY-MENT PERSON YEARS
CALIFORNIA	0.	0.	7471.	240.	0.	0.	1.	0.5
OREGON	0.	0.	0.	0.	0.	0.	0.	0.0
WASHINGTON	0.	0.	0.	0.	0.	0.	0.	0.0
ALASKA	0.	0.	9041.	118.	0.	1.	2.	1.4
HAWAII	0.	0.	9546.	304.	0.	1.	6.	0.9
NATIONAL TOTAL	0.	0.	26058.	662.	0.	2.	9.	2.8

Table H-12. The Percentage of Estimated Annual Tsunami Loss Saved Due to a 50 Year Flood Plane Mitigation in 2000

STATE	BUILDING DAMAGE %	CONTENTS DAMAGE %	INCOME LOSS %	SUPPLIER LOSS %	LIFE LOSS %	HOMES LOST %	HOMELESS-NESS %	UNEMPLOY-MENT %
CALIFORNIA	0.5	0.5	2.3	2.3	0.0	0.5	2.4	2.2
OREGON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WASHINGTON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ALASKA	3.7	3.7	4.6	4.2	0.0	3.7	4.6	4.7
HAWAII	0.4	0.4	1.0	1.7	0.0	0.4	1.9	0.7
NATIONAL AVERAGE	0.1	0.0	1.8	0.0	0.0	0.6	2.3	1.4

Table H-13. The Estimated Annual Tsunami Loss Saved Due to a 100 Year Flood Plain Mitigation in 2000

STATE	BUILDING DAMAGE / 1970$ 10^6	CONTENTS DAMAGE / 1970$ 10^6	INCOME LOSS / 1970$	SUPPLIER LOSS / 1970$	LIFE LOSS / LIVES	HOMES LOST / HOUSING UNITS	HOMELESS-NESS / PERSON YEARS	UNEMPLOY-MENT / PERSON YEARS
CALIFORNIA	0.	0.	13643.	386.	1.	1.	1.	1.4
OREGON	0.	0.	4.	0.	0.	0.	0.	0.0
WASHINGTON	0.	0.	5.	0.	0.	0.	0.	0.0
ALASKA	0.	0.	21621.	284.	0.	4.	6.	3.8
HAWAII	0.	0.	10501.	322.	0.	1.	6.	0.9
NATIONAL TOTAL	0.	0.	45774.	992.	1.	6.	13.	6.1

Table H-14. The Percentage of Estimated Annual Tsunami Loss Saved Due to a 100 Year Flood Plane Mitigation in 2000

STATE	BUILDING DAMAGE / %	CONTENTS DAMAGE / %	INCOME LOSS / %	SUPPLIER LOSS / %	LIFE LOSS / %	HOMES LOST / %	HOMELESS-NESS / %	UNEMPLOY-MENT / %
CALIFORNIA	1.6	1.6	4.2	3.7	5.0	1.6	4.1	4.7
OREGON	0.6	0.6	0.6	0.7	0.0	0.6	0.6	0.6
WASHINGTON	0.1	0.1	0.2	0.1	0.0	0.1	0.2	0.3
ALASKA	10.3	10.3	11.0	10.1	0.0	10.3	10.9	11.1
HAWAII	0.5	0.5	1.1	1.8	0.0	0.5	2.0	0.8
NATIONAL AVERAGE	0.3	0.0	3.1	2.3	2.3	1.8	3.3	3.1

STORM SURGE TABLES

H - 15 Annual Loss in 1970

H - 16 Annual Loss rates in 1970

H - 17 Annual Losses in 2000

H - 18 Annual Loss rates in 2000

H - 19 The savings due to a 50-year flood plain mitigation (see Chapter 9 for details) in 2000

H - 20 The percentage of losses saved due to the use of the 50-year flood plain mitigation

H - 21 The savings due to a 4ft. flood-proofing mitigation in 2000

H - 22 The percentage of losses saved due to the use of the 4ft. flood-proofing mitigation in 2000

Table H-15. The Estimated Annual Storm Surge Losses in 1970

STATE	BUILDING DAMAGE (1970$ 10^6)	CONTENTS DAMAGE (1970$ 10^6)	INCOME LOSS (1970$)	SUPPLIER LOSS (1970$)	LIFE LOSS (LIVES)	HOMES LOST (HOUSING UNITS)	HOMELESSNESS (PERSON YEARS)	UNEMPLOYMENT (PERSON YEARS)
ALABAMA	4.	1.98	15340.	187.	0.	295.	95.	2.6
CONNECTICUT	10.	5.36	31410.	348.	1.	368.	40.	19.6
DELAWARE	1.	0.31	1524.	18.	0.	26.	5.	0.2
FLORIDA	195.	82.65	1014000.	10590.	17.	12617.	4076.	130.0
GEORGIA	4.	2.19	47620.	489.	0.	279.	150.	8.4
LOUISIANA	84.	37.60	651000.	9683.	7.	4651.	1477.	126.0
MAINE	1.	0.28	438.	4.	0.	27.	2.	0.1
MARYLAND	4.	1.99	18610.	228.	0.	182.	29.	2.5
MASSACHUSETTS	13.	6.11	65580.	668.	1.	392.	39.	9.3
MISSISSIPPI	13.	6.59	101800.	983.	1.	805.	494.	23.4
NEW HAMPSHIRE	0.	0.02	8.	0.	0.	1.	0.	0.0
NEW JERSEY	11.	5.63	43150.	511.	1.	521.	54.	4.8
NEW YORK	50.	22.88	160200.	2123.	4.	1407.	79.	12.1
NORTH CAROLINA	8.	3.98	44700.	413.	1.	598.	196.	8.2
RHODE ISLAND	7.	3.46	33210.	401.	1.	326.	38.	3.4
SOUTH CAROLINA	7.	3.27	28760.	284.	1.	448.	247.	5.5
TEXAS	16.	7.40	88950.	1189.	1.	884.	179.	11.8
VIRGINIA	14.	5.54	20230.	364.	1.	694.	90.	1.8
NATIONAL TOTAL	442.	197.24	2366530.	28483.	37.	24521.	7290.	369.7

Table H-16. The Estimated Annual Proportion of the Value at Risk Lost to Storm Surge in 1970

STATE	① BUILDING DAMAGE	② CONTENTS DAMAGE	③ INCOME LOSS	④ SUPPLIER LOSS	⑤ LIFE LOSS	⑥ HOMES LOST	⑦ HOMELESSNESS	⑧ UNEMPLOYMENT
ALABAMA	1.5-03	1.2-03	1.1-05	1.3-07	1.0-06	2.5-03	2.5-04	7.1-06
CONNECTICUT	4.6-04	3.8-04	2.8-06	3.1-08	4.5-07	6.0-04	2.1-05	7.1-06
DELAWARE	9.4-05	8.0-05	5.0-07	5.9-09	8.6-08	1.5-04	9.1-06	3.3-07
FLORIDA	3.9-03	3.3-03	4.5-05	3.2-07	3.2-06	6.3-03	7.6-04	2.6-05
GEORGIA	1.8-03	1.5-03	3.9-05	4.0-07	1.4-06	3.1-03	5.3-04	3.0-05
LOUISIANA	3.9-03	3.3-03	5.3-05	7.9-07	3.1-06	6.0-03	6.1-04	4.0-05
MAINE	1.3-04	1.2-04	2.1-07	2.2-09	1.0-07	2.0-04	4.3-06	1.6-07
MARYLAND	1.6-04	1.4-04	1.5-06	1.9-08	1.6-07	2.6-04	1.3-05	1.0-06
MASSACHUSETTS	3.8-04	3.3-04	3.9-06	3.9-08	3.9-07	4.2-04	1.4-05	2.8-06
MISSISSIPPI	7.0-03	6.5-03	1.2-04	1.1-06	4.8-06	1.2-02	2.1-03	1.0-04
NEW HAMPSHIRE	2.0-05	2.2-05	9.0-09	1.0-10	2.0-08	2.8-05	0.0 00	2.3-09
NEW JERSEY	2.3-04	1.9-04	1.7-06	2.0-08	2.5-07	3.9-04	1.3-05	1.0-06
NEW YORK	3.1-04	2.8-04	1.9-06	2.6-08	3.9-07	3.9-04	7.0-06	8.4-07
NORTH CAROLINA	2.0-03	1.6-03	2.3-05	2.2-07	1.3-06	3.3-03	3.6-04	1.6-05
RHODE ISLAND	7.6-04	6.0-04	6.9-06	8.4-08	6.5-07	1.1-03	4.0-05	3.4-06
SOUTH CAROLINA	1.6-03	1.3-03	1.4-05	1.4-07	1.2-06	2.8-03	4.7-04	1.1-05
TEXAS	5.3-04	4.3-04	5.2-06	7.0-08	4.7-07	8.9-04	6.1-05	3.1-06
VIRGINIA	1.2-03	1.0-03	4.2-06	7.5-08	1.1-06	2.0-03	8.0-05	1.7-06
NATIONAL AVERAGE	1.0-03	8.3-04	1.1-05	1.3-07	9.6-07	1.9-03	1.9-04	8.4-06

Table H-17. The Estimated Annual Storm Surge Losses in 2000

STATE	BUILDING DAMAGE / 1970$ 10^6	CONTENTS DAMAGE / 1970$ 10^6	INCOME LOSS / 1970$	SUPPLIER LOSS / 1970$	LIFE LOSS / LIVES	HOMES LOST / HOUSING UNITS	HOMELESSNESS / PERSON YEARS	UNEMPLOYMENT / PERSON YEARS
ALABAMA	10.	9.72	36140.	467.	1.	395.	111.	6.5
CONNECTICUT	22.	27.59	71970.	813.	2.	622.	49.	42.7
DELAWARE	1.	1.69	3864.	47.	0.	45.	7.	0.5
FLORIDA	647.	608.14	3344000.	36610.	57.	27082.	6673.	444.0
GEORGIA	10.	11.06	114300.	1201.	1.	384.	180.	21.7
LOUISIANA	171.	169.94	1432000.	21330.	15.	5683.	1591.	295.0
MAINE	1.	1.29	885.	9.	0.	39.	2.	0.2
MARYLAND	9.	10.34	44680.	550.	1.	289.	40.	6.3
MASSACHUSETTS	31.	33.83	172500.	1778.	3.	675.	57.	25.9
MISSISSIPPI	28.	31.70	234200.	2349.	2.	1110.	542.	56.4
NEW HAMPSHIRE	0.	0.09	17.	0.	0.	2.	0.	0.0
NEW JERSEY	25.	27.73	95950.	1152.	2.	784.	69.	11.3
NEW YORK	106.	109.55	337600.	4526.	9.	2397.	114.	28.0
NORTH CAROLINA	17.	19.63	103700.	968.	2.	792.	230.	21.0
RHODE ISLAND	15.	16.32	72210.	893.	1.	469.	48.	8.2
SOUTH CAROLINA	15.	15.38	66400.	685.	1.	618.	291.	13.7
TEXAS	38.	40.47	231300.	3204.	3.	1377.	242.	32.7
VIRGINIA	30.	25.96	44840.	800.	3.	994.	84.	4.2
NATIONAL TOTAL	1176.	1160.43	6406556.	77382.	103.	43757.	10330.	1018.3

Table H-18. The Estimated Annual Proportion of the Value at Risk Lost to Storm Surge in 2000

STATE	(1) BUILDING DAMAGE	(2) CONTENTS DAMAGE	(3) INCOME LOSS	(4) SUPPLIER LOSS	(5) LIFE LOSS	(6) HOMES LOST	(7) HOMELESSNESS	(8) UNEMPLOYMENT
ALABAMA	1.4-03	1.2-03	1.0-05	1.3-07	1.9-06	2.5-03	2.5-04	7.1-06
CONNECTICUT	4.5-04	3.7-04	2.4-06	2.8-08	7.6-07	6.6-04	1.9-05	6.2-06
DELAWARE	9.2-05	7.8-05	4.5-07	5.5-09	1.5-07	1.7-04	9.3-06	3.2-07
FLORIDA	3.9-03	3.4-03	4.1-05	4.5-07	6.0-06	6.7-03	7.0-04	2.4-05
GEORGIA	1.8-03	1.6-03	3.8-05	4.1-07	2.6-06	3.2-03	5.5-04	3.0-05
LOUISIANA	3.6-03	3.0-03	4.8-05	7.2-07	5.6-06	5.9-03	6.0-04	3.8-05
MAINE	1.2-04	1.1-04	1.8-07	1.9-09	1.9-07	2.2-04	3.8-06	1.4-07
MARYLAND	1.7-04	1.5-04	1.5-06	1.9-08	3.0-07	2.9-04	1.5-05	1.1-06
MASSACHUSETTS	3.8-04	3.3-04	3.9-06	4.0-08	7.0-07	4.7-04	1.5-05	3.0-06
MISSISSIPPI	6.6-03	6.5-03	1.1-04	1.1-06	9.2-06	1.1-02	2.0-03	9.4-05
NEW HAMPSHIRE	1.9-05	1.8-05	7.7-09	8.8-11	3.6-08	3.4-05	0.0 00	2.1-09
NEW JERSEY	2.2-04	1.9-04	1.5-06	1.8-08	4.2-07	4.0-04	1.3-05	9.9-07
NEW YORK	3.0-04	2.7-04	1.7-06	2.3-08	6.5-07	4.2-04	8.0-06	8.2-07
NORTH CAROLINA	1.9-03	1.5-03	2.0-05	1.8-07	2.3-06	3.3-03	3.6-04	1.3-05
RHODE ISLAND	7.3-04	5.8-04	6.3-06	7.7-08	1.1-06	1.1-03	4.2-05	3.3-06
SOUTH CAROLINA	1.5-03	1.3-03	1.3-05	1.3-07	2.1-06	2.8-03	4.7-04	1.0-05
TEXAS	4.7-04	3.9-04	4.6-06	6.3-08	8.1-07	8.6-04	5.8-05	2.9-06
VIRGINIA	1.2-03	1.0-03	3.8-06	6.7-08	1.9-06	2.1-03	6.0-05	1.6-06
NATIONAL AVERAGE	1.1-03	9.1-04	1.1-05	1.3-07	2.0-06	2.2-03	2.0-04	8.8-06

Table H-19. The Estimated Annual Storm Surge Losses Saved Due to a 50 Year Flood Plain Mitigation in 2000

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESSNESS PERSON YEARS	UNEMPLOYMENT PERSON YEARS
ALABAMA	1.	1.	3288.	0.	0.	36.	10.	0.3
CONNECTICUT	4.	5.	12019.	0.	0.	104.	8.	34.2
DELAWARE	0.	0.	723.	0.	0.	8.	1.	0.0
FLORIDA	208.	195.	1006463.	0.	18.	8693.	1942.	109.0
GEORGIA	1.	1.	12460.	0.	0.	39.	20.	1.6
LOUISIANA	9.	8.	68728.	0.	1.	284.	73.	8.6
MAINE	0.	0.	44.	0.	0.	3.	0.	0.0
MARYLAND	1.	2.	7551.	0.	0.	45.	7.	0.7
MASSACHUSETTS	6.	7.	35018.	0.	1.	130.	12.	3.0
MISSISSIPPI	2.	2.	14518.	0.	0.	72.	32.	2.0
NEW HAMPSHIRE	0.	0.	3.	0.	0.	0.	0.	0.0
NEW JERSEY	3.	3.	12378.	0.	0.	98.	9.	1.0
NEW YORK	14.	15.	45577.	0.	1.	321.	15.	3.6
NORTH CAROLINA	2.	2.	9645.	0.	1.	76.	21.	1.3
RHODE ISLAND	2.	2.	8160.	0.	0.	53.	5.	0.7
SOUTH CAROLINA	1.	2.	6508.	0.	0.	61.	28.	1.0
TEXAS	7.	7.	40932.	0.	0.	249.	42.	4.6
VIRGINIA	4.	3.	5605.	0.	1.	125.	10.	0.7
NATIONAL TOTAL	265.	255.	1289620.	0.	23.	10397.	2235.	172.3

Table H-20. The Percentage of Estimated Annual Storm Surge Losses Saved Due to a 50 Year Flood Plane Mitigation in 2000

STATE	BUILDING DAMAGE %	CONTENTS DAMAGE %	INCOME LOSS %	SUPPLIER LOSS %	LIFE LOSS %	HOMES LOST %	HOMELESSNESS %	UNEMPLOYMENT %
ALABAMA	9.1	9.1	9.1	0.0	0.0	9.1	9.1	9.1
CONNECTICUT	16.8	16.8	16.7	0.0	0.0	16.8	16.7	16.7
DELAWARE	18.8	18.8	18.7	0.0	0.0	18.8	18.7	18.7
FLORIDA	32.1	32.1	30.1	0.0	31.6	32.1	29.1	30.4
GEORGIA	10.2	10.2	10.9	0.0	0.0	10.2	11.0	10.8
LOUISIANA	5.0	5.0	4.8	0.0	6.7	5.0	4.6	4.9
MAINE	7.9	7.9	5.0	0.0	0.0	7.9	4.4	5.4
MARYLAND	15.5	15.5	16.9	0.0	0.0	15.5	17.5	16.7
MASSACHUSETTS	19.3	19.3	20.3	0.0	33.3	19.3	20.6	20.2
MISSISSIPPI	6.5	6.5	6.2	0.0	0.0	6.5	5.9	6.2
NEW HAMPSHIRE	16.8	16.8	16.7	0.0	0.0	16.8	16.7	16.7
NEW JERSEY	12.5	12.5	12.9	0.0	0.0	12.5	13.1	12.7
NEW YORK	13.4	13.4	13.5	0.0	11.1	13.4	13.5	13.4
NORTH CAROLINA	9.6	9.6	9.3	0.0	50.0	9.6	9.3	9.4
RHODE ISLAND	11.2	11.2	11.3	0.0	0.0	11.2	11.3	11.2
SOUTH CAROLINA	9.8	9.8	9.8	0.0	0.0	9.8	9.7	9.8
TEXAS	18.1	18.1	17.7	0.0	0.0	18.1	17.3	17.8
VIRGINIA	12.6	12.6	12.5	0.0	33.3	12.6	12.3	12.5
NATIONAL AVERAGE	22.5	22.5	22.3	0.0	31.0	22.5	21.6	16.9

Table H-21. The Estimated Annual Storm Surge Losses Saved Due to a Flood Proofing Mitigation to 4ft in 2000

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESS-NESS PERSON YEARS	UNEMPLOY-MENT PERSON YEARS
ALABAMA	5.	5.	20417.	140.	1.	222.	63.	3.0
CONNECTICUT	10.	13.	33539.	0.	1.	291.	23.	95.5
DELAWARE	1.	1.	2125.	14.	0.	25.	4.	0.3
FLORIDA	454.	427.	2303830.	19907.	40.	19012.	4558.	248.0
GEORGIA	4.	5.	54299.	320.	1.	174.	86.	6.6
LOUISIANA	80.	80.	678692.	4668.	7.	2660.	756.	83.6
MAINE	0.	0.	247.	0.	0.	12.	1.	0.0
MARYLAND	5.	6.	25112.	173.	1.	156.	23.	2.6
MASSACHUSETTS	12.	13.	69863.	92.	1.	265.	23.	5.9
MISSISSIPPI	14.	15.	114270.	724.	1.	541.	262.	14.5
NEW HAMPSHIRE	0.	0.	6.	0.	0.	1.	0.	0.0
NEW JERSEY	11.	12.	43946.	69.	1.	347.	32.	4.0
NEW YORK	42.	44.	135379.	386.	3.	959.	46.	11.2
NORTH CAROLINA	8.	9.	49573.	260.	1.	380.	110.	6.3
RHODE ISLAND	5.	6.	25417.	0.	0.	165.	17.	2.3
SOUTH CAROLINA	8.	8.	35460.	174.	0.	338.	154.	4.6
TEXAS	21.	22.	128810.	883.	1.	761.	135.	14.8
VIRGINIA	17.	15.	25693.	192.	2.	573.	48.	3.3
NATIONAL TOTAL	697.	681.	3746678.	28002.0	61.	26882.	6341.	506.5

Table H-22. The Percentage of Estimated Annual Storm Surge Losses Saved Due to a Flood Proofing Mitigation to 4ft in 2000

STATE	BUILDING DAMAGE %	CONTENTS DAMAGE %	INCOME LOSS %	SUPPLIER LOSS %	LIFE LOSS %	HOMES LOST %	HOMELESS-NESS %	UNEMPLOY-MENT %
ALABAMA	56.2	56.2	56.5	30.0	100.0	56.2	56.6	56.5
CONNECTICUT	46.8	46.8	46.6	0.0	50.0	46.8	46.7	46.6
DELAWARE	54.9	54.9	55.0	29.8	0.0	54.9	55.0	55.0
FLORIDA	70.2	70.2	68.9	54.4	70.2	70.2	68.3	69.1
GEORGIA	45.4	45.4	47.5	26.6	100.0	45.4	47.5	47.6
LOUISIANA	46.8	46.8	47.4	21.9	46.7	46.8	47.5	47.4
MAINE	30.2	30.2	27.9	0.0	0.0	30.2	27.4	28.2
MARYLAND	54.0	54.0	56.2	31.5	100.0	54.0	57.1	55.8
MASSACHUSETTS	39.3	39.3	40.5	5.2	33.3	39.3	40.9	40.4
MISSISSIPPI	48.7	48.7	48.8	30.8	50.0	48.7	48.3	48.8
NEW HAMPSHIRE	37.9	37.9	37.9	0.0	0.0	37.9	37.9	37.9
NEW JERSEY	44.2	44.2	45.8	6.0	50.0	44.2	46.7	45.6
NEW YORK	40.0	40.0	40.1	8.5	33.3	40.0	40.1	40.0
NORTH CAROLINA	48.0	48.0	47.8	26.9	50.0	48.0	47.8	47.8
RHODE ISLAND	35.1	35.1	35.2	0.0	0.0	35.1	35.3	35.2
SOUTH CAROLINA	54.7	54.7	53.4	25.4	0.0	54.7	53.0	53.6
TEXAS	55.3	55.3	55.7	27.6	33.3	55.3	55.6	55.5
VIRGINIA	57.6	57.6	57.3	24.0	66.7	57.6	56.9	57.4
NATIONAL AVERAGE	59.3	59.3	58.5	36.2	59.2	59.3	61.4	49.7

SEVERE WIND TABLES

H - 23 Annual Losses in 1970

H - 24 Annual Loss rates in 1970

H - 25 Annual Losses in 2000

H - 26 Annual Loss rates in 2000

H - 27 The savings due to a building code mitigation of 1.5 x UBC (see Chapter 9 for details) in 2000

H - 28 The percentage of losses saved due to a building code mitigation of 1.5 x UBC in 2000

H - 29 The savings due to a building code mitigation of 3.0 x UBC in 2000

H - 30 The percentage of losses saved due to a building code mitigation of 3.0 x UBC in 2000

Table H-23. The Estimated Annual Severe Wind Losses in 1970

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESS-NESS PERSON YEARS	UNEMPLOY-MENT PERSON YEARS
ALABAMA	0.	0.00	532.	5.	0.	0.	0.	0.1
ARIZONA	0.	0.01	7400.	68.	0.	3.	4.	1.4
ARKANSAS	0.	0.00	204.	2.	0.	0.	0.	0.0
CALIFORNIA	1.	0.32	147500.	1426.	0.	35.	57.	20.8
COLORADO	0.	0.15	72210.	719.	0.	21.	30.	11.9
CONNECTICUT	0.	0.19	74400.	708.	0.	16.	28.	31.2
DELAWARE	0.	0.01	4915.	54.	0.	1.	2.	0.9
DIST. OF COLUMBIA	0.	0.00	282.	2.	0.	0.	0.	0.0
FLORIDA	0.	0.06	33740.	297.	0.	8.	13.	6.5
GEORGIA	0.	0.01	4068.	41.	0.	1.	1.	0.8
IDAHO	0.	0.03	13120.	136.	0.	5.	6.	2.5
ILLINOIS	1.	0.33	149500.	1616.	0.	36.	56.	22.6
INDIANA	0.	0.19	81080.	893.	0.	23.	34.	13.9
IOWA	0.	0.12	52490.	497.	0.	15.	23.	10.1
KANSAS	0.	0.09	42440.	422.	0.	14.	20.	8.3
KENTUCKY	0.	0.01	3790.	33.	0.	1.	1.	0.8
LOUISIANA	0.	0.04	25520.	327.	0.	6.	10.	5.5
MAINE	0.	0.00	1632.	19.	0.	1.	2.	0.3
MARYLAND	0.	0.02	12610.	136.	0.	3.	5.	2.3
MASSACHUSETTS	1.	0.33	137800.	1368.	0.	32.	55.	20.4
MICHIGAN	0.	0.03	14490.	170.	0.	5.	8.	2.5
MINNESOTA	0.	0.15	72540.	854.	0.	23.	36.	12.6
MISSISSIPPI	0.	0.01	3491.	31.	0.	1.	1.	0.8
MISSOURI	0.	0.06	28290.	286.	0.	8.	11.	4.9
MONTANA	0.	0.05	25450.	268.	0.	10.	13.	4.7
NEBRASKA	0.	0.08	35420.	344.	0.	11.	15.	6.8
NEVADA	0.	0.02	10580.	89.	0.	4.	4.	1.6
NEW HAMPSHIRE	0.	0.01	4128.	40.	0.	1.	2.	0.7
NEW JERSEY	1.	0.32	131300.	1565.	0.	31.	52.	18.8
NEW MEXICO	0.	0.03	15450.	134.	0.	4.	7.	2.9
NEW YORK	1.	0.34	151800.	1616.	0.	23.	37.	18.8
NORTH CAROLINA	0.	0.07	34530.	317.	0.	13.	18.	7.8
NORTH DAKOTA	0.	0.05	23650.	260.	0.	9.	13.	4.9
OHIO	0.	0.11	48380.	571.	0.	13.	21.	7.8
OKLAHOMA	0.	0.15	86270.	749.	0.	25.	35.	17.1
OREGON	0.	0.02	9002.	105.	0.	3.	4.	1.5
PENNSYLVANIA	0.	0.18	72160.	842.	0.	17.	28.	11.3
RHODE ISLAND	0.	0.07	28080.	293.	0.	8.	14.	4.6
SOUTH CAROLINA	0.	0.02	10300.	96.	0.	3.	4.	2.3
SOUTH DAKOTA	0.	0.06	26320.	239.	0.	10.	14.	5.5
TENNESSEE	0.	0.00	336.	3.	0.	0.	0.	0.1
TEXAS	1.	0.39	220400.	2272.	0.	56.	95.	44.2
UTAH	0.	0.03	16820.	158.	0.	5.	9.	3.0
VERMONT	0.	0.00	51.	1.	0.	0.	0.	0.0
VIRGINIA	0.	0.10	51320.	584.	0.	13.	21.	10.2
WASHINGTON	0.	0.08	38210.	413.	0.	12.	16.	5.9
WEST VIRGINIA	0.	0.00	99.	1.	0.	0.	0.	0.0
WISCONSIN	0.	0.07	33670.	411.	0.	9.	15.	5.9
WYOMING	0.	0.03	16500.	159.	0.	6.	7.	3.1
ALASKA	0.	0.01	4101.	50.	0.	1.	1.	0.5
HAWAII	0.	0.02	11950.	110.	0.	2.	4.	2.0
NATIONAL TOTAL	6.	4.47	2090321.	21900.	0.	547.	852.	373.1

Table H-24. The Estimated Annual Proportion of the Value at Risk Lost to Severe Wind in 1970

STATE	(1) BUILDING DAMAGE	(2) CONTENTS DAMAGE	(3) INCOME LOSS	(4) SUPPLIER LOSS	(5) LIFE LOSS	(6) HOMES LOST	(7) HOMELESS-NESS	(8) UNEMPLOY-MENT
ALABAMA	9.1-08	0.0 00	4.0-08	4.0-10	3.2-10	1.6-07	0.0 00	3.5-08
ARIZONA	2.3-06	1.1-06	8.0-07	7.3-09	9.6-09	4.9-06	2.3-06	6.4-07
ARKANSAS	6.8-08	0.0 00	3.0-08	2.9-10	2.2-10	1.2-07	0.0 00	2.6-08
CALIFORNIA	3.7-06	2.6-06	1.3-06	1.3-08	1.9-08	5.0-06	2.9-06	1.1-06
COLORADO	1.8-05	1.3-05	6.3-06	6.3-08	8.1-08	2.9-05	1.4-05	5.3-06
CONNECTICUT	1.3-05	8.4-06	3.8-06	3.7-08	6.5-08	1.7-05	9.2-06	6.6-06
DELAWARE	4.1-06	2.6-06	1.6-06	1.8-08	1.9-08	8.6-06	3.6-06	1.5-06
DIST. OF COLUMBIA	1.2-07	0.0 00	5.4-08	4.6-10	8.9-10	1.6-07	0.0 00	4.7-08
FLORIDA	2.7-06	1.9-06	1.2-06	1.1-08	1.1-08	3.3-06	1.9-06	1.0-06
GEORGIA	4.6-07	4.1-07	1.9-07	2.0-09	1.9-09	8.7-07	2.2-07	1.7-07
IDAHO	1.1-05	8.4-06	4.3-06	4.4-08	4.4-08	2.1-05	8.4-06	3.6-06
ILLINOIS	6.3-06	4.2-06	2.2-06	2.4-08	3.2-08	9.7-06	5.0-06	1.9-06
INDIANA	8.6-06	5.7-06	3.1-06	3.4-08	3.6-08	1.4-05	6.5-06	2.7-06
IOWA	1.1-05	7.3-06	4.1-06	3.9-08	4.3-08	1.6-05	8.1-06	3.6-06
KANSAS	1.1-05	7.6-06	4.2-06	4.2-08	4.5-08	1.7-05	8.9-06	3.6-06
KENTUCKY	6.9-07	6.4-07	2.7-07	2.4-09	2.4-09	1.1-06	3.1-07	2.3-07
LOUISIANA	3.9-06	2.4-06	1.5-06	2.0-08	1.4-08	5.3-06	2.7-06	1.3-06
MAINE	1.2-06	0.0 00	4.1-07	4.8-09	4.4-09	2.0-06	2.0-06	3.2-07
MARYLAND	1.3-06	8.1-07	5.6-07	6.1-09	7.0-09	2.3-06	1.3-06	5.1-07
MASSACHUSETTS	1.3-05	9.2-06	4.3-06	4.3-08	6.6-08	1.7-05	9.7-06	3.3-06
MICHIGAN	8.0-07	4.7-07	2.9-07	3.4-09	3.7-09	1.6-06	9.0-07	2.8-07
MINNESOTA	1.0-05	6.7-06	3.7-06	4.4-08	4.6-08	1.9-05	9.5-06	3.2-06
MISSISSIPPI	1.1-06	1.1-06	4.8-07	4.3-09	3.3-09	1.8-06	4.5-07	3.8-07
MISSOURI	3.4-06	2.2-06	1.2-06	1.3-08	1.5-08	5.1-06	2.4-06	1.1-06
MONTANA	2.2-05	1.5-05	8.4-06	8.9-08	9.0-08	4.1-05	1.9-05	7.2-06
NEBRASKA	1.3-05	1.0-05	5.3-06	5.2-08	5.7-08	2.2-05	1.0-05	4.5-06
NEVADA	1.1-05	7.6-06	3.7-06	3.1-08	5.8-08	2.6-05	8.2-06	3.0-06
NEW HAMPSHIRE	3.3-06	2.3-06	1.1-06	1.1-08	1.5-08	5.1-06	2.7-06	8.5-07
NEW JERSEY	9.3-06	6.3-06	3.1-06	3.6-08	4.9-08	1.3-05	7.3-06	2.4-06
NEW MEXICO	8.9-06	6.9-06	3.4-06	3.0-08	3.6-08	1.3-05	6.9-06	2.9-06
NEW YORK	4.2-06	2.8-06	1.3-06	1.4-08	2.4-08	3.8-06	2.0-06	9.3-07
NORTH CAROLINA	3.9-06	2.7-06	1.6-06	1.5-08	1.4-08	8.1-06	3.5-06	1.4-06
NORTH DAKOTA	2.7-05	1.9-05	1.1-05	1.2-07	9.4-08	4.7-05	2.1-05	9.1-06
OHIO	2.4-06	1.6-06	8.3-07	9.8-09	1.1-08	3.7-06	2.0-06	7.3-07
OKLAHOMA	1.8-05	1.2-05	7.4-06	6.4-08	7.2-08	2.7-05	1.4-05	6.6-06
OREGON	2.5-06	1.7-06	9.2-07	1.1-08	1.1-08	4.5-06	1.9-06	7.9-07
PENNSYLVANIA	3.7-06	2.5-06	1.2-06	1.4-08	1.6-08	4.5-06	2.4-06	9.4-07
RHODE ISLAND	1.8-05	1.2-05	5.9-06	6.1-08	7.8-08	2.4-05	1.5-05	4.5-06
SOUTH CAROLINA	2.5-06	1.5-06	1.0-06	9.4-09	8.5-09	4.4-06	1.5-06	8.8-07
SOUTH DAKOTA	2.6-05	2.0-05	1.1-05	9.8-08	9.5-08	4.6-05	2.1-05	9.0-06
TENNESSEE	4.9-08	0.0 00	2.0-08	1.9-10	1.7-10	7.5-08	0.0 00	1.8-08
TEXAS	9.9-06	6.8-06	4.0-06	4.1-08	4.1-08	1.5-05	8.5-06	3.6-06
UTAH	8.6-06	5.8-06	3.2-06	3.0-08	3.9-08	1.5-05	8.5-06	2.8-06
VERMONT	7.9-08	0.0 00	2.9-08	3.0-07	3.0-10	1.4-07	0.0 00	2.2-08
VIRGINIA	5.3-06	4.0-06	2.3-06	2.6-08	2.5-08	8.9-06	4.5-06	2.0-06
WASHINGTON	6.0-06	4.1-06	2.3-06	2.4-08	2.8-08	9.6-06	4.7-06	1.9-06
WEST VIRGINIA	2.9-08	0.0 00	1.1-08	1.2-10	1.1-10	5.1-08	0.0 00	1.1-08
WISCONSIN	4.3-06	2.6-06	1.6-06	1.9-08	1.8-08	6.0-06	3.4-06	1.4-06
WYOMING	2.6-05	1.9-05	9.0-06	8.7-08	1.1-07	5.6-05	2.1-05	8.2-06
ALASKA	6.1-06	5.8-06	2.3-06	2.8-08	3.9-08	1.6-05	3.7-06	2.0-06
HAWAII	7.1-06	4.5-06	2.7-06	2.5-08	4.1-08	1.0-05	5.2-06	2.2-06
NATIONAL AVERAGE	2.9-06	3.7-06	2.0-06	2.1-08	0.0 00	8.1-06	4.2-06	1.8-06

Table H-25. The Estimated Annual Severe Wind Losses in 2000

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESSNESS PERSON YEARS	UNEMPLOYMENT PERSON YEARS
ALABAMA	0.	0.01	1225.	13.	0.	0.	0.	0.3
ARIZONA	0.	0.09	20460.	196.	0.	5.	5.	4.0
ARKANSAS	0.	0.00	464.	5.	0.	0.	0.	0.1
CALIFORNIA	2.	1.61	342100.	3448.	1.	52.	74.	48.8
COLORADO	1.	0.80	175800.	1822.	0.	32.	41.	29.1
CONNECTICUT	1.	0.96	173200.	1693.	0.	25.	38.	68.7
DELAWARE	0.	0.05	12120.	144.	0.	2.	3.	2.2
DIST. OF COLUMBIA	0.	0.00	908.	8.	0.	0.	0.	0.1
FLORIDA	1.	0.45	115600.	1051.	0.	19.	26.	22.3
GEORGIA	0.	0.04	9279.	98.	0.	2.	3.	2.0
IDAHO	0.	0.13	28620.	317.	0.	7.	8.	5.8
ILLINOIS	2.	1.59	328700.	3700.	1.	30.	38.	50.5
INDIANA	1.	0.98	192800.	2268.	0.	34.	44.	33.3
IOWA	1.	0.49	107600.	1084.	0.	19.	25.	21.9
KANSAS	0.	0.35	83340.	882.	0.	16.	20.	17.1
KENTUCKY	0.	0.03	8723.	79.	0.	2.	3.	1.9
LOUISIANA	0.	0.21	54610.	713.	0.	8.	12.	11.9
MAINE	0.	0.02	3466.	48.	0.	1.	1.	0.6
MARYLAND	0.	0.12	29470.	339.	0.	4.	6.	5.4
MASSACHUSETTS	2.	1.71	322600.	3291.	1.	47.	70.	48.8
MICHIGAN	0.	0.15	32310.	406.	0.	6.	8.	5.6
MINNESOTA	1.	0.74	160500.	1937.	0.	30.	41.	28.9
MISSISSIPPI	0.	0.03	7632.	71.	0.	2.	2.	1.9
MISSOURI	0.	0.28	58060.	617.	0.	11.	14.	10.3
MONTANA	0.	0.21	48630.	557.	0.	11.	12.	9.2
NEBRASKA	0.	0.33	73980.	773.	0.	14.	18.	15.2
NEVADA	0.	0.15	31290.	278.	0.	9.	8.	4.7
NEW HAMPSHIRE	0.	0.05	9999.	102.	0.	2.	3.	1.7
NEW JERSEY	2.	1.62	303100.	3810.	1.	46.	67.	44.2
NEW MEXICO	0.	0.13	32290.	281.	0.	5.	8.	6.2
NEW YORK	2.	1.57	315100.	3412.	1.	30.	41.	39.9
NORTH CAROLINA	0.	0.33	79760.	752.	0.	18.	22.	19.8
NORTH DAKOTA	0.	0.19	44030.	523.	0.	10.	13.	10.2
OHIO	1.	0.57	115200.	1402.	0.	19.	26.	18.7
OKLAHOMA	1.	0.79	209000.	1832.	0.	37.	45.	41.5
OREGON	0.	0.09	19600.	242.	0.	4.	4.	3.3
PENNSYLVANIA	1.	0.83	156400.	1912.	0.	24.	35.	24.7
RHODE ISLAND	0.	0.33	60500.	651.	0.	10.	15.	10.0
SOUTH CAROLINA	0.	0.09	22830.	222.	0.	5.	6.	5.3
SOUTH DAKOTA	0.	0.21	51760.	509.	0.	12.	14.	11.7
TENNESSEE	0.	0.00	861.	8.	0.	0.	0.	0.2
TEXAS	2.	1.78	468700.	4915.	1.	72.	107.	94.8
UTAH	0.	0.18	42460.	416.	0.	7.	10.	7.5
VERMONT	0.	0.00	116.	1.	0.	0.	0.	0.0
VIRGINIA	1.	0.46	116500.	1333.	0.	19.	27.	23.0
WASHINGTON	0.	0.39	82420.	935.	0.	16.	19.	12.9
WEST VIRGINIA	0.	0.00	202.	2.	0.	0.	0.	0.0
WISCONSIN	0.	0.35	70890.	889.	0.	11.	16.	12.6
WYOMING	0.	0.12	32670.	322.	0.	7.	7.	6.1
ALASKA	0.	0.04	8646.	110.	0.	2.	2.	1.1
HAWAII	0.	0.13	29670.	286.	0.	4.	7.	4.9
NATIONAL TOTAL	22.	21.78	4696191.	50705.	6.	748.	1014.	850.9

Table H-26. The Estimated Annual Proportion of the Value at Risk Lost to Severe Wind in 2000

STATE	(1) BUILDING DAMAGE	(2) CONTENTS DAMAGE	(3) INCOME LOSS	(4) SUPPLIER LOSS	(5) LIFE LOSS	(6) HOMES LOST	(7) HOMELESS-NESS	(8) UNEMPLOY-MENT
ALABAMA	8.5-08	1.2-07	3.4-08	3.5-10	5.9-10	1.6-07	0.0 00	3.0-08
ARIZONA	2.1-06	1.6-06	7.1-07	6.8-09	1.6-08	4.7-06	1.8-06	5.9-07
ARKANSAS	6.3-08	0.0 00	2.5-08	2.6-10	4.2-10	1.2-07	0.0 00	2.1-08
CALIFORNIA	3.5-06	2.5-06	1.2-06	1.2-08	3.3-08	5.0-06	2.8-06	1.0-06
COLORADO	1.7-05	1.2-05	5.7-06	5.9-08	1.5-07	2.9-05	1.4-05	4.8-06
CONNECTICUT	1.2-05	8.0-06	3.4-06	3.3-08	1.1-07	1.7-05	9.4-06	5.9-06
DELAWARE	4.0-06	2.3-06	1.4-06	1.7-08	3.4-08	8.4-06	4.0-06	1.3-06
DIST. OF COLUMBIA	1.1-07	0.0 00	5.0-08	4.2-10	1.5-09	1.2-07	0.0 00	4.4-08
FLORIDA	2.9-06	2.0-06	1.2-06	1.1-08	2.2-08	3.8-06	2.2-06	1.0-06
GEORGIA	3.7-07	2.8-07	1.4-07	1.5-09	3.1-09	9.6-07	4.7-07	1.3-07
IDAHO	1.1-05	8.0-06	3.8-06	4.2-08	8.3-08	2.2-05	1.0-05	3.2-06
ILLINOIS	6.0-06	4.1-06	2.0-06	2.2-08	5.6-08	5.7-06	2.8-06	1.7-06
INDIANA	8.1-06	5.6-06	2.7-06	3.2-08	6.6-08	1.4-05	6.7-06	2.4-06
IOWA	9.9-06	6.9-06	3.5-06	3.5-08	7.9-08	1.6-05	8.3-06	3.0-06
KANSAS	9.0-06	6.5-06	3.3-06	3.5-08	7.6-08	1.6-05	7.9-06	2.9-06
KENTUCKY	6.0-07	3.4-07	2.2-07	2.0-09	4.4-09	1.1-06	7.4-07	1.9-07
LOUISIANA	3.7-06	2.7-06	1.4-06	1.8-08	2.8-08	5.6-06	3.1-06	1.2-06
MAINE	1.2-06	9.0-07	3.8-07	5.3-09	8.5-09	2.1-06	9.5-07	3.0-07
MARYLAND	1.1-06	8.9-07	4.6-07	5.3-09	1.1-08	2.1-06	1.1-06	4.2-07
MASSACHUSETTS	1.3-05	8.9-06	3.9-06	4.0-08	1.2-07	1.7-05	9.4-06	3.0-06
MICHIGAN	7.5-07	4.7-07	2.6-07	3.2-09	6.4-09	1.5-06	7.3-07	2.6-07
MINNESOTA	9.0-06	6.2-06	3.1-06	3.7-08	7.7-08	1.7-05	8.5-06	2.7-06
MISSISSIPPI	1.1-06	6.8-07	4.0-07	3.7-09	6.8-09	1.9-06	8.5-07	2.9-07
MISSOURI	3.0-06	2.2-06	1.0-06	1.1-08	2.5-08	4.9-06	0.0 00	8.8-07
MONTANA	2.1-05	1.6-05	7.3-06	8.4-08	1.7-07	4.1-05	1.8-05	6.4-06
NEBRASKA	1.2-05	9.1-06	4.5-06	4.7-08	1.0-07	2.1-05	1.1-05	3.8-06
NEVADA	1.0-05	7.9-06	3.4-06	3.0-08	9.8-08	2.7-05	9.5-06	2.7-06
NEW HAMPSHIRE	3.2-06	2.1-06	1.0-06	1.0-08	2.7-08	5.2-06	3.1-06	7.8-07
NEW JERSEY	8.8-06	6.1-06	2.7-06	3.4-08	8.3-08	1.3-05	7.0-06	2.2-06
NEW MEXICO	8.0-06	6.4-06	2.9-06	2.6-08	6.3-08	1.2-05	6.9-06	2.6-06
NEW YORK	3.9-06	2.5-06	1.1-06	1.2-08	3.9-08	3.5-06	1.8-06	8.1-07
NORTH CAROLINA	3.4-06	2.3-06	1.3-06	1.2-08	2.4-08	7.4-06	3.4-06	1.1-06
NORTH DAKOTA	2.6-05	1.9-05	9.5-06	1.1-07	1.8-07	4.7-05	2.3-05	7.4-06
OHIO	2.4-06	1.6-06	7.9-07	9.6-09	2.1-08	4.0-06	2.0-06	6.9-07
OKLAHOMA	1.7-05	1.3-05	6.6-06	5.8-08	1.4-07	2.9-05	1.5-05	6.0-06
OREGON	2.3-06	1.6-06	8.1-07	1.0-08	1.9-08	4.4-06	1.6-06	6.9-07
PENNSYLVANIA	3.6-06	2.4-06	1.1-06	1.3-08	3.0-08	4.7-06	2.6-06	8.7-07
RHODE ISLAND	1.7-05	1.2-05	5.2-06	5.6-08	1.4-07	2.4-05	1.3-05	4.1-06
SOUTH CAROLINA	2.3-06	1.3-06	8.2-07	8.0-09	1.5-08	4.2-06	1.9-06	7.0-07
SOUTH DAKOTA	2.5-05	1.8-05	9.1-06	9.0-08	1.8-07	4.6-05	2.1-05	7.6-06
TENNESSEE	4.8-08	0.0 00	1.8-08	1.7-10	3.4-10	7.7-08	0.0 00	1.5-08
TEXAS	8.2-06	5.6-06	3.1-06	3.2-08	6.6-08	1.3-05	7.4-06	2.8-06
UTAH	8.3-06	6.4-06	2.9-06	2.8-08	7.2-08	1.5-05	7.2-06	2.5-06
VERMONT	7.5-08	0.0 00	2.6-08	2.9-10	5.7-10	1.4-07	0.0 00	2.0-08
VIRGINIA	4.4-06	3.3-06	1.8-06	2.0-08	4.1-08	8.0-06	4.2-06	1.5-06
WASHINGTON	5.8-06	4.2-06	2.0-06	2.3-08	5.1-08	9.8-06	4.8-06	1.7-06
WEST VIRGINIA	2.8-08	0.0 00	1.0-08	1.1-10	2.1-10	5.2-08	0.0 00	9.8-09
WISCONSIN	4.1-06	2.8-06	1.4-06	1.7-08	3.2-08	6.0-06	3.1-06	1.2-06
WYOMING	2.4-05	1.7-05	7.8-06	7.7-08	2.0-07	5.4-05	2.1-05	7.2-06
ALASKA	5.8-06	4.8-06	2.1-06	2.6-08	6.9-08	1.6-05	6.2-06	1.8-06
HAWAII	6.7-06	5.3-06	2.5-06	2.4-08	7.0-08	1.0-05	6.3-06	2.0-06
NATIONAL AVERAGE	4.5-06	3.5-06	1.7-06	1.8-08	2.3-08	7.7-06	4.0-06	3.3-06

Table H-27. The Estimated Annual Severe Wind Losses Saved Due to a 1.5 X UBC Mitigations in 2000

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESSNESS PERSON YEARS	UNEMPLOYMENT PERSON YEARS
ALABAMA	0.	0.	212.	3.	0.	0.	0.	0.0
ARIZONA	0.	0.	4337.	49.	0.	1.	1.	0.4
ARKANSAS	0.	0.	77.	1.	0.	0.	0.	0.0
CALIFORNIA	0.	0.	62598.	885.	0.	9.	14.	7.4
COLORADO	0.	0.	30243.	402.	0.	6.	7.	3.7
CONNECTICUT	0.	0.	24245.	414.	0.	3.	5.	43.7
DELAWARE	0.	0.	2011.	32.	0.	0.	0.	0.4
DIST. OF COLUMBIA	0.	0.	119.	1.	0.	0.	0.	0.0
FLORIDA	0.	0.	24961.	294.	0.	4.	6.	2.9
GEORGIA	0.	0.	1587.	22.	0.	0.	1.	0.4
IDAHO	0.	0.	4093.	57.	0.	1.	1.	0.4
ILLINOIS	0.	0.	40756.	722.	0.	4.	5.	4.5
INDIANA	0.	0.	26410.	558.	0.	5.	6.	3.3
IOWA	0.	0.	10224.	152.	0.	2.	2.	1.2
KANSAS	0.	0.	11001.	140.	0.	2.	3.	1.6
KENTUCKY	0.	0.	1221.	13.	0.	0.	0.	0.0
LOUISIANA	0.	0.	9283.	163.	0.	1.	2.	1.2
MAINE	0.	0.	308.	6.	0.	0.	0.	0.0
MARYLAND	0.	0.	4980.	77.	0.	1.	1.	0.4
MASSACHUSETTS	0.	0.	30005.	485.	0.	4.	7.	3.3
MICHIGAN	0.	0.	4298.	79.	0.	1.	1.	0.4
MINNESOTA	0.	0.	19100.	323.	0.	4.	5.	2.5
MISSISSIPPI	0.	0.	1374.	16.	0.	0.	0.	0.4
MISSOURI	0.	0.	7954.	122.	0.	2.	2.	0.8
MONTANA	0.	0.	5836.	82.	0.	1.	1.	0.8
NEBRASKA	0.	0.	7768.	100.	0.	1.	2.	1.2
NEVADA	0.	0.	6570.	76.	0.	2.	2.	0.8
NEW HAMPSHIRE	0.	0.	940.	16.	0.	0.	0.	0.0
NEW JERSEY	0.	0.	39101.	845.	0.	6.	9.	4.1
NEW MEXICO	0.	0.	6039.	66.	0.	1.	1.	0.8
NEW YORK	0.	0.	35604.	575.	0.	3.	5.	3.3
NORTH CAROLINA	0.	0.	13000.	171.	0.	3.	4.	2.1
NORTH DAKOTA	0.	0.	4975.	76.	0.	1.	1.	0.8
OHIO	0.	0.	16238.	338.	0.	3.	4.	2.1
OKLAHOMA	0.	0.	35322.	371.	0.	6.	8.	4.5
OREGON	0.	0.	31.	57.	0.	1.	1.	0.4
PENNSYLVANIA	0.	0.	18766.	397.	0.	3.	4.	2.1
RHODE ISLAND	0.	0.	6352.	116.	0.	1.	2.	0.8
SOUTH CAROLINA	0.	0.	4178.	56.	0.	1.	1.	0.8
SOUTH DAKOTA	0.	0.	5176.	63.	0.	1.	1.	0.8
TENNESSEE	0.	0.	153.	2.	0.	0.	0.	0.0
TEXAS	0.	0.	87183.	1158.	0.	13.	20.	11.1
UTAH	0.	0.	6964.	87.	0.	1.	2.	0.8
VERMONT	0.	0.	10.	0.	0.	0.	0.	0.0
VIRGINIA	0.	0.	21672.	353.	0.	4.	5.	2.9
WASHINGTON	0.	0.	13516.	220.	0.	3.	3.	1.6
WEST VIRGINIA	0.	0.	23.	0.	0.	0.	0.	0.0
WISCONSIN	0.	0.	8861.	186.	0.	1.	2.	1.2
WYOMING	0.	0.	4606.	58.	0.	1.	1.	0.4
ALASKA	0.	0.	1885.	28.	0.	0.	0.	0.4
HAWAII	0.	0.	5933.	68.	0.	1.	1.	0.8
NATIONAL TOTAL	0.	0.	678099.	10581.	0.	108.	149.	123.5

Table H-28. The Percentage of Estimated Annual Severe Wind Losses Saved Due to a 1.5 X UBC Mitigation in 2000

STATE	BUILDING DAMAGE %	CONTENTS DAMAGE %	INCOME LOSS %	SUPPLIER LOSS %	LIFE LOSS %	HOMES LOST %	HOMELESS-NESS %	UNEMPLOY-MENT %
ALABAMA	16.4	16.4	17.3	17.2	0.0	16.4	17.3	17.3
ARIZONA	21.3	21.3	21.2	21.2	0.0	21.3	21.2	21.2
ARKANSAS	15.0	15.0	16.5	16.5	0.0	15.0	16.5	16.5
CALIFORNIA	18.2	18.2	18.3	18.4	0.0	18.2	18.3	18.3
COLORADO	17.3	17.3	17.2	17.3	0.0	17.3	17.2	17.2
CONNECTICUT	13.9	13.9	14.0	13.9	0.0	13.9	14.0	13.9
DELAWARE	16.6	16.6	16.6	16.6	0.0	16.6	16.6	16.6
DIST. OF COLUMBIA	12.5	12.5	13.1	13.1	0.0	12.5	13.1	13.1
FLORIDA	21.6	21.6	21.6	21.6	0.0	21.6	21.6	21.6
GEORGIA	17.2	17.2	17.1	17.0	0.0	17.2	17.1	17.1
IDAHO	14.3	14.3	14.3	14.2	0.0	14.3	14.3	14.2
ILLINOIS	12.4	12.4	12.4	12.4	0.0	12.4	12.4	12.4
INDIANA	13.7	13.7	13.7	13.6	0.0	13.7	13.7	13.6
IOWA	9.6	9.6	9.5	9.6	0.0	9.6	9.5	9.4
KANSAS	13.3	13.3	13.2	13.0	0.0	13.3	13.2	13.2
KENTUCKY	13.9	13.9	14.0	14.0	0.0	13.9	14.0	14.0
LOUISIANA	17.0	17.0	17.0	17.0	0.0	17.0	17.0	17.0
MAINE	9.0	9.0	8.9	8.9	0.0	9.0	8.9	8.9
MARYLAND	16.9	16.9	16.9	16.9	0.0	16.9	16.9	17.0
MASSACHUSETTS	9.3	9.3	9.3	9.3	0.0	9.3	9.3	9.3
MICHIGAN	13.3	13.3	13.3	13.4	0.0	13.3	13.3	13.2
MINNESOTA	12.0	12.0	11.9	12.1	0.0	12.0	12.0	11.9
MISSISSIPPI	18.1	18.1	18.0	17.7	0.0	18.1	18.0	17.9
MISSOURI	13.7	13.7	13.7	13.7	0.0	13.7	13.7	13.7
MONTANA	12.1	12.1	12.0	11.9	0.0	12.1	12.1	12.0
NEBRASKA	10.7	10.7	10.5	10.5	0.0	10.7	10.5	10.4
NEVADA	21.2	21.2	21.0	21.1	0.0	21.2	21.0	21.1
NEW HAMPSHIRE	9.3	9.3	9.4	9.4	0.0	9.3	9.4	9.4
NEW JERSEY	12.9	12.9	12.9	12.9	0.0	12.9	12.9	12.9
NEW MEXICO	18.8	18.8	18.7	18.7	0.0	18.8	18.7	18.8
NEW YORK	11.3	11.3	11.3	11.3	0.0	11.3	11.3	11.3
NORTH CAROLINA	16.4	16.4	16.3	16.3	0.0	16.4	16.3	16.3
NORTH DAKOTA	11.3	11.3	11.3	11.2	0.0	11.3	11.3	11.2
OHIO	14.1	14.1	14.1	14.1	0.0	14.1	14.1	14.1
OKLAHOMA	17.0	17.0	16.9	16.9	0.0	17.0	16.9	16.9
OREGON	15.8	15.8	15.8	15.8	0.0	15.8	15.8	15.8
PENNSYLVANIA	12.0	12.0	12.0	12.0	0.0	12.0	12.0	12.0
RHODE ISLAND	10.5	10.5	10.5	10.5	0.0	10.5	10.5	10.5
SOUTH CAROLINA	18.4	18.4	18.3	18.0	0.0	18.4	18.3	18.3
SOUTH DAKOTA	10.1	10.1	10.0	10.0	0.0	10.1	10.0	10.0
TENNESSEE	17.9	17.9	17.8	17.7	0.0	17.9	17.8	17.7
TEXAS	18.6	18.6	18.6	18.6	0.0	18.6	18.6	18.5
UTAH	16.4	16.4	16.4	16.4	0.0	16.4	16.4	16.3
VERMONT	14.3	14.3	8.8	8.8	0.0	14.3	8.8	8.8
VIRGINIA	18.7	18.7	18.6	18.6	0.0	18.7	18.6	18.6
WASHINGTON	16.4	16.4	16.4	16.5	0.0	16.4	16.4	16.4
WEST VIRGINIA	12.5	12.5	11.4	11.4	0.0	12.5	11.4	11.4
WISCONSIN	12.5	12.5	12.5	12.5	0.0	12.5	12.5	12.4
WYOMING	14.1	14.1	14.1	14.1	0.0	14.1	14.1	14.1
ALASKA	21.7	21.7	21.8	21.8	0.0	21.7	21.8	21.8
HAWAII	20.0	20.0	20.0	19.9	0.0	20.0	20.0	20.0
NATIONAL AVERAGE	14.4	14.4	14.4	20.9	0.0	14.4	14.7	14.5

Table H-29. The Estimated Annual Severe Wind Losses Saved Due to a 3.0 X UBC Mitigations in 2000

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESS-NESS PERSON YEARS	UNEMPLOY-MENT PERSON YEARS
ALABAMA	0.	0.	338.	5.	0.	0.	0.	0.0
ARIZONA	0.	0.	6915.	78.	0.	2.	2.	0.8
ARKANSAS	0.	0.	122.	2.	0.	0.	0.	0.0
CALIFORNIA	1.	0.	99541.	1409.	0.	15.	22.	11.9
COLORADO	0.	0.	48354.	641.	0.	9.	11.	5.8
CONNECTICUT	0.	0.	38620.	661.	0.	6.	8.	69.6
DELAWARE	0.	0.	3198.	50.	0.	1.	1.	0.4
DIST. OF COLUMBIA	0.	0.	190.	2.	0.	0.	0.	0.0
FLORIDA	0.	0.	39753.	468.	0.	7.	9.	4.5
GEORGIA	0.	0.	2524.	36.	0.	1.	1.	0.4
IDAHO	0.	0.	6497.	91.	0.	2.	2.	0.8
ILLINOIS	0.	0.	65078.	1154.	0.	6.	8.	7.0
INDIANA	0.	0.	42025.	894.	0.	7.	10.	5.4
IOWA	0.	0.	16359.	244.	0.	3.	4.	2.1
KANSAS	0.	0.	17585.	224.	0.	3.	4.	2.5
KENTUCKY	0.	0.	1945.	21.	0.	0.	1.	0.4
LOUISIANA	0.	0.	14798.	261.	0.	2.	3.	2.1
MAINE	0.	0.	489.	10.	0.	0.	0.	0.0
MARYLAND	0.	0.	7956.	124.	0.	1.	2.	0.8
MASSACHUSETTS	0.	0.	48073.	776.	0.	7.	10.	4.9
MICHIGAN	0.	0.	6850.	125.	0.	1.	2.	0.8
MINNESOTA	0.	0.	30495.	513.	0.	6.	8.	3.7
MISSISSIPPI	0.	0.	2190.	25.	0.	1.	1.	0.4
MISSOURI	0.	0.	12658.	194.	0.	2.	3.	1.6
MONTANA	0.	0.	9337.	131.	0.	2.	2.	1.2
NEBRASKA	0.	0.	12429.	159.	0.	2.	3.	1.6
NEVADA	0.	0.	10481.	121.	0.	3.	3.	0.8
NEW HAMPSHIRE	0.	0.	1500.	26.	0.	0.	0.	0.0
NEW JERSEY	0.	0.	62441.	1343.	0.	9.	14.	6.2
NEW MEXICO	0.	0.	9655.	105.	0.	2.	2.	1.2
NEW YORK	0.	0.	57029.	921.	0.	5.	7.	5.4
NORTH CAROLINA	0.	0.	20737.	272.	0.	5.	6.	2.9
NORTH DAKOTA	0.	0.	7925.	121.	0.	2.	2.	1.2
OHIO	0.	0.	25912.	537.	0.	4.	6.	2.9
OKLAHOMA	0.	0.	56431.	590.	0.	10.	12.	7.0
OREGON	0.	0.	4940.	91.	0.	1.	1.	0.8
PENNSYLVANIA	0.	0.	29869.	632.	0.	5.	7.	3.3
RHODE ISLAND	0.	0.	10103.	184.	0.	2.	3.	1.2
SOUTH CAROLINA	0.	0.	6667.	89.	0.	1.	2.	0.8
SOUTH DAKOTA	0.	0.	8282.	100.	0.	2.	2.	1.2
TENNESSEE	0.	0.	244.	3.	0.	0.	0.	0.0
TEXAS	1.	1.	138743.	1842.	0.	21.	32.	17.3
UTAH	0.	0.	11083.	139.	0.	2.	3.	1.2
VERMONT	0.	0.	16.	0.	0.	0.	0.	0.0
VIRGINIA	0.	0.	34605.	562.	0.	6.	8.	4.5
WASHINGTON	0.	0.	21593.	349.	0.	4.	5.	2.5
WEST VIRGINIA	0.	0.	37.	1.	0.	0.	0.	0.0
WISCONSIN	0.	0.	14107.	296.	0.	2.	3.	1.6
WYOMING	0.	0.	7350.	92.	0.	2.	2.	0.8
ALASKA	0.	0.	3000.	44.	0.	1.	1.	0.4
HAWAII	0.	0.	9463.	109.	0.	1.	2.	1.2
NATIONAL TOTAL	2.	1.	1086532.	16867.	0.	176.	240.	193.1

Table H-30. The Percentage of the Estimated Annual Severe Wind Losses Saved Due to a 3.0 X UBC Mitigation in 2000

STATE	BUILDING DAMAGE %	CONTENTS DAMAGE %	INCOME LOSS %	SUPPLIER LOSS %	LIFE LOSS %	HOMES LOST %	HOMELESS-NESS %	UNEMPLOY-MENT %
ALABAMA	27.3	27.3	27.6	27.5	0.0	27.3	27.6	27.6
ARIZONA	34.0	34.0	33.8	33.8	0.0	34.0	33.8	33.7
ARKANSAS	25.0	25.0	26.3	26.3	0.0	25.0	26.3	26.3
CALIFORNIA	29.0	29.0	29.1	29.3	0.0	29.0	29.2	29.1
COLORADO	27.6	27.6	27.5	27.6	0.0	27.6	27.5	27.5
CONNECTICUT	22.2	22.2	22.3	22.2	0.0	22.2	22.3	22.2
DELAWARE	26.4	26.4	26.4	26.4	0.0	26.4	26.4	26.4
DIST. OF COLUMBIA	20.8	20.8	20.9	20.9	0.0	20.8	20.9	20.9
FLORIDA	34.4	34.4	34.4	34.4	0.0	34.4	34.4	34.4
GEORGIA	27.2	27.2	27.2	27.2	0.0	27.2	27.2	27.2
IDAHO	22.8	22.8	22.7	22.6	0.0	22.8	22.7	22.7
ILLINOIS	19.8	19.8	19.8	19.8	0.0	19.8	19.8	19.8
INDIANA	21.8	21.8	21.8	21.8	0.0	21.8	21.8	21.7
IOWA	15.2	15.2	15.2	15.4	0.0	15.2	15.2	14.9
KANSAS	21.2	21.2	21.1	20.8	0.0	21.2	21.0	21.0
KENTUCKY	22.3	22.3	22.3	22.3	0.0	22.3	22.3	22.3
LOUISIANA	27.1	27.1	27.1	27.2	0.0	27.1	27.1	27.1
MAINE	14.1	14.1	14.1	14.1	0.0	14.1	14.1	14.1
MARYLAND	27.0	27.0	27.0	27.0	0.0	27.0	27.0	27.1
MASSACHUSETTS	14.9	14.9	14.9	14.9	0.0	14.9	14.9	14.9
MICHIGAN	21.2	21.2	21.2	21.3	0.0	21.2	21.2	21.1
MINNESOTA	19.2	19.2	19.0	19.2	0.0	19.2	19.1	18.9
MISSISSIPPI	29.0	29.0	28.7	28.3	0.0	29.0	28.6	28.6
MISSOURI	21.9	21.9	21.8	21.8	0.0	21.9	21.8	21.8
MONTANA	19.4	19.4	19.2	19.0	0.0	19.4	19.2	19.2
NEBRASKA	17.0	17.0	16.8	16.7	0.0	17.0	16.8	16.5
NEVADA	33.8	33.8	33.5	33.6	0.0	33.8	33.5	33.6
NEW HAMPSHIRE	15.0	15.0	15.0	14.9	0.0	15.0	15.0	15.0
NEW JERSEY	20.5	20.5	20.6	20.5	0.0	20.5	20.6	20.6
NEW MEXICO	30.0	30.0	29.9	29.9	0.0	30.0	29.9	29.9
NEW YORK	18.1	18.1	18.1	18.1	0.0	18.1	18.1	18.1
NORTH CAROLINA	26.1	26.1	26.0	25.9	0.0	26.1	26.0	26.0
NORTH DAKOTA	18.0	18.0	18.0	17.9	0.0	18.0	18.0	17.9
OHIO	22.5	22.5	22.5	22.4	0.0	22.5	22.5	22.5
OKLAHOMA	27.2	27.2	27.0	26.9	0.0	27.2	27.0	26.9
OREGON	25.3	25.3	25.2	25.2	0.0	25.3	25.2	25.2
PENNSYLVANIA	19.1	19.1	19.1	19.1	0.0	19.1	19.1	19.1
RHODE ISLAND	16.7	16.7	16.7	16.7	0.0	16.7	16.7	16.7
SOUTH CAROLINA	29.4	29.4	29.2	28.7	0.0	29.4	29.2	29.1
SOUTH DAKOTA	16.0	16.0	16.0	16.0	0.0	16.0	16.0	15.9
TENNESSEE	28.2	28.2	28.4	28.2	0.0	28.2	28.4	28.3
TEXAS	29.6	29.6	29.6	29.6	0.0	29.6	29.6	29.5
UTAH	26.1	26.1	26.1	26.2	0.0	26.1	26.1	26.1
VERMONT	14.3	14.3	14.0	14.0	0.0	14.3	14.0	14.0
VIRGINIA	29.8	29.8	29.7	29.6	0.0	29.8	29.7	29.7
WASHINGTON	26.2	26.2	26.2	26.2	0.0	26.2	26.2	26.2
WEST VIRGINIA	12.5	12.5	18.2	18.2	0.0	12.5	18.2	18.2
WISCONSIN	20.0	20.0	19.9	19.9	0.0	20.0	19.9	19.8
WYOMING	22.5	22.5	22.5	22.5	0.0	22.5	22.5	22.5
ALASKA	34.6	34.6	34.7	34.7	0.0	34.6	34.7	34.7
HAWAII	32.0	32.0	31.9	31.7	0.0	32.0	31.8	31.9
NATIONAL AVERAGE	23.5	23.5	23.1	33.3	0.0	23.5	23.7	22.7

TORNADO TABLES

H - 31 Annual Losses in 1970

H - 32 Annual Loss rates in 1970

H - 33 Annual Loss in 2000

H - 34 Annual Loss rate in 2000

H - 35 The savings due to a building code mitigation of 1.5 x UBC (see Chapter 9 for details) in 2000

H - 36 The percentage of losses saved due to a building code mitigation of 1.5 x UBC in 2000

H - 37 The savings due to the building code mitigation of 3.0 x UBC in 2000

H - 38 The percentage of losses saved due to a building code mitigation of 3.0 x UBC in 2000

Table H-31. The Estimated Annual Tornado Losses in 1970

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESS-NESS PERSON YEARS	UNEMPLOY-MENT PERSON YEARS
ALABAMA	18.	9.83	6717000.	73840.	8.	914.	2273.	1649.0
ARIZONA	2.	0.96	667300.	6283.	1.	80.	199.	137.0
ARKANSAS	7.	3.95	2656000.	28630.	3.	439.	1010.	699.0
CALIFORNIA	14.	7.08	4412000.	46410.	6.	530.	1219.	668.0
COLORADO	9.	4.54	3064000.	33190.	4.	359.	857.	539.0
CONNECTICUT	6.	3.25	1890000.	18350.	3.	186.	476.	636.0
DELAWARE	1.	0.79	501900.	6393.	1.	49.	127.	89.5
DIST. OF COLUMBIA	1.	0.42	311900.	2351.	0.	31.	63.	51.7
FLORIDA	42.	19.43	14150000.	134800.	19.	2087.	4557.	2872.0
GEORGIA	19.	9.63	6628000.	69990.	8.	806.	2030.	1424.0
IDAHO	0.	0.23	144200.	1569.	0.	20.	49.	29.3
ILLINOIS	152.	82.63	50970000.	604700.	68.	5240.	12500.	8224.0
INDIANA	48.	29.03	16840000.	215400.	21.	2001.	4902.	3007.0
IOWA	19.	10.54	6372000.	68500.	8.	822.	1951.	1297.0
KANSAS	32.	15.94	10560000.	114700.	14.	1406.	3227.	2143.0
KENTUCKY	8.	4.33	3016000.	30410.	4.	379.	922.	676.0
LOUISIANA	13.	6.47	5131000.	66500.	6.	634.	1609.	1195.0
MAINE	1.	0.55	313700.	4093.	0.	41.	116.	62.2
MARYLAND	9.	3.95	2814000.	28980.	4.	278.	692.	527.0
MASSACHUSETTS	35.	18.33	10880000.	112200.	16.	1217.	2994.	1808.0
MICHIGAN	40.	24.45	14350000.	168100.	18.	1496.	3731.	2363.0
MINNESOTA	20.	10.74	6708000.	81610.	9.	770.	1911.	1198.0
MISSISSIPPI	8.	4.69	3116000.	31410.	4.	476.	1205.	841.0
MISSOURI	55.	29.33	18310000.	209200.	25.	2307.	5177.	3370.0
MONTANA	0.	0.20	135500.	1521.	0.	19.	45.	26.4
NEBRASKA	12.	6.24	4013000.	42230.	6.	556.	1281.	823.0
NEVADA	0.	0.07	46840.	415.	0.	6.	14.	7.5
NEW HAMPSHIRE	3.	1.56	892000.	9611.	1.	111.	287.	165.0
NEW JERSEY	26.	14.13	8203000.	110400.	12.	847.	2072.	1307.0
NEW MEXICO	2.	1.03	740800.	6467.	1.	93.	239.	148.0
NEW YORK	11.	5.53	3306000.	38390.	5.	392.	946.	498.0
NORTH CAROLINA	13.	7.19	4759000.	46890.	6.	622.	1574.	1129.0
NORTH DAKOTA	2.	1.09	677000.	7674.	1.	108.	266.	150.0
OHIO	42.	24.73	14460000.	187700.	19.	1608.	3980.	2456.0
OKLAHOMA	43.	21.13	15940000.	150200.	19.	2087.	4553.	3302.0
OREGON	0.	0.18	114400.	1483.	0.	15.	34.	19.8
PENNSYLVANIA	20.	11.16	6512000.	90770.	9.	775.	1919.	1128.0
RHODE ISLAND	0.	0.25	146900.	1608.	0.	18.	44.	26.8
SOUTH CAROLINA	8.	4.68	2971000.	33230.	4.	402.	1049.	728.0
SOUTH DAKOTA	3.	1.49	947800.	9305.	1.	144.	352.	213.0
TENNESSEE	10.	5.53	3751000.	38260.	5.	491.	1188.	820.0
TEXAS	93.	46.40	34570000.	393900.	41.	4110.	9480.	7163.0
UTAH	0.	0.21	150200.	1466.	0.	16.	43.	27.9
VERMONT	1.	0.41	246600.	2852.	0.	37.	1.	47.8
VIRGINIA	8.	4.02	2810000.	30680.	4.	331.	818.	586.0
WASHINGTON	0.	0.19	119700.	1442.	0.	18.	40.	19.9
WEST VIRGINIA	1.	0.53	428900.	5292.	0.	53.	126.	85.9
WISCONSIN	18.	10.66	6185000.	79560.	8.	762.	1919.	1125.0
WYOMING	0.	0.23	171400.	1718.	0.	23.	55.	32.9
NATIONAL TOTAL	875.	469.93	302821040.	3450673.	392.	36212.	86122.	57541.6

Table H-32. The Estimated Annual Proportion of the Value at Risk Lost to Tornado in 1970

STATE	① BUILDING DAMAGE	② CONTENTS DAMAGE	③ INCOME LOSS	④ SUPPLIER LOSS	⑤ LIFE LOSS	⑥ HOMES LOST	⑦ HOMELESS-NESS	⑧ UNEMPLOY-MENT
ALABAMA	6.9-04	6. -04	5.0-04	5.5-06	2.4-06	8.2-04	0.0 00	4.7-04
ARIZONA	1.2-04	1.1-04	7.6-05	7.2-07	5.1-07	1.5-04	1.2-04	6.6-05
ARKANSAS	5.3-04	4.8-04	3.9-04	4.3-06	1.7-06	6.6-04	5.3-04	3.6-04
CALIFORNIA	8.0-05	7.2-05	5.1-05	5.4-07	4.0-07	9.8-05	7.9-05	4.6-05
COLORADO	4.4-04	4.1-04	2.9-04	3.1-06	2.1-06	5.3-04	4.2-04	2.6-04
CONNECTICUT	1.6-04	1.4-04	9.8-05	9.5-07	8.5-07	2.0-04	1.6-04	1.4-04
DELAWARE	2.4-04	2.0-04	1.7-04	2.1-06	1.1-06	2.9-04	2.3-04	1.6-04
DIST. OF COLUMBIA	8.5-05	8.1-05	6.0-05	4.5-07	6.3-07	1.1-04	8.3-05	5.5-05
FLORIDA	6.9-02	6.3-04	5.0-04	4.8-06	2.8-06	8.4-04	6.7-04	4.6-04
GEORGIA	4.5-04	4.0-04	3.1-04	3.3-06	1.8-06	5.5-04	4.4-04	2.9-04
IDAHO	8.3-05	7.4-05	5.7-05	6.2-07	3.3-07	9.9-05	8.1-05	5.1-05
ILLINOIS	1.2-03	1.0-03	7.6-04	9.0-06	6.1-06	1.4-03	1.1-03	6.8-04
INDIANA	9.8-04	8.6-04	6.4-04	8.1-06	4.1-06	1.2-03	9.4-04	5.9-04
IOWA	7.2-04	6.4-04	5.0-04	5.4-06	3.0-06	8.6-04	6.9-04	4.6-04
KANSAS	1.5-03	1.3-03	1.0-03	1.1-05	6.4-06	1.8-03	1.4-03	9.4-04
KENTUCKY	3.1-04	2.8-04	2.2-04	2.2-06	1.1-06	3.6-04	2.9-04	2.0-04
LOUISIANA	4.4-04	4.0-04	3.1-04	4.0-06	1.6-06	5.5-04	4.4-04	2.9-04
MAINE	1.3-04	1.1-04	8.0-05	1.0-06	4.7-07	1.5-04	1.2-04	7.0-05
MARYLAND	1.7-04	1.6-04	1.3-04	1.3-06	9.8-07	2.2-04	1.8-04	1.2-04
MASSACHUSETTS	5.6-04	5.1-04	3.4-04	3.5-06	2.8-06	6.7-04	5.3-04	2.9-04
MICHIGAN	4.5-04	3.9-04	2.9-04	3.4-06	2.1-06	5.4-04	4.3-04	2.8-04
MINNESOTA	5.4-04	4.8-04	3.5-04	4.2-06	2.4-06	6.3-04	5.0-04	3.1-04
MISSISSIPPI	5.8-04	5.0-04	4.3-04	4.3-06	1.7-06	6.8-04	5.4-04	3.9-04
MISSOURI	1.2-03	1.1-03	8.1-04	9.2-06	5.3-06	1.4-03	1.1-03	7.3-04
MONTANA	9.8-05	9.0-05	6.8-05	7.6-07	4.1-07	1.2-04	9.7-05	6.1-05
NEBRASKA	8.6-04	7.8-04	6.0-04	6.3-06	3.7-06	1.1-03	8.6-04	5.4-04
NEVADA	3.2-05	3.1-05	2.0-05	1.8-07	1.7-07	4.0-05	3.3-05	1.7-05
NEW HAMPSHIRE	3.8-04	3.5-04	2.4-04	2.6-06	1.7-06	4.8-04	3.9-04	2.1-04
NEW JERSEY	3.1-04	2.8-04	1.9-04	2.6-06	1.6-06	3.7-04	2.9-04	1.7-04
NEW MEXICO	2.5-04	2.4-04	1.7-04	1.5-06	1.0-06	3.0-04	2.4-04	1.5-04
NEW YORK	1.4-04	1.3-04	8.8-05	1.0-06	6.7-07	1.7-04	1.3-04	7.6-05
NORTH CAROLINA	3.2-04	2.7-04	2.3-04	2.2-06	1.1-06	3.8-04	3.1-04	2.0-04
NORTH DAKOTA	4.6-04	4.1-04	3.3-04	3.7-06	1.6-06	5.4-04	4.3-04	2.8-04
OHIO	3.9-04	3.5-04	2.5-04	3.2-06	1.8-06	4.7-04	3.7-04	2.3-04
OKLAHOMA	1.9-03	1.7-03	1.4-03	1.3-05	7.6-06	2.2-03	1.8-03	1.3-03
OREGON	2.9-05	2.6-05	1.9-05	2.5-07	1.4-07	3.7-05	3.0-05	1.7-05
PENNSYLVANIA	1.8-04	1.6-04	1.1-04	1.5-06	7.8-07	2.1-04	1.7-04	9.6-05
RHODE ISLAND	5.0-05	4.4-05	3.1-05	3.4-07	2.2-07	5.8-05	4.6-05	2.6-05
SOUTH CAROLINA	4.0-04	3.6-04	2.9-04	3.3-06	1.4-06	5.0-04	4.0-04	2.7-04
SOUTH DAKOTA	5.5-04	4.9-04	3.9-04	3.8-06	2.0-06	6.5-04	5.3-04	3.5-04
TENNESSEE	3.3-04	2.8-04	2.3-04	2.3-06	1.2-06	3.8-04	3.0-04	2.0-04
TEXAS	9.3-04	8.3-04	6.5-04	7.4-06	3.9-06	1.1-03	8.9-04	6.0-04
UTAH	4.4-05	4.2-05	3.0-05	2.9-07	2.0-07	5.5-05	4.3-05	2.8-05
VERMONT	2.1-04	1.9-04	1.4-04	1.6-06	8.0-07	2.4-04	2.2-06	1.2-04
VIRGINIA	1.7-04	1.6-04	1.2-04	1.4-06	8.2-07	2.2-04	1.8-04	1.1-04
WASHINGTON	4.2-05	3.8-05	2.8-05	3.4-07	1.7-07	5.1-05	4.0-05	2.6-05
WEST VIRGINIA	9.5-05	8.8-05	6.4-05	7.9-07	3.4-07	1.2-04	9.3-05	6.3-05
WISCONSIN	4.5-04	4.0-04	2.9-04	3.7-06	1.9-06	5.4-04	4.4-04	2.7-04
WYOMING	1.7-04	1.6-04	1.1-04	1.1-06	7.3-07	2.3-04	1.9-04	1.0-04
NATIONAL AVERAGE	4.9-04	4.4-04	3.3-04	3.8-06	2.2-06	6.0-04	4.8-04	3.2-04

Table H-33. The Estimated Annual Tornado Losses in 2000

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESSNESS PERSON YEARS	UNEMPLOYMENT PERSON YEARS
ALABAMA	44.	50.48	16830000.	196300.	20.	1283.	2782.	4204.0
ARIZONA	6.	6.10	2041000.	20440.	2.	154.	331.	423.0
ARKANSAS	17.	19.54	6588000.	76810.	8.	572.	1148.	1892.0
CALIFORNIA	32.	36.34	10700000.	119800.	14.	793.	1594.	1652.0
COLORADO	23.	24.78	7971000.	91980.	10.	558.	1163.	1416.0
CONNECTICUT	13.	16.88	4672000.	47230.	6.	286.	623.	1467.0
DELAWARE	3.	4.31	1312000.	18150.	1.	79.	177.	241.0
DIST. OF COLUMBIA	4.	2.79	1043000.	7872.	2.	67.	112.	174.0
FLORIDA	133.	135.62	46270000.	471000.	60.	4186.	7861.	9588.0
GEORGIA	50.	54.57	18510000.	209300.	22.	1297.	2831.	4087.0
IDAHO	1.	1.07	344600.	4079.	0.	26.	56.	74.0
ILLINOIS	333.	405.72	117900000.	1486000.	149.	6980.	14172.	19310.0
INDIANA	111.	147.78	42100000.	581800.	50.	2852.	6082.	7627.0
IOWA	37.	44.97	14100000.	163300.	17.	999.	2085.	3096.0
KANSAS	70.	73.64	24480000.	289000.	31.	1828.	3675.	5149.0
KENTUCKY	20.	24.45	8243000.	87850.	9.	570.	1214.	1888.0
LOUISIANA	28.	31.01	11640000.	154900.	13.	787.	1740.	2789.0
MAINE	2.	2.48	681500.	10410.	1.	52.	125.	140.0
MARYLAND	22.	21.45	7489000.	81160.	10.	457.	997.	1414.0
MASSACHUSETTS	82.	94.38	26470000.	286600.	37.	1813.	3887.	4499.0
MICHIGAN	88.	120.52	33970000.	424500.	40.	2098.	4569.	5592.0
MINNESOTA	49.	56.46	17220000.	219900.	22.	1144.	2503.	3161.0
MISSISSIPPI	19.	22.22	7525000.	78690.	8.	592.	1319.	2240.0
MISSOURI	122.	141.12	42740000.	527200.	55.	3096.	6104.	8088.0
MONTANA	1.	0.82	281100.	3488.	0.	21.	44.	56.0
NEBRASKA	26.	27.67	9148000.	105800.	12.	700.	1430.	2041.0
NEVADA	0.	0.49	148600.	1437.	0.	12.	24.	24.1
NEW HAMPSHIRE	7.	8.39	2317000.	26520.	3.	171.	381.	437.0
NEW JERSEY	61.	72.73	20220000.	291500.	27.	1303.	2784.	3263.0
NEW MEXICO	5.	4.61	1685000.	15030.	2.	120.	265.	343.0
NEW YORK	23.	26.99	7574000.	92960.	10.	536.	1125.	1173.0
NORTH CAROLINA	32.	39.30	12720000.	131600.	14.	913.	1988.	3276.0
NORTH DAKOTA	4.	4.15	1402000.	17800.	2.	117.	253.	361.0
OHIO	92.	118.79	33970000.	464300.	41.	2223.	4799.	5801.0
OKLAHOMA	104.	107.93	40420000.	393600.	47.	2967.	5682.	8429.0
OREGON	1.	0.89	269100.	3780.	0.	21.	42.	47.7
PENNSYLVANIA	43.	52.67	14810000.	222100.	19.	1032.	2202.	2596.0
RHODE ISLAND	1.	1.22	333700.	3830.	0.	25.	53.	62.1
SOUTH CAROLINA	19.	24.26	7497000.	89020.	8.	572.	1293.	1950.0
SOUTH DAKOTA	6.	5.85	2041000.	22310.	2.	164.	345.	501.0
TENNESSEE	26.	31.00	10170000.	110100.	12.	749.	1584.	2318.0
TEXAS	229.	255.95	90560000.	1085000.	103.	6179.	12486.	18920.0
UTAH	1.	1.12	405400.	4244.	1.	25.	59.	76.0
VERMONT	2.	2.07	585900.	7551.	1.	49.	102.	118.0
VIRGINIA	22.	21.15	7363000.	81680.	10.	509.	1094.	1556.0
WASHINGTON	1.	0.84	250800.	3301.	0.	22.	43.	44.0
WEST VIRGINIA	2.	2.38	944800.	12240.	1.	63.	129.	188.0
WISCONSIN	40.	50.31	14430000.	194500.	18.	1027.	2232.	2701.0
WYOMING	1.	1.06	394400.	4087.	0.	30.	61.	75.6
NATIONAL TOTAL	2058.	2401.32	750780900.	9042049.	920.	52119.	107650.	146568.5

Table H-34. The Estimated Annual Proportion of the Value at Risk Lost to Tornado in 2000

STATE	(1) BUILDING DAMAGE	(2) CONTENTS DAMAGE	(3) INCOME LOSS	(4) SUPPLIER LOSS	(5) LIFE LOSS	(6) HOMES LOST	(7) HOMELESS-NESS	(8) UNEMPLOY-MENT
ALABAMA	6.8-04	6.1-04	4.7-04	5.5-06	4.7-06	8.3-04	6.7-04	4.4-04
ARIZONA	1.2-04	1.1-04	7.4-05	7.4-07	9.2-07	1.5-04	1.2-04	6.5-05
ARKANSAS	5.2-04	4.7-04	3.6-04	4.2-06	3.5-06	6.6-04	5.3-04	3.3-04
CALIFORNIA	7.7-05	7.1-05	4.8-05	5.4-07	7.0-07	9.8-05	7.8-05	4.4-05
COLORADO	4.4-04	4.1-04	2.7-04	3.2-06	3.9-06	5.4-04	4.3-04	2.5-04
CONNECTICUT	1.6-04	1.4-04	9.2-05	9.3-07	1.5-06	1.9-04	1.5-04	1.3-04
DELAWARE	2.3-04	2.0-04	1.5-04	2.1-06	2.0-06	2.9-04	2.3-04	1.5-04
DIST. OF COLUMBIA	8.3-05	8.2-05	5.7-05	4.3-07	1.1-06	1.1-04	7.5-05	5.3-05
FLORIDA	6.7-04	6.2-04	4.7-04	4.8-06	5.1-06	8.6-04	6.8-04	4.3-04
GEORGIA	4.3-04	3.8-04	2.9-04	3.3-06	3.5-06	5.6-04	4.5-04	2.7-04
IDAHO	8.2-05	7.6-05	5.4-05	6.4-07	6.3-07	1.0-04	8.1-06	4.9-05
ILLINOIS	1.2-03	1.0-03	7.1-04	8.9-06	1.1-05	1.4-03	1.0-03	6.4-04
INDIANA	9.4-04	8.4-04	5.8-04	8.1-06	7.6-06	1.2-03	9.3-04	5.5-04
IOWA	7.0-04	6.3-04	4.6-04	5.3-06	5.5-06	8.5-04	6.9-04	4.2-04
KANSAS	1.5-03	1.4-03	9.8-04	1.2-05	1.2-05	1.8-03	1.5-03	8.9-04
KENTUCKY	3.1-04	2.8-04	2.1-04	2.2-06	2.3-06	3.8-04	3.0-04	1.9-04
LOUISIANA	4.3-04	3.9-04	2.9-04	3.9-06	3.2-06	5.5-04	4.4-04	2.7-04
MAINE	1.2-04	1.1-04	7.6-05	1.2-06	8.9-07	1.5-04	1.2-04	6.7-05
MARYLAND	1.7-04	1.6-04	1.2-04	1.3-06	1.8-06	2.2-04	1.7-04	1.1-04
MASSACHUSETTS	5.4-04	4.9-04	3.2-04	3.5-06	4.9-06	6.6-04	5.2-04	2.8-04
MICHIGAN	4.4-04	3.8-04	2.7-04	3.4-06	3.7-06	5.4-04	4.3-04	2.6-04
MINNESOTA	5.3-04	4.8-04	3.3-04	4.2-06	4.6-06	6.5-04	5.2-04	3.0-04
MISSISSIPPI	5.7-04	5.1-04	3.9-04	4.1-06	3.6-06	7.0-04	5.6-04	3.5-04
MISSOURI	1.2-03	1.1-03	7.6-04	9.4-06	1.0-05	1.4-03	1.1-03	6.9-04
MONTANA	9.7-05	9.0-05	6.3-05	7.9-07	7.9-07	1.2-04	9.5-05	5.8-05
NEBRASKA	8.3-04	7.6-04	5.5-04	6.4-06	6.9-06	1.1-03	8.5-04	5.1-04
NEVADA	3.2-05	3.0-05	2.0-05	1.9-07	3.0-07	4.1-05	3.3-05	1.8-05
NEW HAMPSHIRE	3.8-04	3.5-04	2.3-04	2.6-06	3.2-06	4.9-04	3.9-04	2.0-04
NEW JERSEY	3.1-04	2.7-04	1.8-04	2.6-06	2.9-06	3.7-04	2.9-04	1.6-04
NEW MEXICO	2.4-04	2.3-04	1.6-04	1.4-06	1.9-06	2.9-04	2.4-04	1.5-04
NEW YORK	1.4-04	1.3-04	8.4-05	1.0-06	1.2-06	1.7-04	1.3-04	7.4-05
NORTH CAROLINA	3.1-04	2.7-04	2.1-04	2.2-06	2.2-06	3.8-04	3.0-04	1.9-04
NORTH DAKOTA	4.6-04	4.2-04	3.1-04	3.9-06	3.2-06	5.6-04	4.5-04	2.6-04
OHIO	3.8-04	3.4-04	2.3-04	3.2-06	3.2-06	4.7-04	3.7-04	2.1-04
OKLAHOMA	1.9-03	1.7-03	1.3-03	1.3-05	1.5-05	2.3-03	1.8-03	1.2-03
OREGON	2.8-05	2.6-05	1.8-05	2.5-07	2.5-07	3.6-05	2.9-05	1.6-05
PENNSYLVANIA	1.7-04	1.5-04	1.0-04	1.5-06	1.4-06	2.1-04	1.7-04	9.3-05
RHODE ISLAND	4.8-05	4.3-05	2.9-05	3.3-07	3.9-07	5.8-05	4.6-05	2.5-05
SOUTH CAROLINA	3.9-04	3.5-04	2.7-04	3.2-06	2.6-06	5.0-04	4.0-04	2.5-04
SOUTH DAKOTA	5.3-04	5.0-04	3.6-04	3.9-06	3.8-06	6.6-04	5.3-04	3.2-04
TENNESSEE	3.3-04	2.8-04	2.2-04	2.3-06	2.3-06	3.9-04	3.1-04	1.9-04
TEXAS	9.1-04	8.3-04	6.1-04	7.3-06	7.4-06	1.1-03	9.0-04	5.7-04
UTAH	4.4-05	4.1-05	2.9-05	3.0-07	3.9-07	5.5-05	4.4-05	2.7-05
VERMONT	2.0-04	1.9-04	1.3-04	1.7-06	1.5-06	2.5-04	2.0-04	1.1-04
VIRGINIA	1.6-04	1.5-04	1.1-04	1.2-06	1.5-06	2.1-04	1.7-04	1.0-04
WASHINGTON	4.1-05	3.7-05	2.6-05	3.4-07	3.2-07	5.0-05	4.0-05	2.4-05
WEST VIRGINIA	9.3-05	8.5-05	6.0-05	7.8-07	6.9-07	1.2-04	9.5-05	5.9-05
WISCONSIN	4.5-04	4.0-04	2.8-04	3.8-06	3.5-06	5.6-04	4.4-04	2.6-04
WYOMING	1.8-04	1.7-04	1.1-04	1.1-06	1.5-06	2.5-04	2.0-04	1.0-04
NATIONAL AVERAGE	3.7-04	5.6-04	3.1-04	3.7-06	4.0-06	6.0-04	4.7-04	3.0-04

Table H-35. The Estimated Annual Tornado Loss Saved Due to a 1.5 X UBC Mitigation in 2000

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESS-NESS PERSON YEARS	UNEMPLOY-MENT PERSON YEARS
ALABAMA	8.	9.	2928002.	48436.	4.	225.	484.	687.0
ARIZONA	1.	1.	442851.	5162.	0.	34.	72.	83.0
ARKANSAS	3.	3.	1106779.	18051.	2.	96.	193.	282.5
CALIFORNIA	6.	7.	2074849.	33795.	3.	154.	309.	359.3
COLORADO	4.	4.	1394978.	20002.	1.	98.	204.	247.5
CONNECTICUT	2.	2.	658821.	11899.	1.	40.	88.	1233.4
DELAWARE	1.	1.	215206.	5298.	0.	13.	29.	34.3
DIST. OF COLUMBIA	0.	0.	136675.	1371.	1.	9.	15.	20.6
FLORIDA	28.	29.	9854552.	124332.	13.	892.	1674.	1860.7
GEORGIA	9.	10.	3423752.	54088.	4.	241.	524.	702.7
IDAHO	0.	0.	50995.	736.	0.	4.	8.	11.0
ILLINOIS	42.	51.	14850234.	316063.	18.	879.	1786.	2366.0
INDIANA	15.	20.	5725015.	157519.	7.	388.	827.	1029.8
IOWA	4.	4.	1353331.	24513.	2.	96.	202.	277.7
KANSAS	10.	10.	3426948.	52421.	4.	258.	515.	694.5
KENTUCKY	3.	4.	1252883.	18522.	1.	87.	186.	263.3
LOUISIANA	5.	6.	2083399.	39122.	3.	141.	311.	451.8
MAINE	0.	0.	59968.	1446.	0.	5.	11.	12.3
MARYLAND	4.	4.	1265624.	18408.	2.	78.	168.	217.3
MASSACHUSETTS	8.	9.	2461319.	42853.	4.	169.	361.	395.6
MICHIGAN	13.	18.	4959284.	120589.	6.	306.	667.	816.5
MINNESOTA	7.	8.	2376332.	44566.	3.	158.	345.	439.5
MISSISSIPPI	3.	4.	1294346.	17694.	1.	102.	227.	340.7
MISSOURI	18.	20.	6112435.	111705.	8.	443.	873.	1102.4
MONTANA	0.	0.	37387.	554.	0.	3.	6.	7.5
NEBRASKA	3.	3.	969710.	13895.	2.	76.	153.	204.3
NEVADA	0.	0.	31050.	374.	0.	3.	5.	4.8
NEW HAMPSHIRE	1.	1.	220087.	4365.	0.	16.	36.	39.8
NEW JERSEY	8.	9.	2507503.	64956.	3.	160.	345.	382.6
NEW MEXICO	1.	1.	330195.	3450.	0.	24.	52.	65.1
NEW YORK	2.	3.	802875.	15050.	1.	57.	119.	115.9
NORTH CAROLINA	6.	7.	2225965.	34976.	2.	160.	348.	500.5
NORTH DAKOTA	0.	0.	162584.	2485.	0.	14.	29.	39.8
OHIO	12.	16.	4585494.	118618.	5.	300.	648.	777.5
OKLAHOMA	17.	18.	6789754.	80269.	8.	498.	955.	1286.2
OREGON	0.	0.	41704.	870.	0.	3.	7.	7.5
PENNSYLVANIA	5.	6.	1658955.	42994.	2.	116.	247.	281.1
RHODE ISLAND	0.	0.	35041.	685.	0.	3.	6.	6.2
SOUTH CAROLINA	3.	4.	1297038.	25785.	1.	99.	224.	313.3
SOUTH DAKOTA	1.	1.	210180.	2698.	0.	17.	36.	48.7
TENNESSEE	5.	5.	1799860.	28198.	2.	133.	280.	375.0
TEXAS	45.	50.	17749897.	297714.	20.	1205.	2447.	2939.2
UTAH	0.	0.	67290.	888.	1.	4.	10.	11.7
VERMONT	0.	0.	51563.	1010.	0.	4.	9.	9.6
VIRGINIA	4.	4.	1288443.	20190.	2.	89.	191.	252.3
WASHINGTON	0.	0.	36868.	683.	0.	3.	6.	6.9
WEST VIRGINIA	0.	0.	104870.	1778.	0.	7.	14.	19.9
WISCONSIN	5.	6.	1731252.	41076.	2.	124.	268.	323.6
WYOMING	0.	0.	55616.	742.	0.	4.	9.	11.0
NATIONAL TOTAL	312.	358.	114299759.	2092894.	139.	8038.	16529.	21959.4

Table H-36. The Percentage of Estimated Annual Tornado Loss Saved Due to a 1.5 X UBC Mitigation in 2000

STATE	BUILDING DAMAGE %	CONTENTS DAMAGE %	INCOME LOSS %	SUPPLIER LOSS %	LIFE LOSS %	HOMES LOST %	HOMELESS-NESS %	UNEMPLOY-MENT %
ALABAMA	17.5	17.5	17.4	17.2	20.0	17.5	17.4	17.4
ARIZONA	21.8	21.8	21.7	21.7	0.0	21.8	21.8	21.7
ARKANSAS	16.8	16.8	16.8	16.7	25.0	16.8	16.8	16.7
CALIFORNIA	19.4	19.4	19.4	19.4	21.4	19.4	19.4	19.4
COLORADO	17.5	17.5	17.5	17.5	10.0	17.5	17.5	17.5
CONNECTICUT	14.1	14.1	14.1	14.1	16.7	14.1	14.1	14.1
DELAWARE	16.4	16.4	16.4	16.4	0.0	16.4	16.4	16.4
DIST. OF COLUMBIA	13.1	13.1	13.1	13.1	50.0	13.1	13.1	13.1
FLORIDA	21.3	21.3	21.3	21.2	21.7	21.3	21.3	21.3
GEORGIA	18.6	18.6	18.5	18.4	18.2	18.6	18.5	18.4
IDAHO	14.9	14.9	14.8	14.7	0.0	14.9	14.8	14.7
ILLINOIS	12.6	12.6	12.6	12.6	12.1	12.6	12.6	12.6
INDIANA	13.6	13.6	13.6	13.6	14.0	13.6	13.6	13.5
IOWA	9.6	9.6	9.6	9.8	11.8	9.6	9.7	9.4
KANSAS	14.1	14.1	14.0	13.9	12.9	14.1	14.0	13.9
KENTUCKY	15.3	15.3	15.2	15.4	11.1	15.3	15.3	15.2
LOUISIANA	17.9	17.9	17.9	17.9	23.1	17.9	17.9	17.9
MAINE	8.8	8.8	8.8	8.8	0.0	8.8	8.8	8.8
MARYLAND	17.0	17.0	16.9	16.6	20.0	17.0	16.9	16.9
MASSACHUSETTS	9.3	9.3	9.3	9.3	10.8	9.3	9.3	9.3
MICHIGAN	14.6	14.6	14.6	14.6	15.0	14.6	14.6	14.5
MINNESOTA	13.8	13.8	13.8	13.9	13.6	13.8	13.8	13.7
MISSISSIPPI	17.2	17.2	17.2	16.9	12.5	17.2	17.2	17.1
MISSOURI	14.3	14.3	14.3	14.3	14.5	14.3	14.3	14.2
MONTANA	13.4	13.4	13.3	13.2	0.0	13.4	13.3	13.3
NEBRASKA	10.8	10.8	10.6	10.6	16.7	10.8	10.7	10.4
NEVADA	21.1	21.1	20.9	21.0	0.0	21.1	20.9	20.9
NEW HAMPSHIRE	9.5	9.5	9.5	9.4	0.0	9.5	9.5	9.5
NEW JERSEY	12.3	12.3	12.4	12.3	11.1	12.3	12.4	12.4
NEW MEXICO	19.8	19.8	19.6	19.6	0.0	19.8	19.7	19.6
NEW YORK	10.6	10.6	10.6	10.6	10.0	10.6	10.6	10.6
NORTH CAROLINA	17.5	17.5	17.5	17.3	14.3	17.5	17.5	17.3
NORTH DAKOTA	11.6	11.6	11.6	11.5	0.0	11.6	11.6	11.5
OHIO	13.5	13.5	13.5	13.5	12.2	13.5	13.5	13.5
OKLAHOMA	16.8	16.8	16.8	16.7	17.0	16.8	16.8	16.7
OREGON	15.5	15.5	15.5	15.5	0.0	15.5	15.5	15.5
PENNSYLVANIA	11.2	11.2	11.2	11.2	10.5	11.2	11.2	11.2
RHODE ISLAND	10.5	10.5	10.5	10.5	0.0	10.5	10.5	10.5
SOUTH CAROLINA	17.3	17.3	17.3	17.0	12.5	17.3	17.3	17.2
SOUTH DAKOTA	10.4	10.4	10.3	10.3	0.0	10.4	10.3	10.2
TENNESSEE	17.7	17.7	17.7	17.5	16.7	17.7	17.7	17.5
TEXAS	19.5	19.5	19.6	19.6	19.4	19.5	19.6	17.0
UTAH	16.5	16.5	16.6	16.6	100.0	16.5	16.6	16.6
VERMONT	8.8	8.8	8.8	8.8	0.0	8.8	8.8	8.8
VIRGINIA	17.5	17.5	17.5	17.4	20.0	17.5	17.5	17.5
WASHINGTON	14.7	14.7	14.7	14.8	0.0	14.7	14.7	14.7
WEST VIRGINIA	11.1	11.1	11.1	11.1	0.0	11.1	11.1	11.1
WISCONSIN	12.1	12.1	12.0	11.9	11.1	12.1	12.0	11.9
WYOMING	14.1	14.1	14.1	14.1	0.0	14.1	14.1	14.1
NATIONAL AVERAGE	15.2	15.2	15.2	23.1	15.1	15.2	15.4	15.0

Table H-37. The Estimated Annual Tornado Loss Saved Due to a 3.0 X UBC Mitigation in 2000

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESSNESS PERSON YEARS	UNEMPLOYMENT PERSON YEARS
ALABAMA	12.	14.	4661245.	77160.	6.	358.	554.	1092.8
ARIZONA	2.	2.	708154.	8255.	0.	54.	115.	132.3
ARKANSAS	4.	5.	1758988.	28751.	2.	153.	307.	450.4
CALIFORNIA	10.	11.	3304786.	54003.	4.	245.	493.	572.5
COLORADO	6.	7.	2223993.	32003.	3.	156.	324.	393.5
CONNECTICUT	3.	4.	1055983.	18988.	2.	64.	141.	1967.7
DELAWARE	1.	1.	343804.	8464.	0.	21.	46.	54.8
DIST. OF COLUMBIA	1.	1.	218054.	2187.	1.	14.	23.	32.9
FLORIDA	45.	46.	15684005.	198814.	21.	1419.	2665.	2961.1
GEORGIA	15.	16.	5459477.	86129.	6.	384.	835.	1118.9
IDAHO	0.	0.	81316.	1172.	0.	6.	13.	17.8
ILLINOIS	67.	82.	23689659.	504196.	30.	1403.	2849.	3774.2
INDIANA	24.	32.	9092671.	251336.	11.	616.	1314.	1640.0
IOWA	6.	7.	2156872.	39271.	3.	153.	321.	442.9
KANSAS	16.	17.	5458639.	83724.	7.	413.	820.	1104.5
KENTUCKY	5.	6.	2002964.	29467.	2.	139.	295.	419.6
LOUISIANA	8.	9.	3328783.	62507.	4.	225.	498.	721.9
MAINE	0.	0.	95404.	2301.	0.	7.	18.	19.2
MARYLAND	6.	6.	2022003.	29386.	3.	124.	268.	346.9
MASSACHUSETTS	12.	14.	3916938.	68197.	6.	268.	575.	629.4
MICHIGAN	21.	28.	7880506.	191621.	10.	487.	1060.	1306.8
MINNESOTA	11.	12.	3771136.	71178.	5.	252.	551.	698.6
MISSISSIPPI	5.	6.	2061924.	28268.	2.	163.	361.	541.6
MISSOURI	28.	32.	9702956.	178102.	13.	706.	1392.	1754.5
MONTANA	0.	0.	59594.	881.	0.	4.	9.	12.3
NEBRASKA	4.	5.	1555196.	22154.	2.	120.	243.	335.3
NEVADA	0.	0.	49472.	599.	0.	4.	8.	7.5
NEW HAMPSHIRE	1.	1.	349823.	7012.	0.	26.	58.	63.8
NEW JERSEY	12.	14.	4003916.	103506.	5.	257.	551.	614.3
NEW MEXICO	1.	1.	527302.	5509.	1.	38.	83.	104.2
NEW YORK	4.	5.	1272481.	23852.	1.	91.	190.	183.7
NORTH CAROLINA	9.	11.	3536104.	56001.	4.	256.	555.	798.7
NORTH DAKOTA	1.	1.	259294.	3954.	1.	22.	47.	63.8
OHIO	20.	26.	7302733.	188910.	9.	478.	1032.	1238.2
OKLAHOMA	28.	29.	10790858.	127853.	13.	795.	1517.	2047.9
OREGON	0.	0.	66457.	1387.	0.	5.	10.	12.3
PENNSYLVANIA	8.	9.	2651366.	68330.	3.	186.	394.	449.1
RHODE ISLAND	0.	0.	55732.	1090.	0.	4.	9.	9.6
SOUTH CAROLINA	5.	7.	2061766.	41256.	2.	158.	356.	591.7
SOUTH DAKOTA	1.	1.	334655.	4296.	0.	27.	57.	78.2
TENNESSEE	7.	9.	2857405.	0.	4.	211.	447.	599.9
TEXAS	71.	80.	28254938.	473912.	32.	1928.	3896.	5377.2
UTAH	0.	0.	107015.	1418.	1.	7.	16.	19.2
VERMONT	0.	0.	82032.	1607.	0.	7.	14.	15.8
VIRGINIA	6.	6.	2054146.	32258.	3.	142.	305.	401.1
WASHINGTON	0.	0.	58938.	1089.	0.	5.	10.	11.0
WEST VIRGINIA	0.	0.	167225.	2835.	0.	11.	23.	31.5
WISCONSIN	8.	10.	2755576.	65584.	4.	197.	426.	516.3
WYOMING	0.	0.	88749.	1185.	0.	7.	14.	17.1
NATIONAL TOTAL	494.	573.	181983033.	3291958.	226.	12816.	26108.	35794.5

Table H-38. The Percentage of Estimated Annual Tornado Loss Saved Due to a 3.0 X UBC Mitigation in 2000

STATE	BUILDING DAMAGE %	CONTENTS DAMAGE %	INCOME LOSS %	SUPPLIER LOSS %	LIFE LOSS %	HOMES LOST %	HOMELESS-NESS %	UNEMPLOY-MENT %
ALABAMA	27.9	27.9	27.7	27.4	30.0	27.9	19.9	27.7
ARIZONA	34.8	34.8	34.7	34.7	0.0	34.8	34.7	34.6
ARKANSAS	26.8	26.8	26.7	26.6	25.0	26.8	26.7	26.6
CALIFORNIA	30.9	30.9	30.9	31.0	28.6	30.9	30.9	30.9
COLORADO	28.0	28.0	27.9	28.0	30.0	28.0	27.9	27.8
CONNECTICUT	22.5	22.5	22.6	22.5	37.5	22.5	22.6	22.5
DELAWARE	26.2	26.2	26.2	26.2	0.0	26.2	26.2	26.2
DIST. OF COLUMBIA	20.9	20.9	20.9	20.9	50.0	20.9	20.9	20.9
FLORIDA	33.9	33.9	33.9	33.9	35.0	33.9	33.9	33.9
GEORGIA	29.6	29.6	29.5	29.3	27.3	29.6	29.5	29.3
IDAHO	23.7	23.7	23.6	23.4	0.0	23.7	23.6	23.5
ILLINOIS	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1
INDIANA	21.6	21.6	21.6	21.7	22.0	21.6	21.6	21.5
IOWA	15.3	15.3	15.3	15.7	17.6	15.3	15.4	15.0
KANSAS	22.6	22.6	22.3	22.2	22.6	22.6	22.3	22.1
KENTUCKY	24.4	24.4	24.3	24.5	22.2	24.4	24.3	24.2
LOUISIANA	28.6	28.6	28.6	28.6	30.8	28.6	28.6	28.6
MAINE	14.1	14.1	14.0	14.0	0.0	14.1	14.0	14.0
MARYLAND	27.1	27.1	27.0	26.5	30.0	27.1	26.9	27.0
MASSACHUSETTS	14.8	14.8	14.8	14.8	16.2	14.8	14.8	14.8
MICHIGAN	23.2	23.2	23.2	23.2	25.0	23.2	23.2	23.2
MINNESOTA	22.0	22.0	21.9	22.2	22.7	22.0	22.0	21.8
MISSISSIPPI	27.5	27.5	27.4	27.0	25.0	27.5	27.4	27.2
MISSOURI	22.8	22.8	22.7	22.8	23.6	22.8	22.8	22.6
MONTANA	21.4	21.4	21.2	21.0	0.0	21.4	21.3	21.2
NEBRASKA	17.2	17.2	17.0	16.9	16.7	17.2	17.0	17.1
NEVADA	33.6	33.6	33.3	33.6	0.0	33.6	33.4	33.4
NEW HAMPSHIRE	15.1	15.1	15.1	15.1	0.0	15.1	15.1	15.1
NEW JERSEY	19.7	19.7	19.8	19.6	18.5	19.7	19.8	19.9
NEW MEXICO	31.6	31.6	31.3	31.3	50.0	31.6	31.3	31.3
NEW YORK	16.9	16.9	16.8	16.8	10.0	16.9	16.9	16.8
NORTH CAROLINA	28.0	28.0	27.8	27.7	28.6	28.0	27.9	27.6
NORTH DAKOTA	18.5	18.5	18.5	18.3	50.0	18.5	18.5	18.4
OHIO	21.5	21.5	21.5	21.5	22.0	21.5	21.5	21.5
OKLAHOMA	26.8	26.8	26.7	26.6	27.7	26.8	26.7	26.6
OREGON	24.7	24.7	24.7	24.7	0.0	24.7	24.7	24.7
PENNSYLVANIA	18.0	18.0	17.9	17.8	15.8	18.0	17.9	17.9
RHODE ISLAND	16.7	16.7	16.7	16.7	0.0	16.7	16.7	16.7
SOUTH CAROLINA	27.7	27.7	27.5	27.2	25.0	27.7	27.5	32.5
SOUTH DAKOTA	16.5	16.5	16.4	16.4	0.0	16.5	16.5	16.3
TENNESSEE	28.2	28.2	28.1	0.0	33.3	28.2	28.2	28.0
TEXAS	31.2	31.2	31.2	31.2	31.1	31.2	31.2	31.1
UTAH	26.4	26.4	26.4	26.5	100.0	26.4	26.4	26.4
VERMONT	14.0	14.0	14.0	14.0	0.0	14.0	14.0	14.0
VIRGINIA	27.9	27.9	27.9	27.8	30.0	27.9	27.9	27.8
WASHINGTON	23.5	23.5	23.5	23.6	0.0	23.5	23.5	23.5
WEST VIRGINIA	17.7	17.7	17.7	17.7	0.0	17.7	17.7	17.7
WISCONSIN	19.2	19.2	19.1	19.0	22.2	19.2	19.1	19.0
WYOMING	22.5	22.5	22.5	22.5	0.0	22.5	22.5	22.5
NATIONAL AVERAGE	24.0	24.0	24.2	36.4	24.6	24.0	24.3	24.4

HURRICANE TABLES

H - 39 Annual Losses in 1970

H - 40 Annual Loss rates in 1970

H - 41 Annual Losses in 2000

H - 42 Annual Loss rates in 2000

H - 43 The savings due to a building code mitigation of 1.5 x UBC (see Chapter 9 for details) in 2000

H - 44 The percentage of losses saved due to a building code mitigation of 1.5 x UBC in 2000

H - 45 The savings due to a building code mitigation of 3.0 x UBC

H - 46 The percentage of losses saved due to a building code mitigation of 3.0 x UBC in 2000

Table H-39. Estimated Annual Hurricane Wind Losses in 1970

STATE	BUILDING DAMAGE (1970$ 10^6)	CONTENTS DAMAGE (1970$ 10^6)	INCOME LOSS (1970$)	SUPPLIER LOSS (1970$)	LIFE LOSS (LIVES)	HOMES LOST (HOUSING UNITS)	HOMELESSNESS (PERSON YEARS)	UNEMPLOYMENT (PERSON YEARS)
ALABAMA	12.	5.37	2476000.	27280.	1.	764.	1160.	595.0
CONNECTICUT	44.	20.27	7134000.	68790.	4.	1520.	1836.	2430.0
DELAWARE	2.	0.72	278400.	3391.	0.	109.	134.	50.2
DIST. OF COLUMBIA	2.	0.55	237800.	1941.	0.	64.	55.	38.5
FLORIDA	190.	72.39	29770000.	290900.	17.	9960.	9734.	5998.0
GEORGIA	8.	3.38	1320000.	14540.	1.	689.	882.	294.0
LOUISIANA	49.	18.91	8799000.	114500.	4.	2797.	3329.	2089.0
MAINE	6.	2.63	851500.	11130.	1.	354.	463.	171.0
MARYLAND	13.	4.75	1876000.	20660.	1.	549.	590.	351.0
MASSACHUSETTS	64.	24.73	8410000.	86360.	6.	2342.	2182.	1411.0
MISSISSIPPI	9.	4.09	1659000.	17350.	1.	667.	982.	451.0
NEW HAMPSIRE	6.	2.34	767400.	8010.	1.	273.	301.	143.0
NEW JERSEY	23.	8.27	2797000.	34860.	2.	977.	978.	438.0
NEW YORK	129.	45.80	15040000.	166000.	11.	3134.	2684.	2135.0
NORTH CAROLINA	33.	15.22	5575000.	55150.	3.	2764.	3823.	1374.0
PENNSYLVANIA	16.	6.33	2110000.	28000.	1.	725.	765.	363.0
RHODE ISLAND	10.	4.41	1470000.	16230.	1.	459.	450.	273.0
SOUTH CAROLINA	10.	4.51	1678000.	18570.	1.	917.	1191.	414.0
TEXAS	31.	12.28	5352000.	64880.	3.	1423.	1343.	1126.0
VERMONT	0.	0.06	20940.	232.	0.	12.	15.	4.0
VIRGINIA	29.	10.56	4181000.	43280.	3.	1386.	1608.	855.0
NATIONAL TOTAL	686.	267.57	101803040.	1092054.	62.	31885.	34505.	21003.7

Table H-40. The Estimated Annual Proportion of the Value at Risk Lost to Hurricane Wind in 1970

STATE	① BUILDING DAMAGE	② CONTENTS DAMAGE	③ INCOME LOSS	④ SUPPLIER LOSS	⑤ LIFE LOSS	⑥ HOMES LOST	⑦ HOMELESSNESS	⑧ UNEMPLOYMENT
ALABAMA	2.1-03	1.6-03	9.2-04	1.0-05	1.3-06	2.9-03	1.4-03	8.5-04
CONNECTICUT	1.3-03	8.9-04	3.7-04	3.5-06	1.3-06	1.6-03	6.1-04	5.2-04
DELAWARE	3.3-04	1.9-04	9.2-05	1.1-06	3.0-07	6.4-04	2.4-04	8.7-05
DIST. OF COLUMBIA	1.6-04	1.1-04	4.5-05	3.7-07	2.3-07	2.3-04	7.3-05	4.1-05
FLORIDA	3.1-03	2.3-03	1.1-03	1.0-05	2.5-06	4.0-03	1.4-03	9.6-04
GEORGIA	8.6-04	5.5-04	2.7-04	1.6-06	5.7-07	1.7-03	6.8-04	2.5-04
LOUISIANA	2.0-03	1.4-03	6.3-04	8.2-06	1.5-06	3.0-03	1.1-03	5.9-04
MAINE	8.3-04	5.8-04	2.3-04	3.0-06	6.1-07	1.4-03	5.1-04	2.0-04
MARYLAND	3.4-04	2.4-04	1.1-04	1.2-06	3.6-07	5.6-04	1.9-04	9.9-05
MASSACHUSETTS	1.0-03	6.9-04	2.6-04	2.7-06	9.8-07	1.3-03	3.8-04	2.3-04
MISSISSIPPI	1.8-03	1.4-03	6.8-04	7.1-06	1.0-06	2.9-03	1.3-03	6.2-04
NEW HAMPSIRE	8.4-04	5.7-04	2.2-04	2.3-06	7.4-07	1.3-03	4.4-04	1.9-04
NEW JERSEY	2.8-04	1.6-04	6.5-05	8.1-07	2.8-07	4.2-04	1.4-04	5.6-05
NEW YORK	8.0-04	5.5-04	1.8-04	2.0-06	9.6-07	7.7-04	2.3-04	1.5-04
NORTH CAROLINA	1.8-03	1.3-03	6.1-04	6.0-06	1.2-06	3.6-03	1.6-03	5.6-04
PENNSYLVANIA	3.0-04	1.9-04	7.7-05	1.0-06	2.8-07	4.5-04	1.5-04	6.7-05
RHODE ISLAND	1.1-03	7.7-04	3.1-04	3.4-06	9.6-07	1.5-03	4.7-04	2.7-04
SOUTH CAROLINA	1.3-03	7.9-01	4.0-04	4.4-06	8.2-07	2.6-03	1.1-03	3.7-04
TEXAS	8.3-04	5.9-04	2.6-04	3.2-06	6.8-07	1.1-03	3.4-04	2.4-04
VERMONT	1.0-04	8.0-01	2.8-05	3.1-07	7.8-08	2.0-04	8.2-05	2.4-05
VIRGINIA	8.5-04	6.4-04	2.8-04	2.9-06	8.9-07	1.5-03	5.7-04	2.6-04
NATIONAL AVERAGE	1.0-03	7.0-04	3.0-04	3.2-06	9.9-07	1.5-03	5.5-04	3.1-04

Table H-41. Estimated Annual Hurricane Wind Losses in 2000

STATE	BUILDING DAMAGE / $1970\$ \, 10^6$	CONTENTS DAMAGE / $1970\$ \, 10^6$	INCOME LOSS / 1970$	SUPPLIER LOSS / 1970$	LIFE LOSS / LIVES	HOMES LOST / HOUSING UNITS	HOMELESSNESS / PERSON YEARS	UNEMPLOYMENT / PERSON YEARS
ALABAMA	27.	26.75	5763000.	67830.	2.	1003.	1341.	1394.0
CONNECTICUT	99.	102.51	17490000.	175300.	9.	2369.	2436.	5566.0
DELAWARE	5.	3.85	719600.	9660.	0.	173.	185.	136.0
DIST. OF COLUMBIA	6.	3.72	773500.	6203.	1.	112.	80.	126.0
FLORIDA	639.	539.71	103500000.	1086000.	56.	21413.	18199.	21260.0
GEORGIA	19.	16.41	3161000.	37340.	2.	1025.	1108.	743.0
LOUISIANA	101.	87.66	19870000.	266300.	9.	3447.	3583.	4860.0
MAINE	13.	11.63	1873000.	28230.	1.	452.	500.	387.0
MARYLAND	30.	23.58	4511000.	53330.	3.	826.	774.	849.0
MASSACHUSETTS	146.	128.26	20700000.	223300.	13.	3533.	2869.	3542.0
MISSISSIPPI	18.	19.22	3771000.	41500.	2.	812.	1042.	1098.0
NEW HAMPSIRE	14.	12.16	1961000.	21720.	1.	432.	399.	371.0
NEW JERSEY	51.	40.32	6520000.	86890.	4.	1423.	1224.	1034.0
NEW YORK	267.	210.67	33080000.	380000.	23.	4055.	2974.	4817.0
NORTH CAROLINA	76.	76.14	14150000.	147600.	7.	3763.	4555.	3997.0
PENNSYLVANIA	33.	29.69	4776000.	67740.	3.	986.	905.	828.0
RHODE ISLAND	22.	21.34	3353000.	38900.	2.	632.	538.	634.0
SOUTH CAROLINA	24.	22.46	4129000.	48520.	2.	1231.	1422.	1104.0
TEXAS	81.	73.67	15270000.	194100.	7.	2410.	1978.	3244.0
VERMONT	0.	0.32	49920.	602.	0.	16.	17.	9.7
VIRGINIA	71.	54.91	10770000.	113900.	6.	2124.	2142.	2224.0
NATIONAL TOTAL	1742.	1504.98	276191020.	3094965.	153.	52237.	48271.	58223.7

Table H-42. The Estimated Annual Proportion of the Value at Risk Lost to Hurricane Wind in 2000

STATE	① BUILDING DAMAGE	② CONTENTS DAMAGE	③ INCOME LOSS	④ SUPPLIER LOSS	⑤ LIFE LOSS	⑥ HOMES LOST	⑦ HOMELESSNESS	⑧ UNEMPLOYMENT
ALABAMA	2.0-03	1.6 03	8.4-04	9.9-06	2.5-06	3.0-03	1.4-03	7.6-04
CONNECTICUT	1.2-03	8.5-04	3.4-04	3.5-06	2.1-06	1.6-03	6.0-04	4.8-04
DELAWARE	3.2-04	1.8-04	8.4-05	1.1-06	5.3-07	6.4-04	2.5-04	8.2-05
DIST. OF COLUMBIA	1.5-04	1.1-04	4.2-05	3.4-07	3.7-07	1.8-04	5.4-05	3.9-05
FLORIDA	3.2-03	2.4-03	1.0-03	1.1-05	4.8-06	4.4-03	1.6-03	9.5-04
GEORGIA	8.1-04	5.3-04	2.4-04	2.9-06	1.1-06	1.8-03	7.2-04	2.2-04
LOUISIANA	1.9-03	1.4-03	5.9-04	8.0-06	2.8-06	3.1-03	1.1-03	5.6-04
MAINE	8.1-04	5.6-04	2.2-04	3.3-06	1.2-06	1.4-03	5.2-04	2.0-04
MARYLAND	3.0-04	2.3-04	9.5-05	1.1-06	6.0-07	5.3-04	1.8-04	8.8-05
MASSACHUSETTS	9.7-04	6.7-04	2.5-04	2.7-06	1.7-06	1.3-03	3.8-04	2.2-04
MISSISSIPPI	1.7-03	1.3-03	6.2-04	6.8-06	2.1-06	2.9-03	1.3-03	5.7-04
NEW HAMPSIRE	8.0-04	5.4-04	2.1-04	2.3-06	1.3-06	1.3-03	4.4-04	1.8-04
NEW JERSEY	2.6-04	1.5-04	5.9-05	7.8-07	4.7-07	4.0-04	1.3-04	5.1-05
NEW YORK	7.4-04	5.1-04	1.7-04	1.9-06	1.6-06	6.9-04	2.0-04	1.4-04
NORTH CAROLINA	1.6-03	1.2-03	5.4-04	5.6-06	2.2-06	3.4-03	1.5-03	5.1-04
PENNSYLVANIA	2.8-04	1.9-04	7.2-05	1.0-06	4.8-07	4.4-04	1.5-04	6.4-05
RHODE ISLAND	1.1-03	7.5-04	2.9-04	3.4-06	1.7-06	1.5-03	4.7-04	2.6-04
SOUTH CAROLINA	1.3-03	7.9-04	3.7-04	4.3-06	1.6-06	2.6-03	1.1-03	3.4-04
TEXAS	8.3-04	6.0-04	2.5-04	3.2-06	1.3-06	1.2-03	3.7-04	2.4-04
VERMONT	9.9-05	6.8-05	2.6-05	3.2-07	1.5-07	2.0-04	7.9-05	2.3-05
VIRGINIA	7.4-04	5.9-04	2.4-04	2.5-06	1.5-06	1.4-03	5.0-04	2.2-04
NATIONAL AVERAGE	1.6-03	1.2-03	4.8-04	5.3-06	3.0-06	2.6-03	9.4-04	5.0-04

Table H-43. Estimated Annual Hurricane Wind Losses Saved Due to a 3.0 X U.B.C. Mitigation in 2000

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESS-NESS PERSON YEARS	UNEMPLOY-MENT PERSON YEARS
ALABAMA	8.	8.	1752016.	28450.	0.	304.	408.	292.9
CONNECTICUT	22.	23.	3953508.	70404.	2.	533.	551.	5372.1
DELAWARE	1.	1.	189259.	3947.	0.	45.	49.	22.8
DIST. OF COLUMBIA	1.	1.	161659.	1831.	1.	23.	17.	18.4
FLORIDA	218.	184.	35285998.	460275.	19.	7302.	6206.	4722.9
GEORGIA	5.	4.	856701.	14654.	1.	278.	300.	130.7
LOUISIANA	28.	24.	5444764.	101863.	3.	941.	982.	828.3
MAINE	2.	2.	264140.	6220.	0.	64.	71.	37.3
MARYLAND	8.	6.	1150397.	19105.	1.	212.	197.	140.9
MASSACHUSETTS	22.	19.	3435470.	52983.	2.	523.	425.	346.1
MISSISSIPPI	5.	5.	984286.	14807.	1.	214.	271.	183.5
NEW HAMPSIRE	2.	2.	294153.	5633.	0.	65.	60.	37.8
NEW JERSEY	10.	8.	1336659.	30518.	0.	290.	250.	149.1
NEW YORK	48.	38.	5987842.	101791.	4.	734.	538.	619.2
NORTH CAROLINA	20.	20.	3693568.	59658.	2.	982.	1189.	637.6
PENNSYLVANIA	6.	5.	873990.	22427.	1.	181.	165.	105.0
RHODE ISLAND	4.	4.	559991.	11084.	0.	106.	90.	65.8
SOUTH CAROLINA	6.	6.	1114790.	22120.	0.	335.	384.	194.6
TEXAS	26.	24.	4947836.	89091.	2.	778.	641.	658.4
VERMONT	0.	0.	6989.	141.	0.	2.	2.	1.0
VIRGINIA	20.	16.	3089641.	46247.	2.	612.	615.	417.3
NATIONAL TOTAL	462.	400.	75383657.	1163249.	41.	14524.	13411.	14981.7

Table H-44. The Percentage of the Estimated Annual Hurricane Wind Losses Saved Due to a 3.0 X U.B.C. Mitigation in 2000

STATE	BUILDING DAMAGE %	CONTENTS DAMAGE %	INCOME LOSS %	SUPPLIER LOSS %	LIFE LOSS %	HOMES LOST %	HOMELESS-NESS %	UNEMPLOY-MENT %
ALABAMA	19.0	19.0	19.1	19.1	0.0	19.0	19.1	19.1
CONNECTICUT	14.1	14.1	14.2	14.1	22.2	14.1	14.2	14.1
DELAWARE	16.5	16.5	16.5	16.5	0.0	16.5	16.5	16.5
DIST. OF COLUMBIA	13.1	13.1	13.1	13.1	0.0	13.1	13.1	13.1
FLORIDA	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4
GEORGIA	17.0	17.0	17.0	17.0	50.0	17.0	17.0	16.9
LOUISIANA	17.1	17.1	17.2	17.2	22.2	17.1	17.2	17.2
MAINE	8.9	8.9	8.9	8.8	0.0	8.9	8.9	8.8
MARYLAND	16.1	16.1	16.0	15.8	33.3	16.1	16.0	16.1
MASSACHUSETTS	9.3	9.3	9.3	9.3	7.7	9.3	9.3	9.3
MISSISSIPPI	16.5	16.5	16.3	16.2	50.0	16.5	16.3	16.3
NEW HAMPSIRE	9.4	9.4	9.4	9.4	0.0	9.4	9.4	9.4
NEW JERSEY	12.8	12.8	12.8	12.7	0.0	12.8	12.8	12.8
NEW YORK	11.3	11.3	11.3	11.3	8.7	11.3	11.3	11.3
NORTH CAROLINA	16.4	16.4	16.4	16.4	14.3	16.4	16.4	16.3
PENNSYLVANIA	11.5	11.5	11.4	11.3	0.0	11.5	11.4	11.5
RHODE ISLAND	10.5	10.5	10.5	10.5	0.0	10.5	10.5	10.5
SOUTH CAROLINA	17.0	17.0	16.9	16.7	0.0	17.0	16.9	16.9
TEXAS	20.3	20.3	20.3	20.2	14.3	20.3	20.3	20.3
VERMONT	8.8	8.8	8.8	8.8	0.0	8.8	8.8	8.8
VIRGINIA	18.0	18.0	18.0	18.1	16.7	18.0	18.0	18.0
NATIONAL AVERAGE	16.6	16.6	17.0	23.6	17.0	16.6	17.4	16.1

Table H-45. The Estimated Annual Hurricane Wind Losses Saved Due to a 1.5 U.B.C. Mitigation in 2000

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESSNESS PERSON YEARS	UNEMPLOYMENT PERSON YEARS
ALABAMA	5.	5.	1100773.	17875.	0.	190.	256.	184.0
CONNECTICUT	14.	14.	2484063.	44120.	2.	334.	346.	3366.4
DELAWARE	1.	1.	118737.	2476.	0.	29.	31.	14.0
DIST. OF COLUMBIA	1.	0.	101327.	1148.	1.	15.	10.	11.6
FLORIDA	137.	115.	22144292.	288853.	12.	4582.	3895.	2954.9
GEORGIA	3.	3.	537414.	9193.	1.	174.	188.	81.8
LOUISIANA	17.	15.	3417881.	63943.	2.	589.	616.	519.9
MAINE	1.	1.	166726.	3882.	0.	40.	45.	23.2
MARYLAND	5.	4.	721818.	11931.	1.	133.	124.	88.6
MASSACHUSETTS	14.	12.	1924691.	33070.	1.	329.	267.	217.4
MISSISSIPPI	3.	3.	614707.	9262.	1.	134.	170.	115.2
NEW HAMPSIRE	1.	1.	184336.	3530.	0.	41.	38.	23.7
NEW JERSEY	6.	5.	834597.	19093.	0.	182.	157.	92.9
NEW YORK	30.	24.	3738266.	63549.	2.	458.	336.	386.8
NORTH CAROLINA	12.	12.	2320862.	37486.	1.	617.	747.	399.4
PENNSYLVANIA	4.	3.	544453.	14001.	0.	113.	103.	66.3
RHODE ISLAND	2.	2.	352090.	6969.	0.	66.	56.	41.1
SOUTH CAROLINA	4.	4.	697776.	13835.	0.	209.	240.	122.5
TEXAS	16.	15.	3100033.	55890.	1.	489.	402.	412.5
VERMONT	0.	0.	4393.	89.	0.	1.	1.	0.5
VIRGINIA	13.	10.	1937754.	29065.	1.	382.	386.	261.9
NATIONAL TOTAL	289.	249.	47046989.	729260.	26.	9107.	8414.	9384.6

Table H-46. The Percentage of the Estimated Annual Hurricane Wind Losses Saved Due to a 1.5 X U.B.C. Mitigation in 2000

STATE	BUILDING DAMAGE %	CONTENTS DAMAGE %	INCOME LOSS %	SUPPLIER LOSS %	LIFE LOSS %	HOMES LOST %	HOMELESSNESS %	UNEMPLOYMENT %
ALABAMA	30.3	30.3	30.4	30.4	0.0	30.3	30.4	30.4
CONNECTICUT	22.5	22.5	22.6	22.5	22.2	22.5	22.6	22.5
DELAWARE	26.3	26.3	26.3	26.3	0.0	26.3	26.3	26.3
DIST. OF COLUMBIA	20.9	20.9	20.9	20.9	100.0	20.9	20.9	20.9
FLORIDA	34.1	34.1	34.1	34.1	33.9	34.1	34.1	34.2
GEORGIA	27.1	27.1	27.1	27.1	50.0	27.1	27.1	27.0
LOUISIANA	27.3	27.3	27.4	27.4	33.3	27.3	27.4	27.4
MAINE	14.1	14.1	14.1	14.1	0.0	14.1	14.1	14.1
MARYLAND	25.7	25.7	25.5	25.3	33.3	25.7	25.5	25.6
MASSACHUSETTS	14.8	14.8	16.6	14.9	15.4	14.8	14.8	14.8
MISSISSIPPI	26.3	26.3	26.1	25.9	50.0	26.3	26.0	26.0
NEW HAMPSIRE	15.1	15.1	15.0	15.0	0.0	15.1	15.0	15.1
NEW JERSEY	20.4	20.4	20.5	20.3	0.0	20.4	20.4	20.5
NEW YORK	18.1	18.1	18.1	18.1	17.4	18.1	18.1	18.1
NORTH CAROLINA	26.1	26.1	26.1	26.1	28.6	26.1	26.1	26.0
PENNSYLVANIA	18.4	18.4	18.3	18.1	33.3	18.4	18.2	18.3
RHODE ISLAND	16.7	16.7	16.7	16.7	0.0	16.7	16.7	16.7
SOUTH CAROLINA	27.2	27.2	27.0	26.7	0.0	27.2	27.0	26.9
TEXAS	32.3	32.3	32.4	32.2	28.6	32.3	32.4	32.4
VERMONT	14.0	14.0	14.0	14.0	0.0	14.0	14.0	14.0
VIRGINIA	28.8	28.8	28.7	28.8	33.3	28.8	28.7	28.7
NATIONAL AVERAGE	26.5	26.5	27.3	37.6	26.8	26.5	27.8	25.7

LANDSLIDE TABLES

H - 47 Annual Building and Life Losses for 1970

H - 48 Annual Building and Life Loss rates for 1970

Note: These results reflect the Krohn and Slosson Landslide data and thus they differ from the results obtained from the synthesis of the subsequent USGS data.

Table H-47. The Estimated Annual Landslide Losses in 1970.

STATE	BUILDING DAMAGE 1970$ 10^6	CONTENTS DAMAGE 1970$ 10^6	INCOME LOSS 1970$	SUPPLIER LOSS 1970$	LIFE LOSS LIVES	HOMES LOST HOUSING UNITS	HOMELESSNESS PERSON YEARS	UNEMPLOYMENT PERSON YEARS
ALABAMA	4.				3.			
ARIZONA	1.				0.			
ARKANSAS	2.				1.			
CALIFORNIA	33.				26.			
COLORADO	3.				3.			
CONNECTICUT	2.				0.			
DELAWARE	0.				0.			
DIST. OF COLUMBIA	1.				0.			
FLORIDA	4.				0.			
GEORGIA	3.				0.			
IDAHO	1.				1.			
ILLINOIS	10.				3.			
INDIANA	3.				0.			
IOWA	3.				2.			
KANSAS	1.				0.			
KENTUCKY	3.				2.			
LOUISIANA	2.				0.			
MAINE	1.				0.			
MARYLAND	12.				12.			
MASSACHUSETTS	4.				0.			
MICHIGAN	6.				0.			
MINNESOTA	6.				5.			
MISSISSIPPI	1.				0.			
MISSOURI	9.				8.			
MONTANA	1.				0.			
NEBRASKA	2.				2.			
NEVADA	0.				0.			
NEW HAMPSHIRE	0.				0.			
NEW JERSEY	5.				0.			
NEW MEXICO	1.				0.			
NEW YORK	15.				0.			
NORTH CAROLINA	3.				1.			
NORTH DAKOTA	1.				1.			
OHIO	13.				9.			
OKLAHOMA	2.				0.			
OREGON	3.				2.			
PENNSYLVANIA	19.				15.			
RHODE ISLAND	1.				0.			
SOUTH CAROLINA	1.				0.			
SOUTH DAKOTA	1.				0.			
TENNESSEE	3.				1.			
TEXAS	7.				1.			
UTAH	3.				3.			
VERMONT	0.				0.			
VIRGINIA	5.				2.			
WASHINGTON	4.				2.			
WEST VIRGINIA	5.				5.			
WISCONSIN	3.				0.			
WYOMING	0.				0.			
	213.0				110.0			

Table H-48. The Estimated Annual Proportion of the Value at Risk Lost to Landslide in 1970.

STATE	(1) BUILDING DAMAGE	(2) CONTENTS DAMAGE	(3) INCOME LOSS	(4) SUPPLIER LOSS	(5) LIFE LOSS	(6) HOMES LOST	(7) HOMELESS-NESS	(8) UNEMPLOY-MENT
ALABAMA	1.5-04				8.6-07			
ARIZONA	7.6-05				2.1-07			
ARKANSAS	1.3-04				5.9-07			
CALIFORNIA	1.5-04				1.3-06			
COLORADO	1.5-04				1.2-06			
CONNECTICUT	6.5-05				0.0 00			
DELAWARE	6.5-05				0.0 00			
DIST. OF COLUMBIA	6.5-05				0.0 00			
FLORIDA	6.3-05				0.0 00			
GEORGIA	6.7-05				2.6-08			
IDAHO	1.8-04				1.4-06			
ILLINOIS	8.2-05				2.7-07			
INDIANA	6.5-05				5.4-09			
IOWA	1.2-04				7.1-07			
KANSAS	6.9-05				5.5-08			
KENTUCKY	1.3-04				6.9-07			
LOUISIANA	6.5-05				0.0 00			
MAINE	6.5-05				0.0 00			
MARYLAND	2.4-04				3.0-06			
MASSACHUSETTS	6.5-05				0.0 00			
MICHIGAN	6.4-05				0.0 00			
MINNESOTA	1.5-04				1.2-06			
MISSISSIPPI	7.8-05				1.2-07			
MISSOURI	1.9-04				1.7-06			
MONTANA	1.0-04				5.5-07			
NEBRASKA	1.7-04				1.4-06			
NEVADA	3.8-05				1.5-07			
NEW HAMPSHIRE	6.5-05				0.0 00			
NEW JERSEY	6.5-05				0.0 00			
NEW MEXICO	7.3-05				1.0-07			
NEW YORK	6.5-05				0.0 00			
NORTH CAROLINA	8.7-05				2.4-07			
NORTH DAKOTA	2.0-04				1.5-06			
OHIO	1.2-04				8.1-07			
OKLAHOMA	7.3-05				1.0-07			
OREGON	1.4-04				1.0-06			
PENNSYLVANIA	1.6-04				1.3-06			
RHODE ISLAND	6.5-05				0.0 00			
SOUTH CAROLINA	6.5-05				0.0 00			
SOUTH DAKOTA	1.3-04				7.1-07			
TENNESSEE	8.7-05				2.4-07			
TEXAS	7.1-05				7.4-08			
UTAH	2.7-04				2.8-06			
VERMONT	6.5-05				0.0 00			
VIRGINIA	9.8-05				4.8-07			
WASHINGTON	1.1-04				7.1-07			
WEST VIRGINIA	3.3-04				3.0-06			
WISCONSIN	7.3-05				1.0-07			
WYOMING	1.1-04				6.1-07			
NATIONAL AVERAGE								

EXPANSIVE SOIL TABLES

H - 49 Annual Residential Building Losses for 1970

H - 50 Annual Residential Building Loss rates for 1970

Note: These losses are for residential structures only.

Table H-49. The Estimated Annual Expansive Soil Losses in 1970.

STATE	BUILDING DAMAGE / 1970$ 10^6	CONTENTS DAMAGE / 1970$ 10^6	INCOME LOSS / 1970$	SUPPLIER LOSS / 1970$	LIFE LOSS / LIVES	HOMES LOST / HOUSING UNITS	HOMELESS-NESS / PERSON YEARS	UNEMPLOY-MENT / PERSON YEARS
ALABAMA	12.							
ARIZONA	4.							
ARKANSAS	6.							
CALIFORNIA	227.							
COLORADO	23.							
CONNECTICUT	13.							
DELAWARE	1.							
DIST. OF COLUMBIA	2.							
FLORIDA	18.							
GEORGIA	24.							
IDAHO	4.							
ILLINOIS	47.							
INDIANA	11.							
IOWA	23.							
KANSAS	28.							
KENTUCKY	12.							
LOUISIANA	44.							
MAINE	4.							
MARYLAND	11.							
MASSACHUSETTS	12.							
MICHIGAN	57.							
MINNESOTA	10.							
MISSISSIPPI	14.							
MISSOURI	63.							
MONTANA	5.							
NEBRASKA	25.							
NEVADA	4.							
NEW HAMPSHIRE	1.							
NEW JERSEY	16.							
NEW MEXICO	5.							
NEW YORK	45.							
NORTH CAROLINA	24.							
NORTH DAKOTA	3.							
OHIO	25.							
OKLAHOMA	20.							
OREGON	17.							
PENNSYLVANIA	26.							
RHODE ISLAND	2.							
SOUTH CAROLINA	7.							
SOUTH DAKOTA	4.							
TENNESSEE	10.							
TEXAS	174.							
UTAH	7.							
VERMONT	1.							
VIRGINIA	14.							
WASHINGTON	8.							
WEST VIRGINIA	5.							
WISCONSIN	11.							
WYOMING	3.							
NATIONAL TOTAL	1132.							

Table H-50. The Estimated Annual Proportion of the Value at Risk Lost to Expansive Soil in 1970.

STATE	① BUILDING DAMAGE	② CONTENTS DAMAGE	③ INCOME LOSS	④ SUPPLIER LOSS	⑤ LIFE LOSS	⑥ HOMES LOST	⑦ HOMELESS-NESS	⑧ UNEMPLOY-MENT
ALABAMA	4.3-04							
ARIZONA	2.3-04							
ARKANSAS	4.8-04							
CALIFORNIA	1.0-03							
COLORADO	1.0-03							
CONNECTICUT	3.7-04							
DELAWARE	2.0-04							
DIST. OF COLUMBIA	2.0-04							
FLORIDA	2.9-04							
GEORGIA	5.7-04							
IDAHO	5.6-04							
ILLINOIS	3.7-04							
INDIANA	2.2-04							
IOWA	9.0-04							
KANSAS	1.3-03							
KENTUCKY	4.7-04							
LOUISIANA	1.5-03							
MAINE	4.5-04							
MARYLAND	2.2-04							
MASSACHUSETTS	2.0-04							
MICHIGAN	6.3-04							
MINNESOTA	2.6-04							
MISSISSIPPI	9.8-04							
MISSOURI	1.4-03							
MONTANA	8.1-04							
NEBRASKA	1.7-03							
NEVADA	7.3-04							
NEW HAMPSHIRE	2.0-04							
NEW JERSEY	2.0-04							
NEW MEXICO	5.2-04							
NEW YORK	2.0-04							
NORTH CAROLINA	6.0-04							
NORTH DAKOTA	5.6-04							
OHIO	2.4-04							
OKLAHOMA	8.9-04							
OREGON	8.5-04							
PENNSYLVANIA	2.3-04							
RHODE ISLAND	2.0-04							
SOUTH CAROLINA	3.7-04							
SOUTH DAKOTA	7.3-04							
TENNESSEE	3.3-04							
TEXAS	1.7-03							
UTAH	6.7-04							
VERMONT	2.3-04							
VIRGINIA	2.8-04							
WASHINGTON	2.2-04							
WEST VIRGINIA	3.8-04							
WISCONSIN	2.7-04							
WYOMING	9.0-04							
NATIONAL AVERAGE								

RIVERINE FLOOD TABLES

H - 51 The Annual Building Losses distributed by value at risk in each state for 1970

H - 52 The Annual Building Losses in 2000

Table H-51. Annual Estimated Riverine Flood Losses in 1970

STATE	BUILDING DAMAGE $\$10^6$	CONTENTS DAMAGE $\$10^6$	INCOME LOSS $	SUPPLIER LOSS $	LIFE LOSS $	HOMES LOST HOUSING UNITS	HOMLESS-NESS PERSON YEARS	UNEMPLOY-MENT PERSON YEARS
ALABAMA	29.							
ARIZONA	15.							
ARKANSAS	20.							
CALIFORNIA	179.							
COLORADO	18.							
CONNECTICUT	22.							
DELAWARE	5.							
DIST. OF COLUMBIA	6.							
FLORIDA	57.							
GEORGIA	39.							
IDAHO	6.							
ILLINOIS	132.							
INDIANA	62.							
IOWA	36.							
KANSAS	29.							
KENTUCKY	25.							
LOUISIANA	38.							
MAINE	7.							
MARYLAND	32.							
MASSACHUSETTS	41.							
MICHIGAN	106.							
MINNESOTA	49.							
MISSISSIPPI	23.							
MISSOURI	60.							
MONTANA	6.							
NEBRASKA	19.							
NEVADA	4.							
NEW HAMPSHIRE	5.							
NEW JERSEY	50.							
NEW MEXICO	9.							
NEW YORK	127.							
NORTH CAROLINA	42.							
NORTH DAKOTA	8.							
OHIO	127.							
OKLAHOMA	27.							
OREGON	19.							
PENNSYLVANIA	82.							
RHODE ISLAND	7.							
SOUTH CAROLINA	22.							
SOUTH DAKOTA	9.							
TENNESSEE	31.							
TEXAS	117.							
UTAH	9.							
VERMONT	3.							
VIRGINIA	38.							
WASHINGTON	31.							
WEST VIRGINIA	14.							
WISCONSIN	53.							
WYOMING	3.							
ALASKA	2.							
HAWAII	7.							
NATIONAL TOTALS	1901.							

Table H-52. Annual Estimated Riverine Flood Losses in 2000

STATE	BUILDING DAMAGE 10^6	CONTENTS DAMAGE 10^6	INCOME LOSS $	SUPPLIER LOSS $	LIFE LOSS $	HOMES LOST HOUSING UNITS	HOMLESS-NESS PERSON YEARS	UNEMPLOY-MENT PERSON YEARS
ALABAMA	50.							
ARIZONA	22.							
ARKANSAS	24.							
CALIFORNIA	252.							
COLORADO	26.							
CONNECTICUT	28.							
DELAWARE	7.							
DIST. OF COLUMBIA	20.							
FLORIDA	152.							
GEORGIA	89.							
IDAHO	6.							
ILLINOIS	197.							
INDIANA	81.							
IOWA	32.							
KANSAS	28.							
KENTUCKY	26.							
LOUISIANA	49.							
MAINE	6.							
MARYLAND	63.							
MASSACHUSETTS	51.							
MICHIGAN	142.							
MINNESOTA	55.							
MISSISSIPPI	24.							
MISSOURI	61.							
MONTANA	6.							
NEBRASKA	19.							
NEVADA	8.							
NEW HAMPSHIRE	6.							
NEW JERSEY	77.							
NEW MEXICO	9.							
NEW YORK	197.							
NORTH CAROLINA	49.							
NORTH DAKOTA	5.							
OHIO	167.							
OKLAHOMA	41.							
OREGON	21.							
PENNSYLVANIA	97.							
RHODE ISLAND	7.							
SOUTH CAROLINA	37.							
SOUTH DAKOTA	6.							
TENNESSEE	31.							
TEXAS	191.							
UTAH	13.							
VERMONT	3.							
VIRGINIA	63.							
WASHINGTON	34.							
WEST VIRGINIA	12.							
WISCONSIN	61.							
WYOMING	3.							
ALASKA	4.							
HAWAII	12.							
NATIONAL TOTALS	2670.							

Appendix I

THE DISTRIBUTION OF BUILDING LOSSES BY DAMAGE TYPE BY STATE IN 1970 AND 2000

This appendix is similar to appendix F because it also provides examples of the computer-produced output. These tables are state level tables that provide the distributions of building damage by damage state. Examination of the damage type distributions of the individual states provides a perspective on the possibilities of sudden losses. These tables are not available for expansive soil, landslide, and riverine flooding losses because these hazards did not have damage estimation techniques that allowed the determination of damage type distributions of building losses.

TOTAL MILL 1970$ AT RISK	=	the replacement value of all buildings located in counties with a non-zero probability of damaging earthquakes in millions of 1970 base year dollars.
TOTAL DAMAGE IN MILL 1970$	=	the annual damage in the year of the table in millions of 1970 base year dollars.
THE TOTAL PERCENT DAMAGE	=	the annual damage derived by the value-at-risk x 100.
TOTAL POPULATION	=	the population in each county with a non-zero probability of a damaging occurrence.
LIVES LOST	=	the estimated number of lives lost derived from the dollar losses to buildings.
DEATH RATE	=	the estimated number of lives lost derived by the total population x 100.
PERCENT OF DAMAGE BY TYPE	=	percentage of total estimated annual damage in each category listed below.

		ratio of replacement to repair			
NO	=	none	0.00%	-	0.50%
LI	=	light	0.58%	-	1.25%
MOD	=	moderate	1.25%	-	7.50%
HEA	=	heavy	7.50%	-	65.00%
SEV	=	severe	65.00%	-	99.99%
COL	=	collapse	99.99%	-	100.00%

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO HURRICANE IN 1970 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

****

BASE LINE HURRICANE

	THE TOTAL MILL 1970$ AT RISK	THE TOTAL DAMAGE IN MILL 1970$	THE TOTAL PERCENT DAMAGE	TOTAL POPULATION	LIVES LOST	DEATH RATE	PERCENT OF DAMAGE BY TYPE NO	LI	MOD	HEA	SEV	COL
AL	5708.75	11.9430	.209	603815.	1.	.130E-03	0.	1.	7.	26.	43.	23.
CT	34984.08	43.6221	.125	3032217.	4.	.126E-03	0.	2.	9.	31.	40.	18.
DE	5721.53	1.8881	.330E-01	548104.	0.	.302E-04	0.	6.	16.	30.	30.	17.
DC	12617.67	1.9553	.155E-01	756510.	0.	.227E-04	0.	9.	18.	27.	29.	17.
FL	61102.03	190.3937	.312	6790360.	17.	.246E-03	0.	2.	11.	33.	37.	17.
GA	9781.70	8.4504	.864E-01	1303764.	1.	.569E-04	0.	5.	16.	32.	29.	17.
LA	24965.32	48.6096	.195	2932205.	4.	.145E-03	0.	3.	13.	34.	33.	17.
ME	7576.08	6.2749	.828E-01	899644.	1.	.612E-04	0.	3.	13.	36.	31.	16.
MD	37846.97	12.7574	.337E-01	3107719.	1.	.360E-04	0.	5.	15.	32.	31.	17.
MA	63383.69	63.6356	.100	5689170.	6.	.981E-04	0.	4.	14.	35.	30.	17.
MS	4873.78	8.6664	.178	733690.	1.	.104E-03	0.	2.	9.	30.	40.	19.
NH	6857.29	5.7608	.840E-01	682767.	1.	.740E-04	0.	4.	14.	35.	30.	17.
NJ	83728.33	23.0582	.275E-01	7172164.	2.	.282E-04	0.	7.	16.	31.	30.	16.
NY	162422.98	129.4565	.797E-01	11828164.	11.	.960E-04	0.	4.	14.	36.	31.	16.
NC	18354.91	32.8907	.179	2436792.	3.	.118E-03	0.	3.	12.	33.	35.	17.
PA	52805.40	15.6957	.297E-01	5015281.	1.	.275E-04	0.	5.	15.	33.	30.	16.
RI	9276.74	10.3759	.112	949723.	1.	.958E-04	0.	3.	13.	36.	31.	17.
SC	8002.80	10.4625	.131	1115912.	1.	.822E-04	0.	5.	16.	32.	29.	17.
TX	36804.03	30.6223	.832E-01	3928296.	3.	.684E-04	0.	3.	14.	34.	31.	17.
VT	1597.19	.1626	.102E-01	182569.	0.	.781E-05	0.	5.	15.	34.	31.	16.
VA	34067.79	28.7778	.845E-01	2832398.	3.	.891E-04	0.	3.	14.	34.	32.	17.

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO HURRICANE IN 2000 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

BASE LINE HURRICANE

	THE TOTAL MILL 1970$ AT RISK	THE TOTAL DAMAGE IN MILL 1970$	THE TOTAL PERCENT DAMAGE	TOTAL POPULATION	LIVES LOST	DEATH RATE	PERCENT OF DAMAGE BY TYPE NO	LI	MOD	HEA	SEV	COL
AL	13224,15	26,7867	,203	925950,	2,	,254E-03	0,	1,	7,	26,	43,	23,
CT	82591,01	98,5922	,119	4049541,	9,	,214E-03	0,	2,	9,	31,	39,	19,
DE	14391,93	4,5580	,317E-01	754715,	0,	,530E-04	0,	6,	16,	30,	30,	17,
DC	42386,32	6,2787	,148E-01	1490054,	1,	,370E-04	0,	9,	18,	27,	29,	17,
FL	198751,11	639,0956	,322	11611945,	56,	,483E-03	0,	2,	11,	32,	37,	17,
GA	22997,80	18,6505	,811E-01	1543394,	2,	,106E-03	0,	5,	16,	32,	29,	18,
LA	54466,02	101,1545	,186	3145660,	9,	,282E-03	0,	3,	13,	33,	33,	18,
ME	15728,62	12,6907	,807E-01	963848,	1,	,115E-03	0,	3,	13,	35,	31,	17,
MD	97394,34	29,5524	,303E-01	4290610,	3,	,604E-04	0,	5,	16,	31,	31,	17,
MA	151343,19	146,0535	,965E-01	7478653,	13,	,171E-03	0,	4,	14,	35,	30,	17,
MS	10803,49	18,3606	,170	778244,	2,	,207E-03	0,	2,	9,	30,	40,	20,
NH	16923,65	13,6094	,804E-01	900315,	1,	,133E-03	0,	4,	14,	34,	30,	17,
NJ	199247,52	50,7438	,255E-01	9527490,	4,	,467E-04	0,	7,	16,	31,	30,	16,
NY	360226,42	267,0138	,741E-01	14834724,	23,	,158E-03	0,	4,	14,	36,	31,	16,
NC	46442,49	75,6986	,163	3074120,	7,	,216E-03	0,	3,	12,	33,	35,	17,
PA	116596,07	32,9017	,282E-01	6016157,	3,	,480E-04	0,	5,	15,	32,	30,	17,
RI	20374,98	21,8624	,107	1144544,	2,	,168E-03	0,	3,	13,	35,	31,	17,
SC	18910,08	23,6372	,125	1333202,	2,	,156E-03	0,	5,	16,	32,	30,	17,
TX	97386,31	80,7881	,830E-01	5293412,	7,	,134E-03	0,	3,	14,	33,	31,	18,
VT	3609,94	,3558	,986E-02	214614,	0,	,145E-04	0,	5,	15,	34,	31,	16,
VA	96449,57	71,0852	,737E-01	4244049,	6,	,147E-03	0,	3,	14,	34,	32,	18,

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO TORNADO IN 1970 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

BASE LINE TORNADO

	THE TOTAL MILL 1970$ AT RISK	THE TOTAL DAMAGE IN MILL 1970$	THE TOTAL PERCENT DAMAGE	TOTAL POPULATION	LIVES LOST	DEATH RATE	PERCENT OF DAMAGE BY TYPE NO	LI	MOD	HEA	SEV	COL
AL	26731,34	18,5668	,687E-01	3444266,	8,	,239E-03	0,	0,	0,	7,	33,	60,
AZ	16118,25	1,9248	,119E-01	1687589,	1,	,511E-04	0,	0,	0,	7,	32,	61,
AR	13587,19	7,2533	,534E-01	1923239,	3,	,169E-03	0,	0,	0,	7,	32,	60,
CA	172852,54	13,8440	,801E-02	15493757,	6,	,401E-04	0,	0,	1,	7,	32,	61,
CO	21278,49	9,3785	,441E-01	2039570,	4,	,206E-03	0,	0,	1,	7,	32,	60,
CT	34984,08	5,7284	,164E-01	3032217,	3,	,847E-04	0,	0,	0,	6,	31,	62,
DE	5721,53	1,3660	,239E-01	548104,	1,	,112E-03	0,	0,	0,	7,	32,	61,
DC	12617,67	1,0665	,845E-02	756510,	0,	,632E-04	0,	0,	1,	8,	33,	57,
FL	61064,11	41,8185	,685E-01	6784880,	19,	,276E-03	0,	0,	1,	7,	32,	60,
GA	41493,20	18,5886	,448E-01	4589981,	8,	,182E-03	0,	0,	1,	7,	33,	60,
ID	5386,52	,4457	,827E-02	607437,	0,	,329E-04	0,	0,	0,	7,	32,	61,
IL	126788,90	152,2148	,120	11123874,	68,	,613E-03	0,	0,	1,	7,	32,	61,
IN	48799,02	47,7521	,979E-01	5195332,	21,	,412E-03	0,	0,	0,	7,	32,	61,
IA	25828,81	18,5870	,720E-01	2825379,	8,	,295E-03	0,	0,	0,	6,	32,	61,
KS	21534,30	32,2783	,150	2249071,	14,	,643E-03	0,	0,	0,	7,	32,	61,
KY	25607,66	7,9641	,311E-01	3219345,	4,	,111E-03	0,	0,	0,	7,	33,	60,
LA	30253,42	13,2597	,438E-01	3643180,	6,	,163E-03	0,	0,	0,	7,	33,	60,
ME	8073,30	1,0089	,125E-01	970270,	0,	,466E-04	0,	0,	0,	6,	32,	61,
MD	49206,47	8,5657	,174E-01	3924804,	4,	,978E-04	0,	0,	1,	7,	33,	59,
MA	63383,69	35,3173	,557E-01	5689170,	16,	,278E-03	0,	0,	1,	7,	31,	61,
~~MI~~	~~89230,56~~	~~40,0569~~	~~,449E-01~~	~~8675591,~~	~~18,~~	~~,207E-03~~	~~0,~~	~~0,~~	~~0,~~	~~7,~~	~~32,~~	~~61,~~
MN	37639,51	20,2537	,538E-01	3801378,	9,	,239E-03	0,	0,	1,	7,	32,	61,
MS	14593,15	8,4093	,576E-01	2216994,	4,	,170E-03	0,	0,	0,	7,	33,	60,
MO	45083,92	55,2397	,123	4677969,	25,	,529E-03	0,	0,	0,	7,	32,	61,
MT	4332,26	,4239	,978E-02	462503,	0,	,411E-04	0,	0,	0,	7,	32,	61,
NE	14271,01	12,3319	,864E-01	1485321,	6,	,372E-03	0,	0,	0,	7,	32,	61,
NV	4985,27	,1583	,318E-02	421980,	0,	,168E-04	0,	0,	1,	7,	32,	61,
NH	7353,07	2,8150	,383E-01	737681,	1,	,171E-03	0,	0,	0,	7,	32,	61,
NJ	83728,33	26,1847	,313E-01	7172164,	12,	,164E-03	0,	0,	1,	7,	32,	61,
NM	8921,37	2,2057	,247E-01	988726,	1,	,100E-03	0,	0,	0,	7,	32,	60,
NY	75687,72	10,6864	,141E-01	7191829,	5,	,666E-04	0,	0,	1,	7,	32,	61,
NC	39967,02	12,7283	,318E-01	5084430,	6,	,112E-03	0,	0,	0,	7,	32,	60,
ND	4736,59	2,1733	,459E-01	611665,	1,	,159E-03	0,	0,	0,	7,	32,	61,
OH	106332,66	41,8874	,394E-01	10656533,	19,	,176E-03	0,	0,	0,	7,	32,	61,
OK	23129,24	43,4512	,188	2559463,	19,	,761E-03	0,	0,	0,	7,	33,	60,
OR	12095,45	,3535	,292E-02	1146595,	0,	,138E-04	0,	0,	0,	7,	32,	61,
PA	114528,69	20,0566	,175E-01	11606634,	9,	,775E-04	0,	0,	0,	7,	32,	61,
RI	9276,74	,4603	,496E-02	949723,	0,	,217E-04	0,	0,	0,	6,	31,	62,
SC	19642,80	7,8697	,401E-01	2590210,	4,	,136E-03	0,	0,	0,	7,	32,	60,
SD	5323,12	2,9011	,545E-01	666257,	1,	,195E-03	0,	0,	0,	7,	32,	61,
TN	30822,40	10,0461	,326E-01	3924927,	5,	,115E-03	0,	0,	0,	7,	32,	60,
TX	99784,48	92,5561	,928E-01	10697193,	41,	,388E-03	0,	0,	1,	7,	32,	60,
UT	10178,11	,4505	,443E-02	1006364,	0,	,201E-04	0,	0,	1,	7,	33,	60,
VT	3798,95	,7928	,209E-01	444732,	0,	,799E-04	0,	0,	0,	6,	32,	61,
VA	48821,39	8,4624	,173E-01	4652328,	4,	,815E-04	0,	0,	1,	7,	33,	59,
WA	9021,84	,3818	,423E-02	995142,	0,	,172E-04	0,	0,	0,	7,	32,	61,
WV	10732,14	1,0216	,952E-02	1361257,	0,	,336E-04	0,	0,	0,	7,	33,	60,
WI	40852,82	18,2322	,446E-01	4372453,	8,	,187E-03	0,	0,	0,	6,	32,	61,
WY	2808,05	,4764	,170E-01	292732,	0,	,730E-04	0,	0,	0,	7,	32,	60,

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO TORNADO IN 2000 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

BASE LINE TORNADO

	THE TOTAL MILL 1970$ AT RISK	THE TOTAL DAMAGE IN MILL 1970$	THE TOTAL PERCENT DAMAGE	TOTAL POPULATION	LIVES LOST	DEATH RATE	PERCENT OF DAMAGE BY TYPE NO	LI	MOD	HEA	SEV	COL
AL	65030.60	43.8828	.675E-01	4166567.	20.	.472E-03	0.	0.	0.	7.	33.	59.
AZ	46183.14	5.5278	.120E-01	2680526.	2.	.924E-04	0.	0.	1.	7.	32.	60.
AR	32350.04	16.7874	.519E-01	2178930.	8.	.345E-03	0.	0.	0.	7.	33.	60.
CA	410732.85	31.7807	.774E-02	20350532.	14.	.700E-04	0.	0.	1.	7.	32.	60.
CO	53163.18	23.2114	.437E-01	2695641.	10.	.386E-03	0.	0.	1.	7.	32.	60.
CT	82591.01	13.1872	.160E-01	4049541.	6.	.146E-03	0.	0.	1.	7.	32.	61.
DE	14391.93	3.3406	.232E-01	754715.	1.	.198E-03	0.	0.	1.	7.	33.	60.
DC	42386.32	3.5103	.828E-02	1490054.	2.	.106E-03	0.	0.	1.	9.	34.	57.
FL	198662.29	132.7791	.668E-01	11605556.	60.	.513E-03	0.	0.	1.	7.	32.	60.
GA	115963.14	49.9104	.430E-01	6320544.	22.	.354E-03	0.	0.	1.	7.	33.	59.
ID	11864.85	.9709	.818E-02	691221.	0.	.630E-04	0.	0.	0.	7.	33.	60.
IL	286839.32	333.3427	.116	13599815.	149.	.110E-02	0.	0.	1.	7.	32.	60.
IN	118326.58	110.8774	.937E-01	6558977.	50.	.758E-03	0.	0.	0.	7.	32.	60.
IA	53442.88	37.1641	.695E-01	3028474.	17.	.550E-03	0.	0.	0.	7.	32.	60.
KS	46951.71	69.6526	.148	2518298.	31.	.124E-02	0.	0.	1.	7.	32.	60.
KY	65823.03	20.4072	.310E-01	4039791.	9.	.226E-03	0.	0.	1.	7.	33.	59.
LA	66338.59	28.3102	.427E-01	3917818.	13.	.324E-03	0.	0.	1.	7.	33.	59.
ME	16643.06	2.0476	.123E-01	1027151.	1.	.894E-04	0.	0.	0.	7.	32.	61.
MD	133335.87	22.4063	.168E-01	5710884.	10.	.176E-03	0.	0.	1.	8.	33.	59.
MA	151343.19	81.5184	.539E-01	7478653.	37.	.489E-03	0.	0.	1.	7.	32.	61.
MI	203089.19	88.3861	.435E-01	10665183.	40.	.372E-03	0.	0.	0.	7.	32.	60.
MN	91756.79	48.7523	.531E-01	4805779.	22.	.455E-03	0.	0.	1.	7.	32.	60.
MS	32950.93	18.8464	.572E-01	2362983.	8.	.358E-03	0.	0.	0.	7.	33.	60.
MO	101157.15	122.4418	.121	5397171.	55.	.102E-02	0.	0.	1.	7.	32.	60.
MT	8472.35	.8181	.966E-02	462784.	0.	.793E-04	0.	0.	0.	7.	33.	60.
NE	31162.48	25.7780	.827E-01	1672613.	12.	.691E-03	0.	0.	0.	7.	32.	60.
NV	15208.57	.4877	.321E-02	736138.	0.	.297E-04	0.	0.	1.	7.	32.	60.
NH	18060.86	6.8838	.381E-01	966640.	3.	.319E-03	0.	0.	1.	7.	32.	60.
NJ	199247.52	61.0336	.306E-01	9527490.	27.	.287E-03	0.	0.	1.	7.	32.	60.
NM	19696.55	4.6246	.235E-01	1121149.	2.	.185E-03	0.	0.	0.	7.	33.	60.
NY	166528.56	23.1973	.139E-01	8459845.	10.	.123E-03	0.	0.	1.	7.	32.	60.
NC	102973.62	31.9593	.310E-01	6534686.	14.	.219E-03	0.	0.	0.	7.	33.	60.
ND	8804.91	4.0059	.455E-01	563068.	2.	.319E-03	0.	0.	0.	7.	32.	60.
OH	242519.33	92.2921	.381E-01	12824512.	41.	.323E-03	0.	0.	1.	7.	32.	60.
OK	55817.31	104.0507	.186	3083001.	47.	.151E-02	0.	0.	1.	7.	33.	59.
OR	28271.58	.7928	.280E-02	1424295.	0.	.250E-04	0.	0.	1.	7.	32.	60.
PA	248729.54	42.7656	.172E-01	13288032.	19.	.144E-03	0.	0.	0.	7.	32.	61.
RI	20374.98	.9862	.484E-02	1144544.	0.	.386E-04	0.	0.	0.	7.	32.	61.
SC	47765.77	18.6208	.390E-01	3196826.	8.	.261E-03	0.	0.	0.	7.	33.	60.
SD	10370.55	5.5240	.533E-01	652821.	2.	.379E-03	0.	0.	0.	7.	33.	60.
TN	79762.04	25.9020	.325E-01	5041162.	12.	.230E-03	0.	0.	1.	7.	33.	60.
TX	252317.66	229.0035	.908E-01	13841185.	103.	.742E-03	0.	0.	1.	7.	33.	59.
UT	26290.68	1.1487	.437E-02	1335705.	1.	.386E-04	0.	0.	1.	7.	33.	59.
VT	8626.66	1.7546	.203E-01	515341.	1.	.153E-03	0.	0.	0.	7.	32.	61.
VA	132794.01	21.5136	.162E-01	6465731.	10.	.149E-03	0.	0.	1.	7.	33.	59.
WA	18549.54	.7535	.406E-02	1062832.	0.	.318E-04	0.	0.	0.	7.	32.	60.
WV	22438.61	2.0922	.932E-02	1356995.	1.	.691E-04	0.	0.	0.	7.	33.	59.
WI	88776.88	39.5587	.446E-01	5049915.	18.	.351E-03	0.	0.	0.	7.	32.	60.
WY	5613.00	.9866	.176E-01	298385.	0.	.148E-03	0.	0.	0.	7.	33.	60.

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO STRG WINDS IN 1970 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

BASE LINE SEVERE WIND

	THE TOTAL MILL 1970$ AT RISK	THE TOTAL DAMAGE IN MILL 1970$	THE TOTAL PERCENT DAMAGE	TOTAL POPULATION	LIVES LOST	DEATH RATE	PERCENT OF DAMAGE BY TYPE NO	LI	MOD	HEA	SEV	COL
AL	26731,34	,0024	,910E-05	3444266,	0,	,317E-07	0,	7,	8,	12,	41,	32,
AZ	16857,38	,0381	,226E-03	1772658,	0,	,964E-06	0,	8,	8,	13,	42,	30,
AR	13587,19	,0009	,679E-05	1923239,	0,	,215E-07	0,	7,	8,	12,	41,	32,
CA	228004,98	,8397	,368E-03	19963945,	0,	,189E-05	0,	8,	8,	13,	40,	31,
CO	22685,83	,3974	,175E-02	2207259,	0,	,807E-05	0,	8,	8,	13,	41,	30,
CT	34984,08	,4373	,125E-02	3032217,	0,	,647E-05	0,	8,	9,	13,	39,	32,
DE	5721,53	,0237	,414E-03	548104,	0,	,194E-05	0,	7,	8,	12,	40,	33,
DC	12617,67	,0015	,119E-04	756510,	0,	,887E-07	0,	7,	8,	12,	41,	32,
FL	61102,03	,1654	,271E-03	6790360,	0,	,109E-05	0,	7,	8,	12,	40,	32,
GA	41493,20	,0191	,459E-04	4589981,	0,	,186E-06	0,	7,	8,	13,	42,	30,
ID	6252,56	,0706	,113E-02	712837,	0,	,444E-05	0,	8,	8,	12,	41,	30,
IL	126788,90	,7981	,629E-03	11123874,	0,	,322E-05	0,	7,	9,	13,	40,	32,
IN	48799,02	,4180	,857E-03	5195332,	0,	,361E-05	0,	8,	8,	13,	41,	31,
IA	25828,81	,2722	,105E-02	2825379,	0,	,432E-05	0,	8,	8,	12,	40,	31,
KS	21534,30	,2273	,106E-02	2249071,	0,	,453E-05	0,	8,	8,	12,	41,	31,
KY	25607,66	,0175	,685E-04	3219345,	0,	,244E-06	0,	7,	8,	12,	40,	32,
LA	30253,42	,1164	,385E-03	3643180,	0,	,143E-05	0,	7,	8,	13,	42,	30,
ME	8260,02	,0098	,118E-03	993722,	0,	,440E-06	0,	8,	9,	12,	41,	31,
MD	49206,47	,0613	,125E-03	3924804,	0,	,700E-06	0,	7,	8,	12,	40,	32,
MA	63383,69	,8409	,133E-02	5689170,	0,	,663E-05	0,	8,	9,	13,	40,	31,
MI	90848,50	,0725	,798E-04	8880122,	0,	,366E-06	0,	8,	8,	12,	41,	31,
MN	37664,48	,3859	,102E-02	3804801,	0,	,455E-05	0,	8,	8,	12,	41,	31,
MS	14593,15	,0165	,113E-03	2216994,	0,	,334E-06	0,	7,	8,	12,	41,	31,
MO	45083,92	,1512	,335E-03	4677969,	0,	,145E-05	0,	8,	8,	13,	41,	31,
MT	6381,99	,1393	,218E-02	694345,	0,	,899E-05	0,	8,	8,	12,	42,	30,
NE	14271,01	,1897	,133E-02	1485321,	0,	,572E-05	0,	8,	8,	12,	41,	31,
NV	5804,42	,0633	,109E-02	488738,	0,	,581E-05	0,	7,	9,	14,	41,	29,
NH	7353,07	,0246	,334E-03	737681,	0,	,149E-05	0,	8,	9,	13,	40,	31,
NJ	83728,33	,7824	,934E-03	7172164,	0,	,489E-05	0,	8,	9,	13,	40,	31,
NM	9148,84	,0812	,888E-03	1016000,	0,	,358E-05	0,	8,	8,	12,	42,	29,
NY	229614,05	,9668	,421E-03	18241266,	0,	,238E-05	0,	8,	9,	12,	38,	33,
NC	39967,02	,1564	,391E-03	5084430,	0,	,138E-05	0,	7,	8,	12,	40,	32,
ND	4781,53	,1301	,272E-02	617792,	0,	,944E-05	0,	8,	8,	12,	41,	31,
OH	106332,66	,2556	,240E-03	10656533,	0,	,108E-05	0,	8,	8,	13,	41,	31,
OK	23129,24	,4094	,177E-02	2559463,	0,	,717E-05	0,	7,	8,	13,	42,	30,
OR	19883,96	,0490	,246E-03	2091533,	0,	,105E-05	0,	8,	8,	13,	41,	31,
PA	116078,50	,4272	,368E-03	11797342,	0,	,162E-05	0,	8,	9,	13,	41,	30,
RI	9276,74	,1653	,178E-02	949723,	0,	,780E-05	0,	8,	9,	13,	40,	31,
SC	19642,80	,0491	,250E-03	2590210,	0,	,850E-06	0,	7,	8,	13,	42,	30,
SD	5323,12	,1408	,264E-02	666257,	0,	,947E-05	0,	8,	8,	12,	41,	31,
TN	30822,40	,0015	,494E-05	3924927,	0,	,174E-07	0,	7,	8,	12,	41,	31,
TX	103745,70	1,0233	,986E-03	11196852,	0,	,410E-05	0,	7,	8,	13,	41,	31,
UT	10603,18	,0916	,864E-03	1059273,	0,	,388E-05	0,	8,	8,	13,	43,	28,
VT	3798,95	,0003	,786E-05	444732,	0,	,301E-07	0,	8,	8,	11,	41,	32,
VA	48821,39	,2585	,530E-03	4652328,	0,	,249E-05	0,	7,	8,	13,	42,	30,
WA	35644,87	,2137	,599E-03	3410519,	0,	,281E-05	0,	8,	8,	13,	41,	31,
WV	14179,78	,0004	,293E-05	1744237,	0,	,107E-07	0,	7,	8,	12,	42,	31,
WI	41194,87	,1772	,430E-03	4417933,	0,	,180E-05	0,	8,	8,	13,	40,	31,
WY	3194,34	,0815	,255E-02	332416,	0,	,110E-04	0,	8,	9,	13,	42,	28,
AK	3887,56	,0238	,612E-03	273464,	0,	,390E-05	0,	8,	8,	13,	43,	28,
HI	10007,03	,0707	,707E-03	769913,	0,	,412E-05	0,	8,	8,	13,	41,	30,

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO STRG WINDS IN 2000 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

BASE LINE SEVERE WIND

	THE TOTAL MILL 1970$ AT RISK	THE TOTAL DAMAGE IN MILL 1970$	THE TOTAL PERCENT DAMAGE	TOTAL POPULATION	LIVES LOST	DEATH RATE	PERCENT OF DAMAGE BY TYPE NU	LI	MOD	HEA	SEV	COL
AL	65030.60	.0055	.847E-05	4166567.	0.	.593E-07	0.	7.	8.	13.	43.	30.
AZ	47834.87	.1018	.213E-03	2779419.	0.	.164E-05	0.	8.	8.	13.	43.	28.
AR	32350.04	.0020	.633E-05	2178930.	0.	.422E-07	0.	7.	8.	12.	43.	30.
CA	539809.08	1.9133	.354E-03	26027715.	1.	.330E-05	0.	8.	8.	13.	42.	29.
CO	56088.13	.9467	.169E-02	2868152.	0.	.148E-04	0.	8.	8.	13.	42.	28.
CT	82591.01	.9802	.119E-02	4049541.	0.	.109E-04	0.	8.	8.	13.	41.	30.
DE	14391.93	.0572	.397E-03	754715.	0.	.340E-05	0.	7.	8.	12.	41.	32.
DC	42386.32	.0048	.114E-04	1490054.	0.	.145E-06	0.	8.	8.	12.	41.	31.
FL	198751.11	.5672	.285E-03	11611945.	0.	.219E-05	0.	7.	8.	13.	41.	31.
GA	115963.14	.0430	.371E-04	6320544.	0.	.305E-06	0.	7.	8.	13.	43.	29.
ID	13516.47	.1461	.108E-02	790842.	0.	.828E-05	0.	8.	8.	13.	43.	28.
IL	286839.32	1.7080	.595E-03	13599815.	1.	.563E-05	0.	8.	8.	13.	41.	30.
IN	118326.58	.9597	.811E-03	6558977.	0.	.656E-05	0.	8.	8.	13.	42.	29.
IA	53442.88	.5306	.993E-03	3028474.	0.	.785E-05	0.	8.	8.	13.	42.	29.
KS	46951.71	.4241	.903E-03	2518298.	0.	.755E-05	0.	8.	8.	13.	42.	29.
KY	65823.03	.0395	.601E-04	4039791.	0.	.439E-06	0.	7.	8.	12.	42.	31.
LA	66338.59	.2453	.370E-03	3917818.	0.	.281E-05	0.	7.	8.	14.	43.	28.
ME	17015.43	.0199	.117E-03	1051446.	0.	.848E-06	0.	8.	8.	12.	42.	30.
MD	133335.87	.1418	.106E-03	5710884.	0.	.111E-05	0.	7.	8.	13.	41.	31.
MA	151343.19	1.9231	.127E-02	7478653.	1.	.115E-04	0.	8.	8.	13.	41.	29.
MI	206559.03	.1551	.751E-04	10890193.	0.	.638E-06	0.	8.	8.	12.	42.	30.
MN	91804.57	.8226	.896E-03	4808881.	0.	.767E-05	0.	8.	8.	13.	42.	29.
MS	32950.93	.0359	.109E-03	2362983.	0.	.680E-06	0.	7.	8.	13.	43.	29.
MO	101157.15	.3013	.298E-03	5397171.	0.	.250E-05	0.	8.	8.	13.	42.	29.
MT	12328.54	.2537	.206E-02	681093.	0.	.167E-04	0.	8.	8.	13.	43.	28.
NE	31162.48	.3797	.122E-02	1672613.	0.	.102E-04	0.	8.	8.	13.	42.	29.
NV	17712.11	.1846	.104E-02	844720.	0.	.980E-05	0.	8.	8.	14.	42.	28.
NH	18060.86	.0579	.321E-03	966640.	0.	.269E-05	0.	8.	8.	13.	42.	29.
NJ	199247.52	1.7561	.881E-03	9527490.	1.	.826E-05	0.	8.	8.	13.	42.	29.
NM	20198.13	.1607	.796E-03	1151862.	0.	.626E-05	0.	8.	8.	13.	44.	27.
NY	511336.71	1.9784	.387E-03	22557743.	1.	.393E-05	0.	8.	9.	13.	39.	31.
NC	102973.62	.3493	.339E-03	6534686.	0.	.240E-05	0.	7.	8.	12.	42.	30.
ND	8880.53	.2275	.256E-02	567986.	0.	.180E-04	0.	8.	8.	13.	42.	29.
OH	242519.33	.5910	.244E-03	12824512.	0.	.207E-05	0.	8.	8.	13.	42.	29.
OK	55817.31	.9729	.174E-02	3083001.	0.	.141E-04	0.	8.	8.	13.	43.	28.
OR	45150.66	.1045	.231E-03	2494110.	0.	.188E-05	0.	8.	8.	13.	42.	29.
PA	251988.12	.8999	.357E-03	13494101.	0.	.299E-05	0.	8.	8.	14.	42.	29.
RI	20374.98	.3460	.170E-02	1144544.	0.	.136E-04	0.	6.	8.	13.	41.	29.
SC	47765.77	.1072	.225E-03	3196826.	0.	.150E-05	0.	8.	8.	13.	43.	29.
SD	10370.55	.2586	.249E-02	652821.	0.	.178E-04	0.	8.	8.	13.	43.	29.
TN	79762.04	.0039	.483E-05	5041162.	0.	.342E-07	0.	7.	8.	13.	43.	30.
TX	260651.80	2.1248	.815E-03	14367119.	1.	.663E-05	0.	7.	8.	13.	42.	29.
UT	27243.39	.2249	.826E-03	1394154.	0.	.723E-05	0.	8.	8.	14.	44.	26.
VT	8626.66	.0007	.754E-05	515341.	0.	.566E-07	0.	8.	8.	12.	42.	30.
VA	132794.01	.5841	.440E-03	6465731.	0.	.405E-05	0.	8.	8.	13.	43.	28.
WA	78465.66	.4532	.578E-03	3993431.	0.	.509E-05	0.	8.	8.	13.	42.	29.
WV	29445.01	.0008	.279E-05	1734946.	0.	.212E-07	0.	8.	7.	13.	44.	29.
WI	89478.83	.3620	.405E-03	5097284.	0.	.318E-05	0.	8.	8.	13.	42.	29.
WY	6386.06	.1504	.236E-02	338436.	0.	.199E-04	0.	8.	8.	14.	43.	26.
AK	8563.78	.0494	.577E-03	322655.	0.	.686E-05	0.	8.	8.	13.	44.	27.
HI	26169.58	.1741	.665E-03	1112343.	0.	.702E-05	0.	8.	8.	13.	43.	28.

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO STRM SURGE IN 1970 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

BASE LINE STORM SURGE

	THE TOTAL MILL 1970$ AT RISK	THE TOTAL DAMAGE IN MILL 1970$	THE TOTAL PERCENT DAMAGE	TOTAL POPULATION	LIVES LOST	DEATH RATE	PERCENT OF DAMAGE BY TYPE NO	LI	MOD	HEA	SEV	COL
AL	2839,88	4,3230	,152	376690,	0,	,101E-03	0,	2,	46,	52,	0,	0,
CT	20883,01	9,6839	,464E-01	1883434,	1,	,451E-04	0,	15,	22,	62,	0,	0,
DE	5721,53	,5359	,937E-02	548104,	0,	,858E-05	0,	24,	35,	41,	0,	0,
FL	49618,89	195,2714	,394	5388415,	17,	,318E-03	0,	6,	16,	77,	0,	0,
GA	2450,49	4,3545	,178	281157,	0,	,136E-03	0,	2,	35,	59,	4,	0,
LA	21857,16	84,4820	,387	2424740,	7,	,306E-03	0,	1,	13,	86,	0,	0,
ME	4173,53	,5273	,126E-01	464883,	0,	,995E-05	0,	13,	77,	9,	0,	0,
MD	24735,25	4,0437	,163E-01	2247668,	0,	,158E-04	0,	11,	20,	69,	0,	0,
MA	33559,51	12,6350	,376E-01	2862093,	1,	,387E-04	0,	5,	30,	65,	0,	0,
MS	1892,82	13,1779	,696	239944,	1,	,482E-03	0,	1,	28,	70,	1,	0,
NH	1635,73	,0322	,197E-02	138951,	0,	,203E-05	0,	26,	70,	4,	0,	0,
NJ	48915,79	11,4063	,233E-01	4078262,	1,	,245E-04	0,	13,	27,	59,	0,	0,
NY	161699,95	50,0486	,310E-01	11345837,	4,	,387E-04	0,	17,	23,	60,	0,	0,
NC	3819,45	7,7233	,202	543966,	1,	,125E-03	0,	11,	16,	73,	0,	0,
RI	9276,74	7,0748	,763E-01	949723,	1,	,653E-04	0,	5,	15,	80,	0,	0,
SC	4457,83	6,9993	,157	530405,	1,	,116E-03	0,	3,	48,	49,	0,	0,
TX	29929,11	15,7246	,525E-01	2955290,	1,	,467E-04	0,	4,	11,	85,	0,	0,
VA	11267,31	13,5465	,120	1127685,	1,	,105E-03	0,	11,	60,	29,	0,	0,

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO STRM SURGE IN 2000 VALUED IN MILLIONS OF 1970 $ MGI= 0 0 0 0 0

BASE LINE STORM SURGE

	THE TOTAL MILL 1970$ AT RISK	THE TOTAL DAMAGE IN MILL 1970$	THE TOTAL PERCENT DAMAGE	TOTAL POPULATION	LIVES LOST	DEATH RATE	PERCENT OF DAMAGE BY TYPE NO	LI	MOD	HEA	SEV	CUL
AL	6674.11	9.5529	.143	436490.	1.	.192E-03	0.	3.	46.	51.	0.	0.
CT	49270.03	22.0018	.447E-01	2534940.	2.	.761E-04	0.	17.	24.	59.	0.	0.
DE	14391.93	1.3191	.917E-02	754715.	0.	.153E-04	0.	25.	36.	39.	0.	0.
FL	164988.18	647.4347	.392	9473966.	57.	.599E-03	0.	7.	18.	75.	0.	0.
GA	5552.06	9.8083	.177	325899.	1.	.264E-03	0.	2.	35.	59.	4.	0.
LA	48183.87	171.0262	.355	2657979.	15.	.564E-03	0.	1.	14.	85.	0.	0.
ME	9059.75	1.1115	.123E-01	527690.	0.	.185E-04	0.	16.	76.	9.	0.	0.
MD	55551.93	9.3657	.169E-01	2740592.	1.	.300E-04	0.	12.	22.	67.	0.	0.
MA	81749.48	31.1464	.381E-01	3878709.	3.	.704E-04	0.	5.	31.	64.	0.	0.
MS	4321.73	28.4901	.659	273120.	2.	.915E-03	0.	1.	27.	71.	1.	0.
NH	3957.88	.0758	.192E-02	186895.	0.	.356E-05	0.	30.	66.	4.	0.	0.
NJ	113806.92	24.9549	.219E-01	5251014.	2.	.417E-04	0.	15.	29.	57.	0.	0.
NY	357739.66	106.2247	.297E-01	14303526.	9.	.651E-04	0.	19.	25.	56.	0.	0.
NC	9165.85	17.1368	.187	642763.	2.	.234E-03	0.	11.	18.	71.	0.	0.
RI	20374.98	14.7626	.725E-01	1144544.	1.	.113E-03	0.	5.	17.	78.	0.	0.
SC	10067.08	15.1261	.150	622565.	1.	.213E-03	0.	3.	48.	49.	0.	0.
TX	81132.07	38.4235	.474E-01	4182565.	3.	.806E-04	0.	4.	13.	83.	0.	0.
VA	25984.52	29.9146	.115	1390836.	3.	.189E-03	0.	12.	60.	28.	0.	0.

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO TSUNAMI IN 1970 VALUED IN MILLIONS OF 1970 $ MGI= 0 0 0 0 0

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BASE LINE RUN FOR TSUNAMI

	THE TOTAL MILL 1970$ AT RISK	THE TOTAL DAMAGE IN MILL 1970$	THE TOTAL PERCENT DAMAGE	TOTAL POPULATION	LIVES LOST	DEATH RATE	PERCENT OF DAMAGE BY TYPE NO	LI	MOD	HEA	SEV	COL
CA	176290.68	3.4732	.197E-02	14585277.	8.	.531E-04	0.	0.	23.	64.	6.	7.
OR	3440.00	.0501	.146E-02	428927.	0.	.261E-04	0.	0.	25.	74.	0.	0.
WA	24487.56	.7385	.302E-02	2198537.	2.	.749E-04	0.	0.	83.	17.	0.	0.
AK	3101.89	.3620	.117E-01	218197.	1.	.370E-03	0.	0.	3.	30.	14.	54.
HI	10007.50	4.1454	.414E-01	769913.	9.	.120E-02	0.	0.	4.	36.	13.	46.

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO TSUNAMI IN 2000 VALUED IN MILLIONS OF 1970 $ MGI= 0 0 0 0 0

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BASE LINE RUN FOR TSUNAMI

	THE TOTAL MILL 1970$ AT RISK	THE TOTAL DAMAGE IN MILL 1970$	THE TOTAL PERCENT DAMAGE	TOTAL POPULATION	LIVES LOST	DEATH RATE	PERCENT OF DAMAGE BY TYPE NO	LI	MOD	HEA	SEV	COL
CA	413174.79	8.8488	.214E-02	19079631.	20.	.103E-03	0.	0.	20.	57.	5.	9.
OR	7004.58	.1015	.145E-02	455966.	0.	.496E-04	0.	0.	24.	72.	0.	0.
WA	55669.37	1.8816	.338E-02	2701395.	4.	.155E-03	0.	0.	74.	15.	0.	0.
AK	6833.10	1.3950	.204E-01	257447.	3.	.121E-02	0.	0.	1.	18.	10.	45.
HI	26170.36	7.5288	.288E-01	1112343.	17.	.151E-02	0.	0.	4.	35.	13.	44.

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO EARTHQUAKE IN 1970 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

BASE LINE EARTHQUAKE

	THE TOTAL MILL 1970$ AT RISK	THE TOTAL DAMAGE IN MILL 1970$	THE TOTAL PERCENT DAMAGE	TOTAL POPULATION	LIVES LOST	DEATH RATE	PERCENT OF DAMAGE BY TYPE NO	LI	MOD	HEA	SEV	COL
AL	5155.53	.0227	.441E-03	719282.	0.	.536E-05	0.	55.	45.	0.	0.	0.
AZ	16857.38	.7435	.441E-02	1772658.	1.	.390E-04	0.	25.	50.	26.	0.	0.
AR	4184.27	3.2508	.777E-01	655667.	3.	.433E-03	0.	25.	50.	24.	0.	0.
CA	227787.29	439.6156	.193	19935761.	154.	.774E-03	0.	30.	30.	40.	0.	0.
CO	22478.10	20.2387	.900E-01	2182386.	10.	.479E-03	0.	15.	36.	49.	1.	0.
CT	34984.08	.7674	.219E-02	3032217.	1.	.214E-04	0.	54.	46.	0.	0.	0.
DE	5721.53	.0694	.121E-02	548104.	0.	.178E-04	0.	67.	33.	0.	0.	0.
DC	12617.67	.0573	.454E-03	756510.	0.	.920E-05	0.	93.	7.	0.	0.	0.
FL	48006.71	.9489	.198E-02	5193583.	1.	.160E-04	0.	28.	52.	20.	0.	0.
GA	14625.85	.4528	.310E-02	1925636.	1.	.285E-04	0.	32.	49.	19.	0.	0.
ID	5792.37	1.5354	.265E-01	657563.	1.	.212E-03	0.	17.	40.	43.	0.	0.
IL	30920.55	.9548	.309E-02	2926304.	1.	.318E-04	0.	28.	37.	35.	0.	0.
IN	11223.70	.1347	.120E-02	1221265.	0.	.155E-04	0.	59.	37.	3.	0.	0.
IA	6355.07	.0331	.521E-03	683683.	0.	.898E-05	0.	66.	34.	0.	0.	0.
KS	12963.83	.1662	.128E-02	1377462.	0.	.208E-04	0.	36.	56.	8.	0.	0.
KY	5764.57	1.3022	.226E-01	841404.	1.	.147E-03	0.	21.	41.	37.	0.	0.
LA	29489.11	1.8901	.641E-02	3517946.	2.	.496E-04	0.	21.	41.	38.	0.	0.
ME	6972.62	.0323	.463E-03	823851.	0.	.747E-05	0.	98.	2.	0.	0.	0.
MD	30486.01	.1389	.455E-03	2265774.	0.	.952E-05	0.	77.	22.	1.	0.	0.
MA	50020.91	1.6877	.337E-02	4260448.	1.	.316E-04	0.	34.	53.	13.	0.	0.
MI	67761.31	.9454	.140E-02	6464101.	1.	.150E-04	0.	53.	35.	12.	0.	0.
MN	4241.89	.0019	.445E-04	599727.	0.	.123E-05	0.	90.	10.	0.	0.	0.
MS	11525.36	.4190	.364E-02	1686699.	1.	.335E-04	0.	43.	38.	19.	0.	0.
MO	22739.31	15.2595	.671E-01	2214259.	9.	.416E-03	0.	18.	33.	48.	1.	0.
MT	5766.38	1.4403	.250E-01	627717.	1.	.222E-03	0.	15.	42.	42.	0.	0.
NE	14271.01	.1660	.116E-02	1485321.	0.	.219E-04	0.	40.	47.	12.	0.	0.
NV	5793.06	2.6977	.466E-01	487790.	2.	.406E-03	0.	36.	57.	7.	0.	0.
NH	5795.51	.2091	.361E-02	565163.	0.	.440E-04	0.	61.	39.	0.	0.	0.
NJ	83728.33	3.4298	.410E-02	7172164.	3.	.410E-04	0.	41.	59.	0.	0.	0.
NM	8028.13	1.1620	.145E-01	887902.	1.	.122E-03	0.	23.	47.	30.	0.	0.
NY	209387.24	20.2367	.966E-02	16020800.	12.	.734E-04	0.	59.	41.	0.	0.	0.
NC	24632.32	.0781	.317E-03	3256881.	0.	.509E-05	0.	88.	12.	0.	0.	0.
ND	3224.53	.0083	.256E-03	401228.	0.	.550E-05	0.	36.	45.	20.	0.	0.
OH	88663.07	1.0400	.117E-02	8874684.	1.	.142E-04	0.	54.	38.	8.	0.	0.
OK	22307.83	.5157	.231E-02	2445099.	1.	.231E-04	0.	35.	57.	9.	0.	0.
OR	17447.94	1.7062	.978E-02	1807847.	2.	.894E-04	0.	25.	50.	26.	0.	0.
PA	66824.41	.3810	.570E-03	6500033.	0.	.732E-05	0.	67.	22.	11.	0.	0.
RI	8439.58	.0684	.811E-03	864017.	0.	.111E-04	0.	64.	36.	0.	0.	0.
SC	19423.46	1.9364	.997E-02	2556543.	2.	.622E-04	0.	22.	44.	34.	0.	0.
SD	5091.87	.0757	.149E-02	637127.	0.	.228E-04	0.	29.	48.	23.	0.	0.
TN	18332.03	15.1440	.826E-01	2398162.	7.	.308E-03	0.	23.	52.	25.	0.	0.
TX	87076.33	.7542	.866E-03	9075057.	1.	.110E-04	0.	36.	44.	20.	0.	0.
UT	10603.18	12.2015	.115	1059273.	7.	.637E-03	0.	16.	41.	44.	0.	0.
VT	451.42	.0013	.281E-03	55009.	0.	.638E-05	0.	100.	0.	0.	0.	0.
VA	46047.22	.4261	.925E-03	4282881.	1.	.159E-04	0.	54.	41.	4.	0.	0.
WA	34838.53	96.8609	.278	3317835.	40.	.121E-02	0.	16.	41.	43.	0.	0.
WV	9624.81	.0678	.704E-03	1195485.	0.	.930E-05	0.	41.	41.	18.	0.	0.
WI	2142.19	.0203	.949E-03	257938.	0.	.129E-04	0.	59.	41.	0.	0.	0.
WY	2826.69	.0462	.164E-02	294824.	0.	.292E-04	0.	29.	45.	27.	0.	0.
AK	3849.70	3.6247	.942E-01	270801.	3.	.992E-03	0.	29.	55.	16.	0.	0.
HI	1001.77	.2570	.257E-01	109624.	0.	.218E-03	0.	18.	47.	35.	0.	0.

THE VALUES AT RISK AND ANNUAL DAMAGES DUE TO EARTHQUAKE IN 2000 VALUED IN MILLIONS OF 1970 $ MGT= 0 0 0 0 0

BASE LINE EARTHQUAKE

	THE TOTAL MILL 1970$ AT RISK	THE TOTAL DAMAGE IN MILL 1970$	THE TOTAL PERCENT DAMAGE	TOTAL POPULATION	LIVES LOST	DEATH RATE	PERCENT OF DAMAGE BY TYPE NO	LI	MOD	HEA	SEV	COL
AL	11951.97	.0446	.373E-03	824154.	0.	.727E-05	0.	62.	38.	0.	0.	0.
AZ	47834.87	1.5642	.327E-02	2779419.	1.	.412E-04	0.	28.	52.	20.	0.	0.
AR	9085.24	6.3216	.696E-01	675802.	4.	.644E-03	0.	28.	52.	19.	0.	0.
CA	539352.31	748.7506	.139	25997681.	217.	.834E-03	0.	39.	36.	31.	0.	0.
CO	55662.12	44.5304	.800E-01	2843493.	18.	.627E-03	0.	17.	39.	44.	0.	0.
CT	82591.01	1.4547	.176E-02	4049541.	1.	.243E-04	0.	64.	36.	0.	0.	0.
DE	14391.93	.1439	.100E-02	754715.	0.	.211E-04	0.	73.	27.	0.	0.	0.
DC	42386.32	.1454	.343E-03	1490054.	0.	.899E-05	0.	97.	3.	0.	0.	0.
FL	157362.40	2.2499	.143E-02	8911756.	2.	.170E-04	0.	32.	54.	14.	0.	0.
GA	35646.32	.8667	.243E-02	2335578.	1.	.364E-04	0.	37.	49.	14.	0.	0.
ID	12667.49	3.0374	.240E-01	738737.	2.	.290E-03	0.	19.	42.	39.	0.	0.
IL	67557.65	1.6907	.250E-02	3421299.	1.	.392E-04	0.	31.	38.	32.	0.	0.
IN	27727.73	.2545	.918E-03	1560667.	0.	.184E-04	0.	64.	33.	2.	0.	0.
IA	12699.12	.0503	.396E-03	714574.	0.	.107E-04	0.	75.	25.	0.	0.	0.
KS	26540.58	.2654	.100E-02	1465267.	0.	.252E-04	0.	44.	50.	6.	0.	0.
KY	13307.53	2.5755	.194E-01	923009.	2.	.209E-03	0.	25.	43.	33.	0.	0.
LA	64741.43	3.8500	.595E-02	3792799.	3.	.722E-04	0.	23.	43.	35.	0.	0.
ME	14525.18	.0555	.382E-03	885332.	0.	.966E-05	0.	99.	1.	0.	0.	0.
MD	92112.87	.3196	.347E-03	3733742.	0.	.102E-04	0.	83.	16.	0.	0.	0.
MA	121580.23	3.3211	.273E-02	5759556.	2.	.367E-04	0.	40.	51.	9.	0.	0.
MI	152899.33	1.7329	.113E-02	7899178.	1.	.183E-04	0.	60.	29.	11.	0.	0.
MN	8930.72	.0032	.354E-04	640563.	0.	.159E-05	0.	94.	6.	0.	0.	0.
MS	26371.92	.7602	.288E-02	1824468.	1.	.445E-04	0.	46.	36.	18.	0.	0.
MO	47922.75	28.1788	.588E-01	2466507.	14.	.554E-03	0.	20.	35.	45.	1.	0.
MT	11212.71	2.2341	.199E-01	620591.	2.	.286E-03	0.	19.	44.	37.	0.	0.
NE	31162.48	.2616	.840E-03	1672613.	0.	.253E-04	0.	48.	44.	8.	0.	0.
NV	17685.38	7.0749	.400E-01	843553.	4.	.461E-03	0.	39.	57.	4.	0.	0.
NH	14488.20	.4201	.290E-02	758272.	0.	.521E-04	0.	70.	30.	0.	0.	0.
NJ	199247.52	6.5226	.327E-02	9527490.	4.	.470E-04	0.	49.	51.	0.	0.	0.
NM	17771.81	2.3050	.130E-01	1011538.	2.	.166E-03	0.	25.	49.	26.	0.	0.
NY	467536.94	36.1238	.773E-02	20040170.	17.	.850E-04	0.	68.	32.	0.	0.	0.
NC	61612.73	.1644	.267E-03	4033334.	0.	.669E-05	0.	93.	7.	0.	0.	0.
ND	5929.93	.0103	.174E-03	367353.	0.	.654E-05	0.	44.	43.	13.	0.	0.
OH	203190.09	1.9543	.962E-03	10730083.	2.	.176E-04	0.	59.	36.	6.	0.	0.
OK	54045.74	1.1601	.215E-02	2962159.	1.	.321E-04	0.	40.	56.	4.	0.	0.
OR	40099.28	3.2410	.808E-02	2187728.	2.	.112E-03	0.	29.	49.	22.	0.	0.
PA	149484.02	.7314	.489E-03	7815333.	1.	.928E-05	0.	67.	24.	9.	0.	0.
RI	18536.28	.1241	.669E-03	1041257.	0.	.134E-04	0.	69.	31.	0.	0.	0.
SC	47245.60	3.8007	.804E-02	3157155.	2.	.786E-04	0.	24.	46.	30.	0.	0.
SD	9944.57	.1079	.109E-02	626023.	0.	.278E-04	0.	36.	48.	16.	0.	0.
TN	45713.63	33.6391	.736E-01	2966145.	13.	.425E-03	0.	26.	55.	19.	0.	0.
TX	224019.18	1.4294	.638E-03	12018890.	1.	.124E-04	0.	42.	41.	17.	0.	0.
UT	27243.39	27.2900	.100	1394154.	12.	.830E-03	0.	18.	44.	38.	0.	0.
VT	1010.55	.0025	.243E-03	59979.	0.	.901E-05	0.	100.	0.	0.	0.	0.
VA	126062.28	.8425	.668E-03	6032150.	1.	.177E-04	0.	62.	35.	3.	0.	0.
WA	76979.18	187.7317	.244	3904717.	62.	.158E-02	0.	19.	44.	38.	0.	0.
WV	20369.73	.1122	.551E-03	1211543.	0.	.126E-04	0.	47.	41.	12.	0.	0.
WI	4678.39	.0370	.790E-03	298828.	0.	.163E-04	0.	67.	33.	0.	0.	0.
WY	5676.80	.0768	.135E-02	301955.	0.	.385E-04	0.	33.	46.	21.	0.	0.
AK	8480.39	7.1353	.841E-01	319513.	4.	.132E-02	0.	32.	56.	12.	0.	0.
HI	1740.26	.3439	.198E-01	101445.	0.	.269E-03	0.	23.	52.	25.	0.	0.

Appendix J

THE COST AND SAVINGS FACTORS FOR BUILDING CODE MITIGATIONS

The following analysis of the costs of building codes has been extracted from a report entitled "Capital Investment Program for the Mitigation of Risks from Natural Hazards," prepared by Larry T. Lee and Ronald T. Eguchi of the J.H. Wiggins Company for the U.S. Naval Facilities Engineering Command. The cost factors used in establishing the cost-feasible mitigations in Chapter Nine were taken from the estimates presented here.

Earthquake Mitigation Cost Data

Cost estimates are provided in Figures J-1 and J-2 for the following earthquake mitigations:

- modifying or designing structural and non-structural systems* to UBC Level 1
- modifying or designing structural and non-structural systems to UBC Level 2
- modifying or designing structural and non-structural systems to UBC Level 3
- modifying or designing structural and non-structural systems to UBC Level S
- modifying or designing non-structural system to UBC Level 1
- modifying or designing non-structural system to UBC Level 2
- modifying or designing non-structural system to UBC Level 3
- modifying or designing non-structural system to UBC Level S

Figure J-1 provides estimates for proposed existing high-rise structures while Figure J-2 gives estimates for proposed low-rise structures. These estimates represent the percent increase over the total original costs. For high-rise structures, estimates are provided for reinforced concrete structures (frame + non-structural) and steel structures (frame + non-structural). For low-rise structures, costs are given for one-, two- or three-story brick or concrete block buildings (frame + non-structural) and one- and two-story wood-frame buildings (frame + non-structural). The source for the high-rise estimates was Leslie, [1972]; the source for the low-rise estimates was the SEAOC Proceedings [1970].

Since the cost of modifying an existing structure to the foregoing levels is considerably higher than that for a proposed structure, the percent increase is multiplied by a factor of 8 to obtain cost factors for existing structures. Therefore, all cost curves in Figures J-1 and J-2 are proposed buildings.

* Non-structural systems are those elements of a building that are not integral to its construction, such as the lighting, fixtures, internal walls, etc.

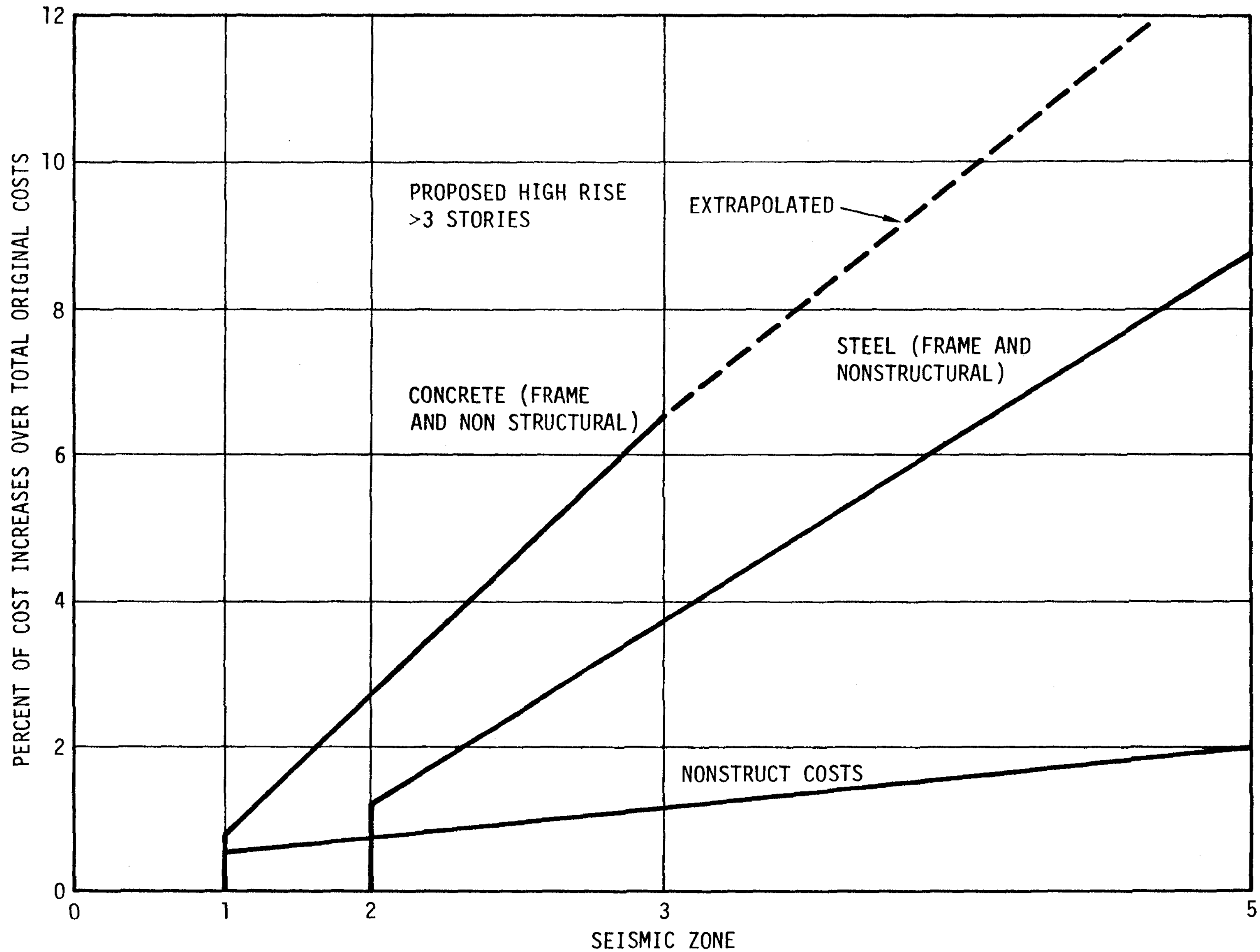


Figure J-1. Earthquake Cost Data - High Rise [Leslie, 1972]

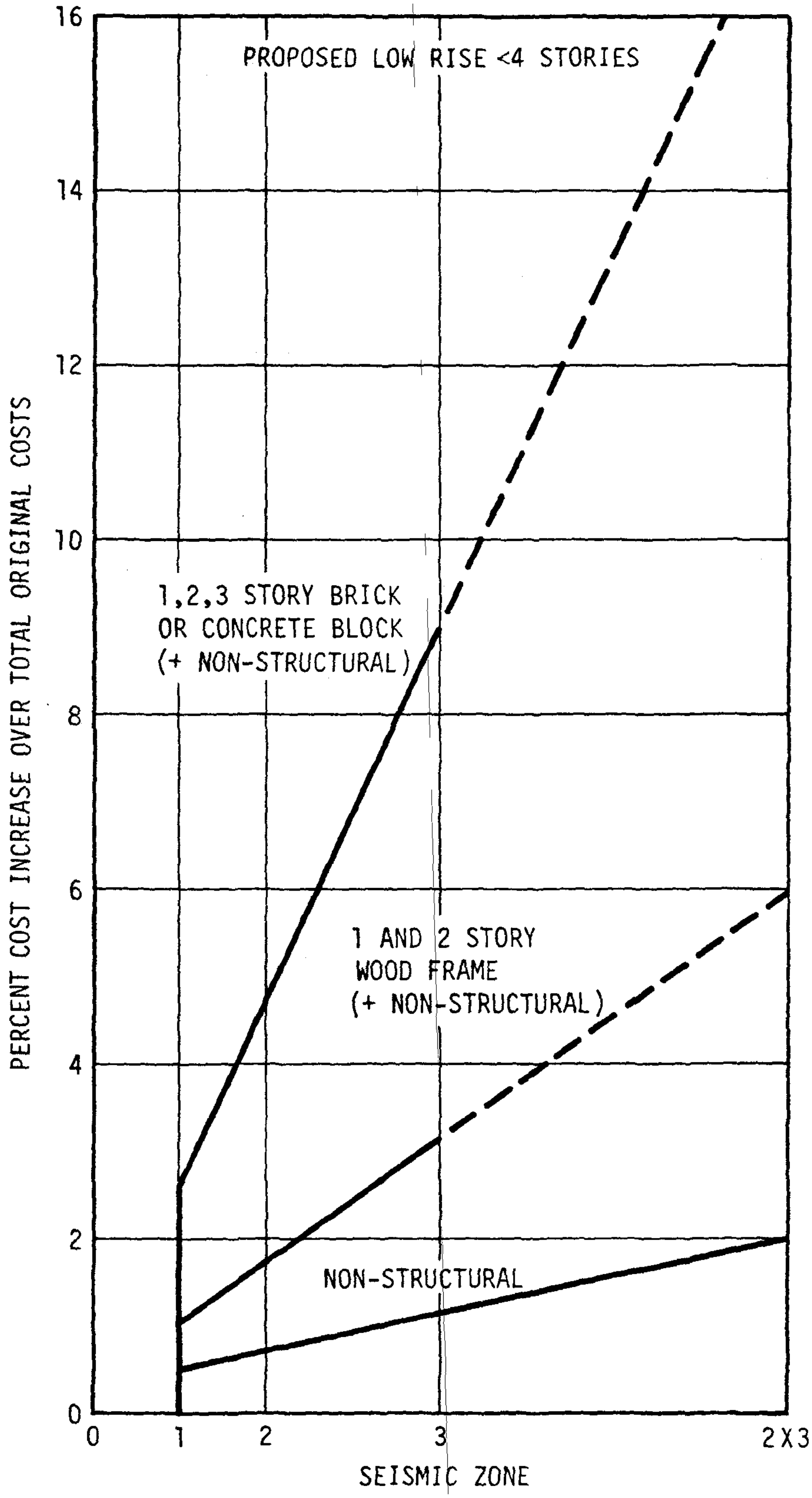


Figure J-2. Earthquake Cost Data - Low Rise (SEAOC, 1970]

Wind Mitigation Cost Data

Cost estimates are provided in Figures J-4 and J-5 for designing or modifying the following structural classficiations to the respective design levels:

STRUCTURAL CLASSIFICATION	STRUCTURAL DESIGN LEVEL
One- to Three-Story Residential Wood Frame	0.75, 1.0, 1.5, 3.0 UBC
One- to Three-Story Residential Concrete or Masonry	0.75, 1.0, 1.5, 3.0 UBC
One- to Three-Story Commercial Wood Frame	0.75 UBC
One- to Three-Story Commercial Concrete or Masonry	0.75 UBC
One- to Three-Story Commercial Metal (non-steel)	0.75 UBC
Four or More Stories, Concrete or Masonry	0.75 UBC
Four or More Stories, Concrete Shear Wall	0.75 UBC
Steel Frame, regardless of height	0.75 UBC
Mobile Home	UBC

The cost estimates were derived from those presented for earthquake (Figures J-1 and J-2) using the following relationship (Figure J-3):

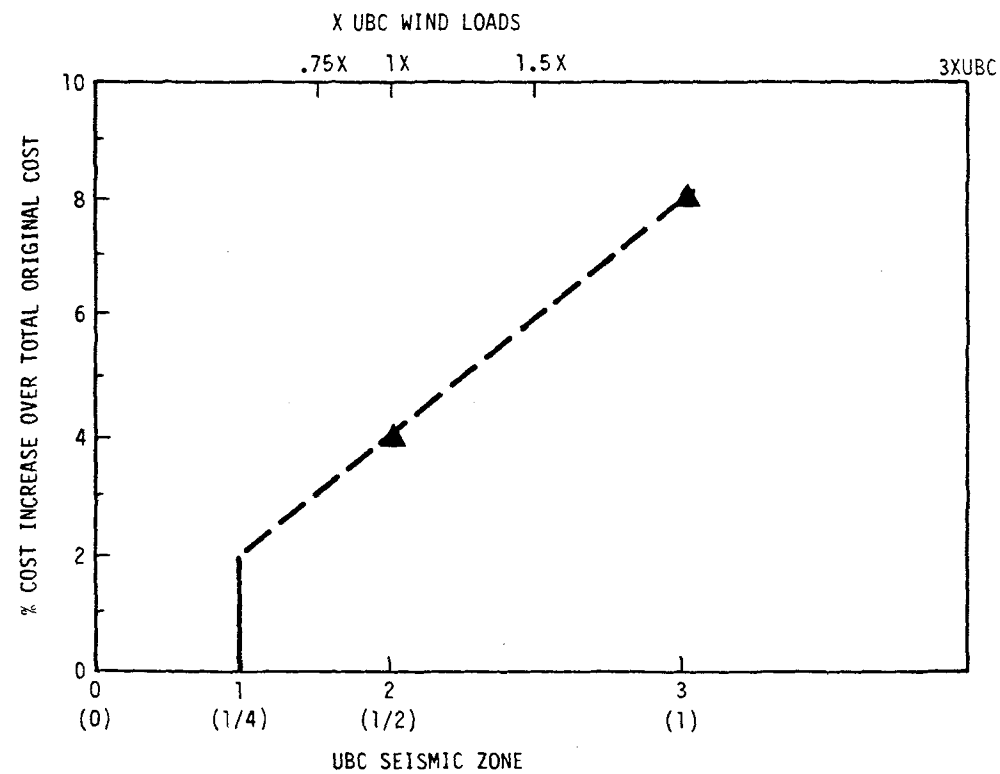


Figure **J**-3. The Relationship Between Cost Factors for Wind Loads and Seismic Zones of the Uniform Building Code. (UBC)

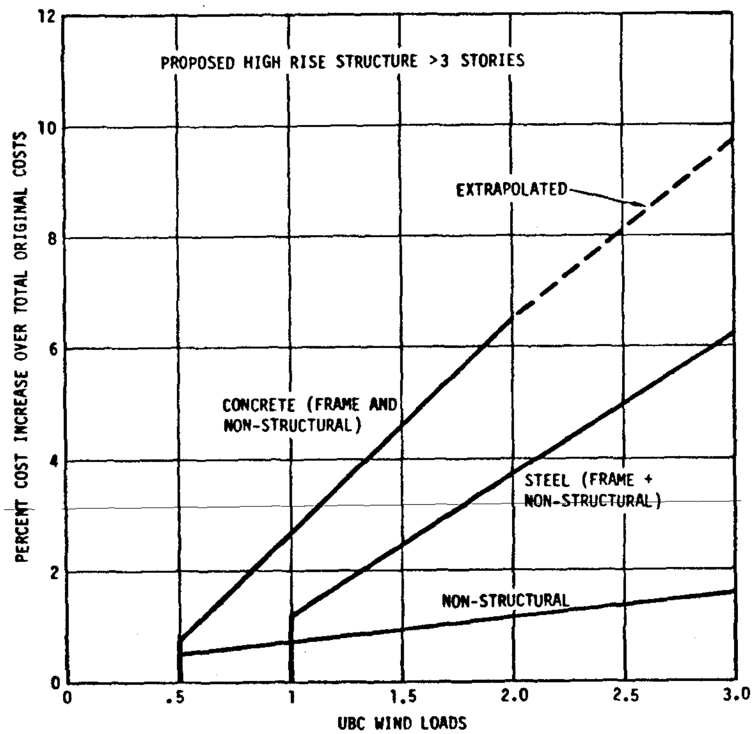


Figure J-4. Wind Cost Data - High Rise

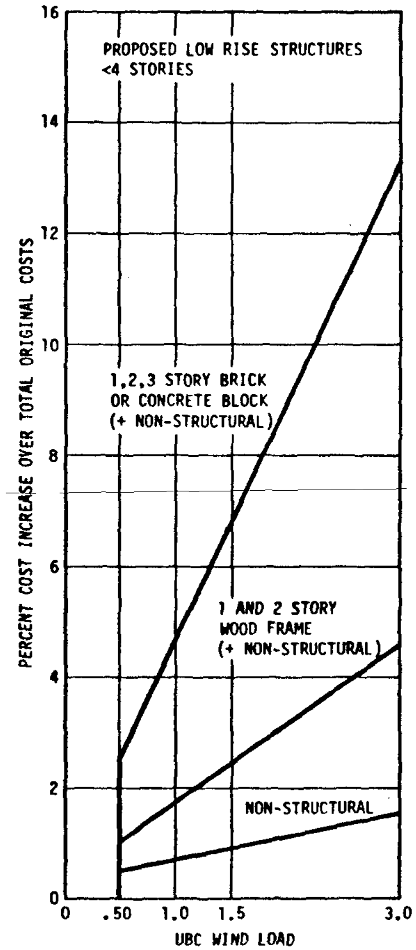


Figure J-5. Wind Cost Data - Low Rise

This figure corresponds to Figure J-1. It represents the percent cost increase in designing a one-, two- or three-story brick or concrete block building to the various design levels. The data points (represented by ▲) were taken from the SEAOC Proceedings [1970]. The data point for seismic Zone 2 cost was developed under the assumption that for areas located in Zones 0, 1, and 2, the percent increase over the original cost is 4 percent (assuming that earthquake regulations are not currently being enforced). The point for Seismic Zone 3 cost was developed under the assumption that for areas which do not presently enforce the UBC design for hurricane, cyclone, tornado, abnormally high winds, or earthquake, the percent increase over the original cost to meet Zone 3 requirements would be 8 percent. If the area does enforce the UBC design requirements for wind, then the increase to meet Zone 3 requirements is only 4 percent. Therefore, using the previous information, one can construct an upper abscissa scale (Figure J-5) that would correspond to UBC wind loads. Since a structure currently designed for UBC level wind resistance requires a 4 percent increase to meet Zone 3 requirements, one can correspond the UBC design wind loads to seismic Zone 2. The other UBC wind loads (i.e., 0.75, 1.5 and 3.0) were obtained by scaling the values on the upper abscissa. This relationship between wind load and seismic zone was used to determine the wind cost factors from the earthquake cost factor.

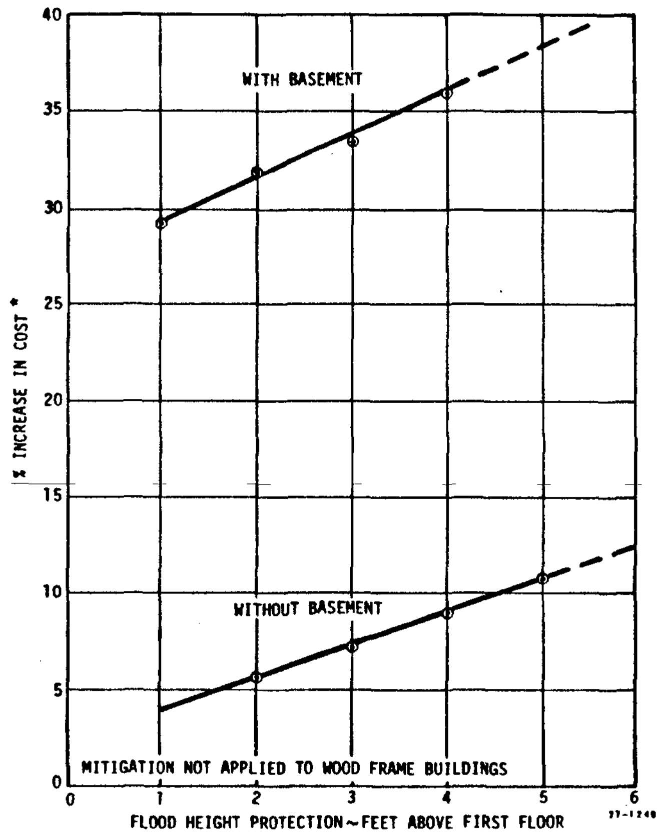
As with earthquake, the percent increase for a proposed building is multiplied by 8 to get the cost (as a function of repalcement value) of modifying an existing building.

The cost of anchoring a mobile structure was found to be approximatley $500 per unit from a telephone survey of several mobile home dealers.

The cost to strengthen windows for wind loading was found to be $0.62 per square foot from <u>Building Construction Cost Data</u> [1972].

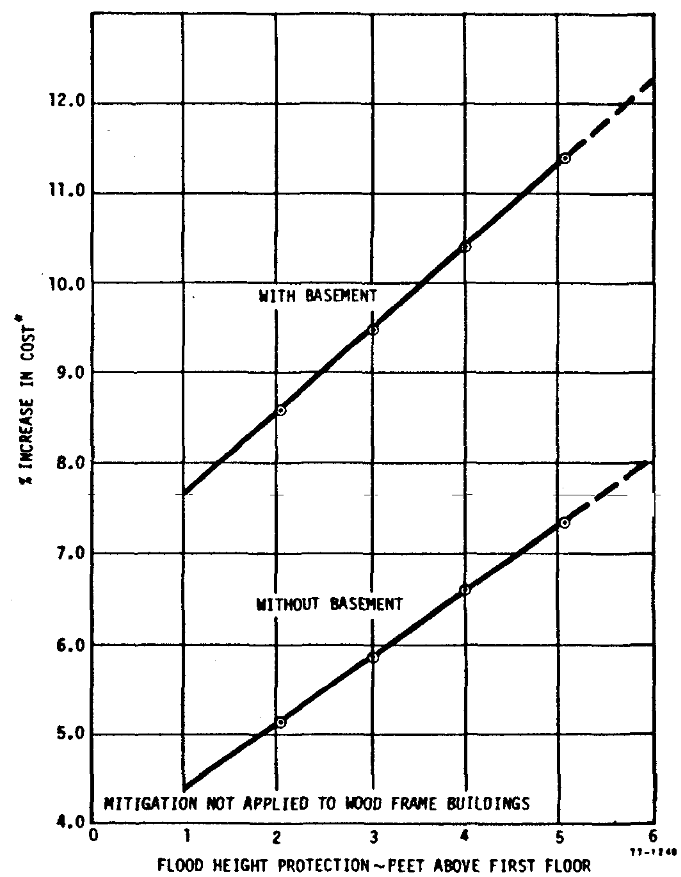
Flood Mitigation Cost Data

The cost data incorporated into this methodology for flood mitigations are summarized in Figures J-6 through J-8. These figures are a very rough approximation of data provided in W.C. Carson [1975], F.I.A. [1976], and "Costs of Placing Fill in Flood Plains", [1975], using an assumed baseline construction cost of $25/sq. ft.



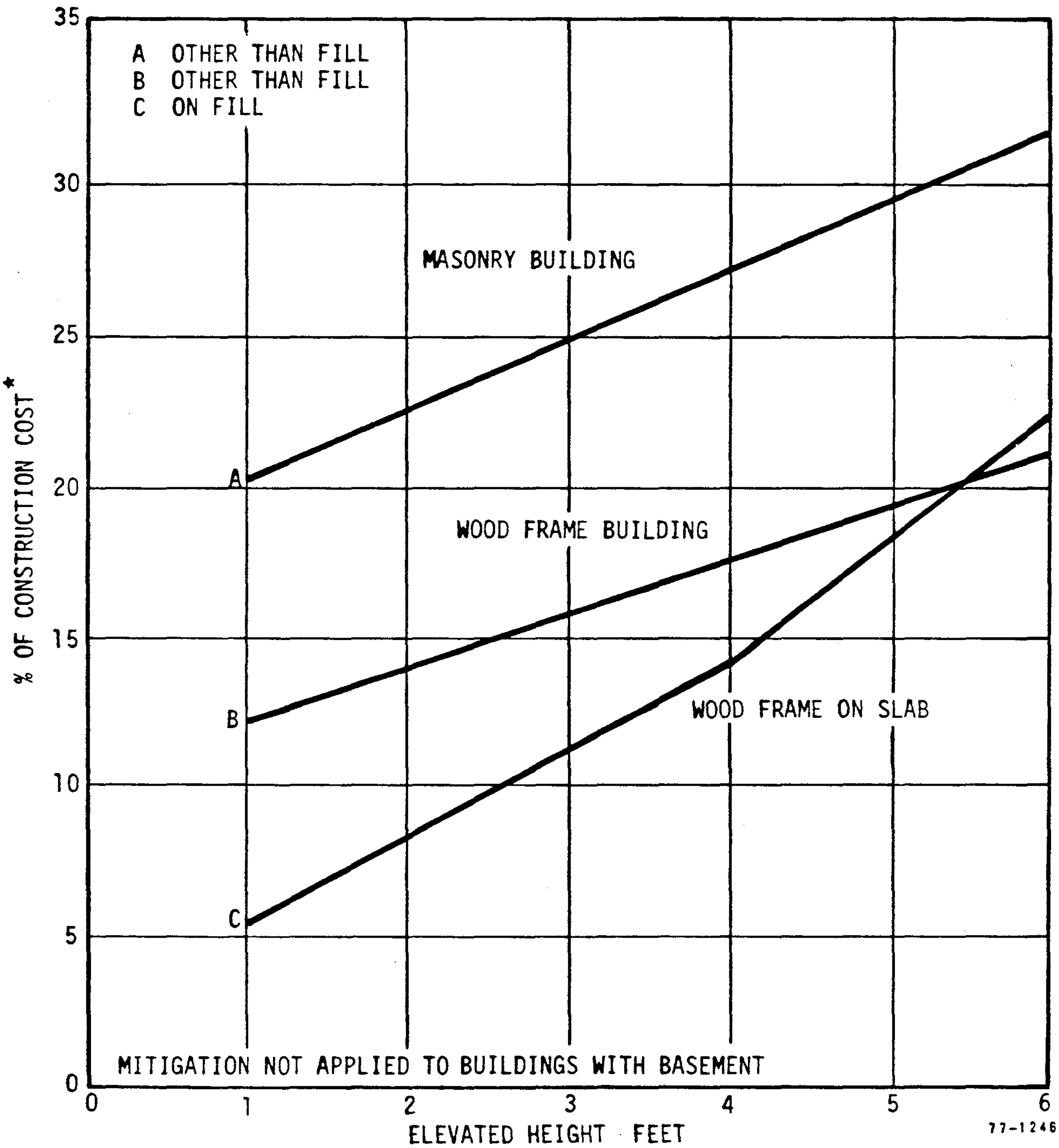
*Assuming a cost of $25/sq. ft. and 1500 sq. ft. building

Figure J-6. Floodproofing to Exclude Water - Residential [W.D. Carson, 1975]



*Assuming a cost of $25/sq. ft. for a 3700 sq. ft. building

Figure J-7. Floodproofing to Exclude Water - Commercial [W.D. Carson, 1975]



*Assuming a cost of $25/sq. ft. and 1500 sq. ft. building

Figure J-8. Elevating Building [F.I.A., 1976; H.E.C., 1975]

The Savings Rates of Building Code Mitigations

The savings rates used in Chapter Nine for the estimation of the cost-saving breakeven damage rates were derived from the sources in this appendix. Two methods were used to make these estimates. The first was a comparison of the annual losses simulated with the mitigation in effect for all exposed structures, with annual losses computed to occur otherwise. This procedure was followed for the savings rates due to storm surge flooding protection and for earthquake building codes. The second method was a survey of experts in the assessment of building strengths to establish a consensus mitigation savings rate. Employment of this method resulted in the estimates of building code savings for wind hazards.

Tables J-9 and J-10 provide the state percentage savings and the mean and standard deviation of these state averages for storm surge and earthquake protection. Also noted is the average savings of the national losses. Table J-3 is taken from Hart, [1976], and furnishes the results of a survey of nine experts in wind strength in buildings. (Details of this survey are available in Hart, 1976.)

STATE	4 FT. PROTECTION	2 FT. PROTECTION
AL	98.22	87.48
CT	98.85	94.79
DE	99.75	98.36
FL	98.26	89.05
GA	89.03	83.12
LA	97.26	90.49
ME	99.99	99.53
MD	99.53	96.01
MA	96.69	91.91
MS	97.69	94.44
NH	100.00	99.74
NJ	99.63	97.89
NY	98.94	95.67
NC	97.94	88.21
RI	95.49	88.22
SC	99.02	86.42
TX	90.52	81.12
VA	99.80	95.22
MEAN	97.65	92.09
STANDARD DEVIATION	(3.13)	(5.60)
NATIONAL AVERAGE	98.86	90.21

Table J-9. Potential % Savings Attributable to Building Protection from Storm Surge.

STATE	UBC ZONE S	UBC ZONE 3	STATE	UBC ZONE S	UBC ZONE 3
AL	64.13	15.02	NV	65.75	4.17
AZ	69.38	12.06	NH	69.27	33.66
AR	71.02	18.14	NJ	71.78	32.60
CA	38.78	NA*	NM	68.90	11.79
CO	68.51	12.79	NY	68.57	31.52
CT	66.50	23.85	NC	57.54	14.66
DE	62.75	16.82	ND	69.90	22.33
DC	57.02	16.44	OH	68.75	27.56
FL	68.31	9.61	OK	68.39	14.02
GA	70.78	18.65	OR	71.44	21.93
ID	70.72	18.22	PA	67.56	25.94
IL	74.56	32.80	RI	67.77	31.43
IN	67.11	28.29	SC	69.37	12.51
IA	66.40	28.73	SD	73.03	28.45
KS	72.27	30.67	TN	70.02	12.00
KY	73.21	24.26	TX	66.57	12.97
LA	67.78	10.94	UT	70.34	15.49
ME	62.34	26.67	VT	64.00	28.00
MD	57.63	11.76	VA	64.53	16.18
MA	74.64	36.07	WA	71.24	16.86
MI	67.08	24.07	WV	70.14	26.38
MN	62.50	25.00	WI	70.27	34.05
MS	66.27	13.59	WY	71.88	23.18
MO	73.54	28.56	AK	67.47	7.08
MT	75.33	29.59	HI	72.35	18.35
ME	72.55	33.33			
			AVERAGE	68.37	21.66
			STANDARD DEVIATION	4.20	8.46
			NATIONAL AVERAGE	66.95	18.42

*California is assumed to be at UBC Zone 3 already.

Table J-10. Savings Potential of Various Building Code Provision for Earthquake in % of Baseline Loss.

$$R_1 = \frac{\text{Damage to 1.5 times UBC Design}}{\text{Damage to UBC design}}$$

$$R_2 = \frac{\text{Damage to 3.0 times UBC Design}}{\text{Damage to UBC Design}}$$

Ratio	Mean	Coeff. Variation
R_1 (structure)	0.63	0.64
R_1 (windows)	0.41	0.34
R_2 (structure	0.41	0.79
R_2 (windows)	0.41	0.59

Actual Data from Questionnaire:

R_1 (structure) = [0.80,1.00,0.40,0.50,0.90,0.91,0.30,0.20,0.70]

R_1 (windows) = [0.85,1.00,0.50,0.57,0.50,0.83,0.35,0.40,0.80]

R_2 (structure) = [0.65,1.00,0.00,0.14,0.80,0.50,0.20,0.10,0.30]

R_2 (windows) = [0.75,1.00,0.10,0.20,0.20,0.45,0.30,0.20,0.50]

Table J-11. Effect of Uniform Building Code Design Level

Source: Hart, G, Air Related Hazards