Chapter 1. Introduction to the Earthquake Loss Estimation Methodology

The earthquake loss estimation provides local, state and regional officials with a state-of-the-art decision support tool for estimating future losses from scenario earthquakes. This forecasting capability will enable users to anticipate the consequences of future earthquakes and to develop plans and strategies for reducing risk. The GIS-based software can be utilized at multiple levels of resolution to accommodate not only budget constraints, but also varying levels of user expertise. The modular approach of the methodology (with different modules addressing various user needs) provides additional flexibility in a variety of applications.

The various users of a loss estimation study will have different needs. A local or state government official may be interested in the costs and benefits of specific mitigation strategies, and thus may want to know the expected losses if mitigation strategies have been applied. Health officials will want information about the demands on medical care facilities and will be interested in the number and severity of casualties for different scenario earthquakes. Fire fighters may be interested in areas where large fires can be expected or where hazardous materials might be released. Emergency response teams may use the results of a loss study in planning and performing emergency response exercises. In particular, they might be interested in the operating capacity of emergency facilities such as fire stations, emergency operations centers, and police stations. Emergency planners may want to know how much temporary shelter will be needed and for how long. Utility company representatives, as well as planners want to know about the locations and lengths of potential utility outages. Federal and state government officials may require an estimate of economic losses (both short term and long term) in order to direct resources toward affected communities. In addition, government agencies may use loss studies to obtain quick estimates of impacts in the hours immediately following an earthquake so as to best direct resources to the disaster area. Insurance companies may be interested in monetary losses so they can assess their exposure. This list of uses of earthquake loss estimation studies is not comprehensive. As users become familiar with the loss estimation methodology, they will determine which uses are most appropriate for their needs and also the limitations of the loss studies.

Some of the first earthquake loss estimation studies were performed in the early 1970's following the 1971 San Fernando earthquake. These earlier studies were funded by Federal agencies and were intended to provide a basis for disaster relief and recovery. These studies put a heavy emphasis on loss of life, injuries and the ability to provide emergency health care. More recent studies have focused on disruption to roads, telecommunications and other lifeline systems. An understanding of disruptions to these systems is essential in planning for post earthquake emergency response. More recently, a few municipalities have invested in earthquake loss estimation methodologies based on geographic information systems (GIS). These municipalities have found that once inventories are collected, these systems have uses beyond the scope of earthquake loss estimation. For example, data collected for an earthquake loss estimation model in San Bernardino County, California (FEMA, 1985) are now being used for city planning purposes. Two useful resources on loss estimation studies are “Estimating Losses from Future Earthquakes” (FEMA, 1989) and “Assessment of the State-of-the-Art of Earthquake Loss Estimation Methodologies” (FEMA, 1994). Other useful applications of earthquake loss estimation methodologies are contained in “Comprehensive Earthquake Preparedness Planning Guidelines” (FEMA, 1985) and “A Cost Benefit Model for the Seismic Rehabilitation of Buildings” (FEMA, 1992).

1.1 Overview of the Methodology

This brief overview of the earthquake loss estimation methodology is intended for local, regional, or state officials contemplating an earthquake loss study. The methodology has been developed for the Federal Emergency Management Agency (FEMA) by the National Institute of Building Sciences (NIBS) to provide a tool for developing earthquake loss estimates for use in:

- Anticipating the possible nature and scope of the emergency response needed to cope with an earthquake-related disaster,
- Developing plans for recovery and reconstruction following a disaster, and
- Mitigating the possible consequences of earthquakes.

If developed for areas of seismic risk across the nation, estimates also will help guide the allocation of federal resources to stimulate risk mitigation efforts and to plan for federal earthquake response.

Use of the methodology will generate an estimate of the consequences to a city or region of a "scenario earthquake", i.e., an earthquake with a specified magnitude and location. The resulting "loss estimate" generally will describe the scale and extent of damage and disruption that may result from a potential earthquake. The following information can be obtained:

- *Quantitative estimates of losses* in terms of direct costs for repair and replacement of damaged buildings and lifeline system components; direct costs associated with loss of function (e.g., loss of business revenue, relocation costs); casualties; people displaced from residences; quantity of debris; and regional economic impacts.
- *Functionality losses* in terms of loss-of-function and restoration times for critical facilities such as hospitals, and components of transportation and utility lifeline systems and simplified analyses of loss-of-system-function for electrical distribution and potable water systems.
- *Extent of induced hazards* in terms of fire ignitions and fire spread, exposed population and building value due to potential flooding and locations of hazardous materials.

To generate this information, the methodology includes:

- Classification systems used in assembling inventory and compiling information on the building stock, the components of highway and utility lifelines, and demographic and economic data.
- Methods for evaluating damage and calculating various losses.
- Databases containing information used as default (built-in) data and useable in calculation of losses.

These systems, methods, and data have been coded into user-friendly software that operates through a Geographic Information System (GIS). GIS technology facilitates the manipulation of data on building stock, population, and the regional economy. The software (**HAZUS**®[1]) can be run under two different GIS platforms: MapInfo and ArcView. The software makes use of GIS technologies for displaying and manipulating inventory, and permitting losses and consequences to be portrayed on both spreadsheets and maps. Collecting needed information and entering it in an analysis program are the major tasks involved in generating a loss estimate. The methodology permits estimates to be made at several levels of sophistication, based on the level of data into the analysis (i.e., default data versus locally enhanced data). The better and more complete the inventory information, the more meaningful the results.

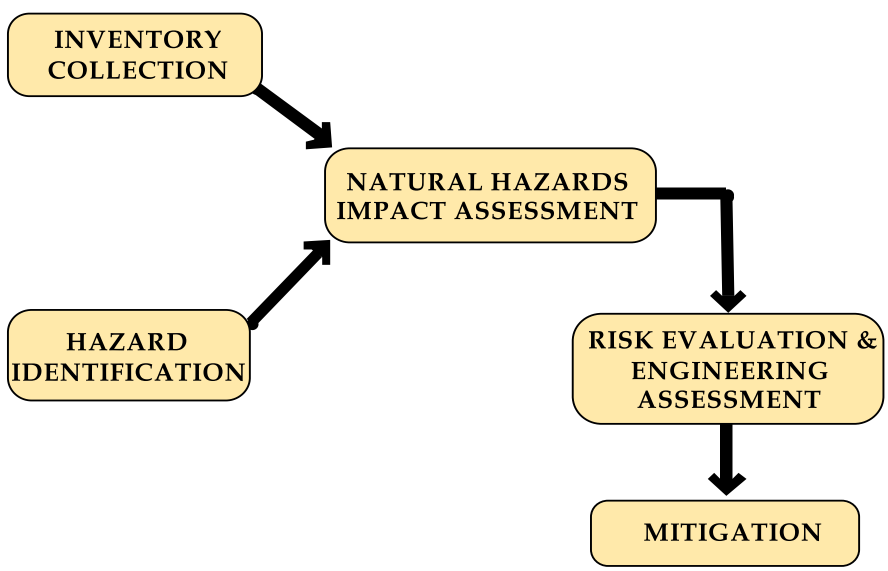

Figure 1.1 Steps in assessing and mitigating losses dues to natural hazards.

Figure 1.1 shows the steps that are typically performed in assessing and mitigating the impacts of a natural hazard such as an earthquake. The methodology incorporates the inventory collection, the hazard identification and the natural hazards impact assessment. In a simplified form, the steps are:

[1] **HAZUS** is a registered trademark of the National Institute of Building Sciences (NIBS) assigned to the Federal Emergency Management Agency (FEMA).

- Select the area to be studied. This may be a city, a county or a group of municipalities. It is generally desirable to select an area that is under the jurisdiction of an existing regional planning group.
- Specify the magnitude and location of the scenario earthquake. In developing the scenario earthquake, consideration should be given to the potential fault locations.
- Provide additional information describing local soil and geological conditions, if available.
- Using formulas embedded in **HAZUS**, probability distributions are computed for damage to different classes of buildings, facilities, and lifeline system components and loss-of-function estimates are made.
- The damage and functionality information is used to compute estimates of direct economic loss, casualties and shelter needs. In addition, the indirect economic impacts on the regional economy are estimated for the years following the earthquake.
- An estimate of the number of ignitions and the extent of fire spread is computed. The amount and type of debris are estimated. If an inundation map is provided, exposure to flooding can also be estimated.

The user plays a major role in selecting the scope and nature of the output of a loss estimation study. A variety of maps can be generated for visualizing the extent of the losses. Numerical results may be examined at the level of the census tract or may be aggregated by county or region.

1.2 Earthquake Hazards Considered in the Methodology

The earthquake-related hazards considered by the methodology in evaluating casualties, damage, and resultant losses are collectively referred to as *potential earth science hazards* (PESH). Most damage and loss caused by an earthquake is directly or indirectly the result of *ground shaking*. Thus, it evaluates the geographic distribution of ground shaking resulting from the specified scenario earthquake and expresses the ground shaking using several quantitative parameters such as peak ground acceleration and spectral acceleration.

Three other features of earthquakes that can cause permanent ground displacements and have an adverse effect upon structures, roadways, pipelines, and other lifeline structures also are considered:

- *Fault rupture*: Ground shaking is caused by fault rupture, usually at some depth below the ground surface. However, fault rupture can reach the surface of the earth as a narrow zone of ground offsets and tear apart structures, pipelines, etc. within this zone.
- *Liquefaction*: This sudden loss of strength and stiffness in soils can occur when loose, water-saturated soils are shaken strongly and can cause settlement and horizontal movement of the ground.
- *Landsliding*: This refers to large downhill movements of soil or rock that are shaken free from hillsides or mountainsides which can destroy anything in their path.

Soil type can have a significant effect on the intensity of ground motion at a particular site. The software contains several options for determining the effect of soil type on ground motions for a given magnitude and location. The user may select the default relations or choose an alternative.

Tsunamis (waves moving across oceans) and seiches (oscillatory waves generated in lakes or reservoirs) are also earthquake-caused phenomena that can result in inundation or waterfront damage. In the methodology, potential sites of these hazards may be identified but they are evaluated only if special supplemental studies are performed.

The definition of the scenario earthquake is not just a matter of earth science. Hazard management and political factors must be considered as well. Planning for mitigation and disaster response generally is based on large, damaging events, but the probability that such events will occur also should be considered. In a region of high seismicity, the *maximum credible earthquake* is generally a suitable choice. In areas of lower seismicity, it may not be prudent to assume a very large but very unlikely earthquake even though it is realized that such an event is possible. In such regions, it is often most appropriate to choose an earthquake with a specified mean recurrence interval, such as the "500 year earthquake." Consideration should be given to repeating loss calculations for several scenario earthquakes withdifferent magnitudes and locations and different probabilities of occurrence, since these factors are a major source of uncertainty.

Data concerning past earthquakes are provided within HAZUS. Chapter 9 provides guidance concerning the selection of scenario earthquakes. It is always desirable to consult local earth science experts during the process of choosing scenario events.

1.3 Types of Buildings and Facilities Considered

The buildings, facilities, and lifeline systems considered by the methodology are as follows:

- *General building stock*: The majority of commercial, industrial and residential buildings in your region are not considered individually when calculating losses. Instead, they are grouped together into 36 model building types and 28 occupancy classes and degrees of damage are computed for groups of buildings. Examples of model building types are light wood frame, mobile home, steel braced frame, concrete frame with unreinforced masonry infill walls, and unreinforced masonry.

Each model building type is further subdivided according to typical number of stories and apparent earthquake resistance (based primarily upon the earthquake zone where they are constructed). Examples of occupancy types are single family dwelling, retail trade, heavy industry, and churches. All structures that are evaluated in this manner are referred to as General Building Stock.

- *Essential facilities*: Essential facilities, including medical care facilities, emergency response facilities and schools, are those vital to emergency response and recovery following a disaster. School buildings are included in this category because of the key role they often play in housing people displaced from damaged homes. Generally there are very few of each type of essential facility in a census tract, making it easier to obtain site-specific information for each facility. Thus, damage and loss-of-function are evaluated on a building-by-building basis for this class of structures, even though the uncertainty in each such estimate is large.
- *Transportation lifeline systems*: Transportation lifelines, including highways, railways, light rail, bus systems, ports, ferry systems and airports, are broken into components such as bridges, stretches of roadway or track, terminals, and port warehouses. Probabilities of damage and losses are computed for each component of each lifeline; however, total *system* performance cannot be evaluated (for example, how well various sections, nodes and connections of the total system perform to enable to move from point A to point B after an earthquake).
- *Utility lifeline systems*: Utility lifelines, including potable water, electric power, waste water, communications, and liquid fuels (oil and gas), are treated in a manner similar to transportation lifelines. Examples of components are electrical substations, water treatment plants, tank farms and pumping stations. System analyses can be performed for potable water systems and electrical systems.

In any region or community there will be certain types of structures or facilities for which damage and losses will not be evaluated unless supplemental studies specific to these facilities are carried out. These omitted structures are referred to as *high potential loss facilities*. Such facilities include dams, nuclear power plants, liquefied natural gas facilities, military installations, and large one-of-a-kind residential or commercial structures. Given the nature of these facilities it would be potentially misleading and politically and legally unwise to estimate damage and losses unless a detailed engineering analysis was performed with the agreement of the owner of the facility. Hence, the approach is to call attention to these facilities, include their locations in the inventory and indicate a potential for loss in the final report. Although the loss cannot be quantified without further investigation, the location of the structures with respect to ground failure or intense ground motions may provide a starting point for more in-depth studies. To include these structures in the loss estimation study outputs, results from supplemental studies, such as damage-motion curves, can be entered.

1.4 Levels of Analysis

To provide flexibility, the losses at estimated at three levels. For each level, the several hazards and the various types of buildings and facilities can be selectively used as appropriate, to meet the needs and desires of the local or regional user.

1.4.1 Analysis Based on Default Information

The basic level of analysis uses only the default databases built into the methodology for information on building square footage and value, population characteristics, costs of building repair, and certain basic economic data. One average soil condition is assumed for the entire study region. The effects of possible liquefaction and landsliding are ignored. Direct economic and social losses associated with the general building stock and essential facilities are computed. Default data for transportation and utility lifelines are included, thus these lifelines are considered in the basic level of analysis. Uncertainty, however, is large. Fire ignitions and fire spread are considered using a simplified model. Indirect economic impacts for the region are calculated but are based on a synthetic economy that may or may not accurately reflect the characteristics of the region. Table 1.1 summarizes the output that can be obtained from an analysis. Outputs that cannot be obtained using only default data are indicated with a star (*).

Table 1.1 Earthquake Loss Estimation Methodology Output

Maps of seismic hazards
- Intensities of ground shaking for each census tract
- Contour maps of intensities of ground shaking
- Permanent ground displacements for each census tract*
- Contour map of permanent ground displacements*
- Liquefaction probability*

Landsliding probability*
- Characterization of damage to general building stock
- Structural and nonstructural damage probabilities by census tract, building type and occupancy class.

Transportation and utility lifelines
- For components of the 13 lifeline systems: damage probabilities, cost of repair or replacement and expected functionality for various times following earthquake
- For all pipeline systems: the estimated number of leaks and breaks
- For potable water and electric power systems: estimate of service outages

Essential facilities
- Damage probabilities
- Probability of functionality
- Loss of beds in hospitals

High potential loss (HPL) facilities
- Locations of dams
- Locations of nuclear plants
- Damage probabilities and cost of repair for of military facilities*
- Locations of other identified HPLs

Fire following earthquake
- Number of ignitions by census tract
- Percentage of burned area by census tract

Inundated areas
- Exposed population and exposed dollar value of general building stock*

Hazardous material sites
- Location of facilities which contain hazardous materials

Debris
- Total debris generated by weight and type of material

Social losses
- Number of displaced households
- Number of people requiring temporary shelter
- Casualties in four categories of severity based on three different times of day

Dollar losses associated with general building stock
- Structural and nonstructural cost of repair or replacement
- Loss of contents
- Business inventory loss
- Relocation costs
- Business income loss
- Employee wage loss
- Loss of rental income

Indirect economic impact
- Long-term economic effects on the region based on a synthetic economy
- Long-term economic effects on the region based on an IMPLAN model *

* Outputs cannot be obtained using only default data.

Other than defining the study region, selecting the scenario earthquake(s) and making decisions concerning the extent and format of the output, an analysis based on default data requires minimal effort from the user. As indicated, however, estimated losses are incomplete and, since default rather than actual data are used to represent local conditions, the estimates involve large uncertainties. This level of analysis is suitable primarily for preliminary evaluations and crude comparisons among different regions.

1.4.2 Analysis with User-Supplied Inventory

Results from an analysis using only default inventory can be improved greatly with a minimum amount of locally developed input. This is generally the intended level of implementation. Table 1.1 summarizes the output that can be obtained from this level of analysis. However, there is no standard analysis with user-supplied data and hence, no minimum or standard amount of input. Such an effort might involve:

- Development of maps of soil conditions affecting ground shaking, liquefaction and landsliding potential. These maps would be used for evaluation of the effects of these local conditions upon damage and losses.
- Use of locally available data or estimates concerning the square footage of buildings in different occupancy classes.
- Use of local expertise to modify, primarily by judgment, the databases concerning percentages of model building types associated with different occupancy classes.
- Preparation of a detailed inventory for all essential facilities.
- Collection of detailed inventory and cost data to improve evaluation of losses and lack of function in various transportation and utility lifelines.
- Use of locally available data concerning construction costs or other economic parameters.
- Collections of data, such as number of fire trucks, for evaluation of the probable extent of areas affected by fires.
- Development of inundation maps.
- Gathering of information concerning high potential loss facilities and facilities housing hazardous materials.
- Synthesis of data for modeling the economy of the study region used in calculation of indirect economic impacts.

Depending upon the size of the region and the number of these features selected by the user, months may be required to assemble the required input. The effort put into preparing the inventory of the building stock can range from minimal to extensive, depending upon the desire to reduce uncertainty in computed results. Assembling and entering required data for lifelines also can involve considerable effort, but the user can choose to omit some lifelines. It will generally be necessary to employ consultants to develop the various soil-related maps and the data needed for the indirect economic analysis. Depending upon the extent of user-supplied inventory, it may be necessary to obtain services of experts in the use of geographic information systems - specifically the platform used by **HAZUS**.

The most detailed type of analysis would include incorporating results from other loss studies that have been completed. A special input concerning the vulnerability of particular model building types or specific high-potential-loss facilities can be entered. It is possible to add the output of loss estimates performed using locally developed traffic models by overlaying maps with links limited to a specific number of damaged bridges. Similar analyses of links can provide information on water distribution or other pipeline systems.

1.5 Assumed Level of Expertise of Users

Users can be broken into two groups: those who are performing the study, and those who are using the results of the study. For some studies these two groups will consist of the same people, but generally this will not be the case. However, the more interaction that occurs between these two groups, the better the study will be. Those who are performing the study must, at minimum, have a basic understanding of earthquakes, their causes and their consequences. In many cases, the results will be presented to audiences (i.e. city councils and other governing bodies) that have little technical knowledge of the earthquake loss problem.

It is assumed that a loss study will be performed by a team consisting of geologists or geotechnical engineers, structural engineers or architects, economists, emergency planners and a representative from the group who will be reviewing/using the loss estimates. These individuals are needed to develop earthquake scenarios, identify problematic soils, develop and classify building inventories, provide and interpret economic data, provide information about the local population, and provide input as to what types of loss estimates are needed to fulfill the goals of the loss study. Ideally, the team would also include representatives from local utilities and public works departments. Other members of the team that would be valuable are a fire official, a hydrologist and a sociologist.

It should be noted that the involvement of the ultimate user of the study on the team is very important. A workshop of earthquake-loss-study users convened in 1986, concluded that many earthquake studies have been of limited usefulness because results were too technical or presented in such a way as to make them difficult for users to interpret (FEMA, 1989). In essence, users in the loss estimation study need to be involved from the beginning to make results more usable.

If a municipality, local acency or state agency is performing the study, it is possible that some of the expertise can be found in-house. For example, the building department may have engineers who know about local seismic design and building practices. The state Department of Geology is another useful source of expertise..

1.5.1 When to Seek Help

Although a loss study can be performed with a minimum of expertise using only the defaults provided by the computer program, the results of such a study should be interpreted with caution, as default values have a great deal of uncertainty associated with them. If the loss estimation team does not include individuals with expertise in the areas described above, then it is likely that one or more outside consultants may be required. Unless a scenario earthquake for the study region has already been developed and is documented in published literature or in previous loss studies, the user may require the expertise of a geologist. Even if a scenario event has been documented, it may be defined using the ground motion characteristics that are different from those used in this methodology (such as MMI or M_s). In this case, a seismologist will be needed to review the scenario earthquake and describe it in terms of moment magnitude (**M**), spectral velocity and spectral acceleration. A scenario event that is defined without an in-depth understanding of earthquake sources, recurrence and the geology of the region, may not be appropriate for the loss study.

If the user intends to modify the defaults data or parameters, it is likely that he will need input from someone with expertise in the field. For example, if the user wishes to change default percentages of model building types for the region, he will need the input of a structural engineer who has knowledge of design and construction practices of the region. Similarly if he wishes to modify the damage-motion relationships (fragility curves), input from a structural engineer will be required. Modifications to defaults in the direct and indirect economic modules will require input from an economist.

Technical help for the users of HAZUS has been established by NIBS via telephone, fax or e-mail support. Users should contact FEMA or NIBS at the addresses given in the “Message to Users” section of this manual for information on technical support.

1.6 Displaying Methodology Results

There is a great deal of flexibility in displaying output. Tables of social and economic losses can be displayed on the screen, printed out or pasted into electronic documents. Most output could also be mapped. Colors, legends and titles can be altered easily. Examples of the type of graphical and numerical output that can be produced by the program are found in Figures 1.2 and 1.3.

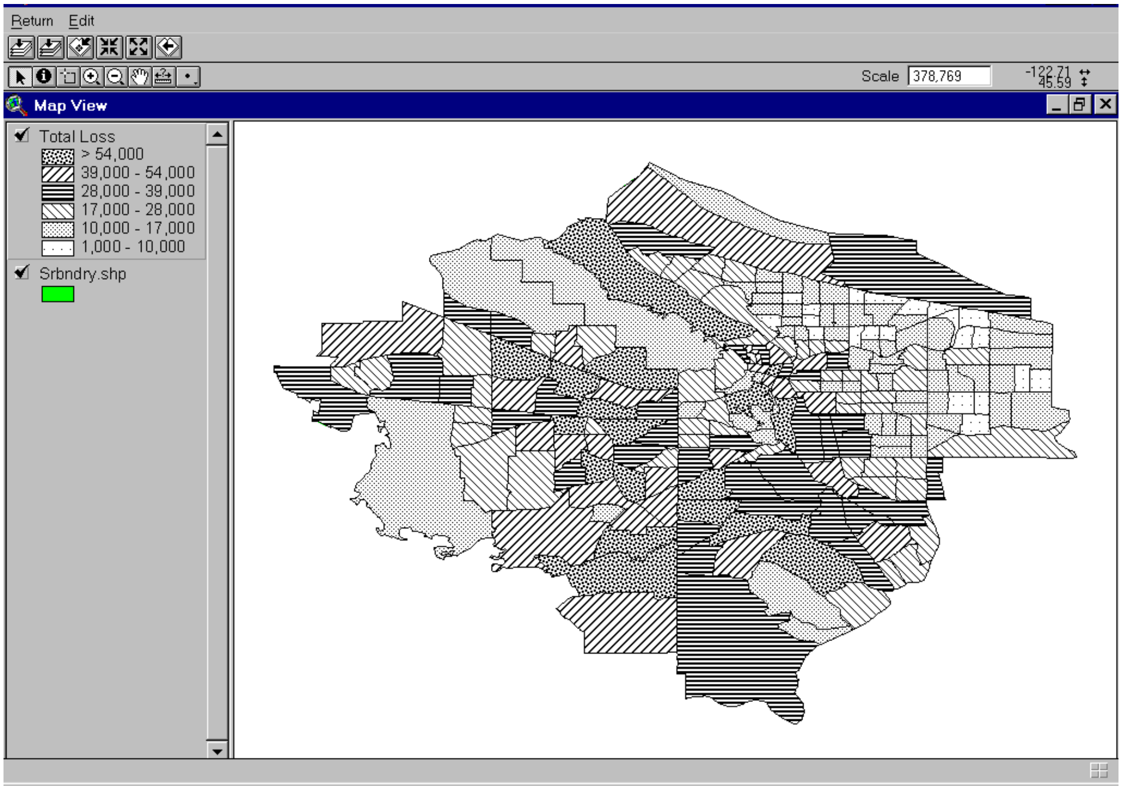

Figure 1.2 Sample output: total loss for a study region.

Casualties Summary Report

Nov 24, 1997

		Total Casualties - 2am				Total Casualties - 2pm				Total Casualties - 5pm			
		At Home	At Work	Commute	Total	At Home	At Work	Commute	Total	At Home	At Work	Commute	Total
Oregon													
Clackamas													
	Severity 1:	359	6	0	365	93	297	2	393	111	105	6	222
	Severity 2:	55	1	1	57	14	54	3	71	17	19	7	43
	Severity 3:	3	0	1	4	1	7	5	13	1	2	13	17
	Severity 4:	3	0	0	4	1	7	1	9	1	2	2	6
	Total:	**420**	**7**	**2**	**430**	**109**	**365**	**11**	**485**	**130**	**129**	**29**	**287**
Multnomah													
	Severity 1:	690	40	2	732	189	1,558	10	1,757	224	733	30	987
	Severity 2:	98	7	2	107	26	271	12	309	31	127	37	195
	Severity 3:	6	1	4	12	2	33	22	57	2	16	66	83
	Severity 4:	6	1	1	8	2	33	4	39	2	16	13	30
	Total:	**801**	**49**	**10**	**859**	**218**	**1,895**	**48**	**2,162**	**259**	**892**	**145**	**1,296**
Washington													
	Severity 1:	827	40	2	869	200	1,018	9	1,227	237	439	24	700
	Severity 2:	131	7	2	141	32	188	11	231	38	81	30	149
	Severity 3:	9	1	4	14	2	25	20	47	3	11	54	67
	Severity 4:	9	1	1	11	2	25	4	31	3	11	10	24
	Total:	**977**	**50**	**9**	**1,036**	**236**	**1,255**	**45**	**1,535**	**280**	**541**	**118**	**940**
Total State	Severity 1	1,876	86	4	1,967	482	2,873	21	3,376	573	1,276	60	1,909
	Severity 2	284	16	5	305	72	512	26	611	86	227	74	387
	Severity 3	19	2	9	30	5	65	47	117	6	29	132	167
	Severity 4	19	2	2	23	5	65	9	79	6	29	25	60
	Total :	**2,198**	**106**	**2**	**2,325**	**564**	**3,515**	**104**	**4,182**	**669**	**1,561**	**292**	**2,522**

Study Region : The Greater Portland Metro Area
Scenario : Portland Hills Event

Page : 1 of 2

Figure 1.3 Sample output; casualties summary report.

1.7 Uncertainties in Loss Estimates

Although the software offers users the opportunity to prepare comprehensive loss estimates, it should be recognized that, even with state-of-the-art techniques, uncertainties are inherent in any such estimation methodology.

History has taught that the next major earthquake to affect a U.S. city or region will likely be quite different from the "scenario earthquake" anticipated as part of an earthquake loss estimation study. The magnitude and location of the earthquake and the associated faulting, ground motions and landsliding will not be precisely what was anticipated. Hence, the results of an earthquake loss study should not be looked upon as a *prediction* but rather as an indication of what the future may hold. This is particularly true in areas where seismicity is poorly understood. Obviously, the better the understanding of the seismic regime of a region, the closer to future reality the loss estimates may be.

Any region or city studied will have an enormous variety of buildings and facilities of different sizes, shapes, and structural systems constructed over the years under diverse seismic design codes. Similarly many different types of components with differing seismic resistance will make up transportation and utility lifeline systems. Due to this complexity, relatively little is certain concerning the structural resistance of most buildings and other facilities. Further, there simply are not sufficient data from past earthquakes or laboratory experiments to permit precise predictions of damage based on known ground motions even for specific buildings and other structures. To deal with this complexity and lack of data, buildings and components of lifelines are lumped into categories, based upon key characteristics. Relationships between key features of ground shaking and average degree of damage and associated losses for each category are based on limited data and available theories. While state-of-the-art in terms of loss estimation, these relationships do contain a certain level of uncertainty.

Possible ranges of losses are best evaluated by conducting multiple analyses and varying certain input parameters to which the losses are most sensitive. Guidance concerning the planning of such *sensitivity studies* is found in Section 9.8.

1.8 Applying Methodology Products

The products of the FEMA methodology for estimating earthquake losses have several pre-earthquake and/or post-earthquake applications in addition to estimating the scale and extent of damage and disruption.

Examples of pre-earthquake applications of the outputs are as follows:

- *Development of earthquake hazard mitigation strategies* that outline polices and programs for reducing earthquake losses and disruptions indicated in the initial loss estimation study. Strategies can involve rehabilitation of hazardous existing buildings (e.g., unreinforced masonry structures), the development of appropriate zoning ordinances for land use planning in areas of liquefiable soils, and the adoption of advanced seismic building codes.
- *Development of preparedness (contingency) planning measures* that identify alternate transportation routes and planning earthquake preparedness and survival education seminars.
- *Anticipation of the nature and scope of response and recovery efforts* including: identifying alternative housing and the location, availability and scope of required medical services; and establishing a priority ranking for restoration of water and power resources.

Post-earthquake applications of the outputs would include:

- *Projection of immediate economic impact assessments for state and federal resource allocation and support* including supporting the declaration of a state and/or federal disaster by calculating direct and indirect economic impact on public and private resources, local governments, and the functionality of the area.
- *Activation of immediate emergency recovery efforts* including search and rescue operations, rapid identification and treatment of casualties, provision of emergency housing shelters, control of fire following earthquake, and rapid repair and availability of essential utility systems.
- *Application of long-term reconstruction plans* including the identification of long-term reconstruction goals, the institution of appropriate wide-range economic development plans for the entire area, allocation of permanent housing needs, and the application of land use planning principles and practices.

Once inventory has been collected, making modifications and running new analyses are simple tasks. The ease with which reports and maps can be generated makes the software a useful tool for a variety of applications.

1.9 Organization of the Manual

The *User's Manual* provides the background and instructions for developing an inventory to complete an earthquake loss estimation study using **HAZUS.** It also provides information on how to install and run the software, and how to interpret and report model output. The contents and organization of the User's Manual are outlined below.

The Technical Manual, a companion publication, documents the methods of calculating losses and the default data. Taken together, the two manuals provide a comprehensive overview of the nationally applicable loss estimation methodology.

Chapter 1 provides the user with a general understanding of the purpose, uses and components of a regional earthquake loss estimation study.

Chapter 2 gives instructions for installing and starting **HAZUS**.

Chapter 3 runs through an analysis using only default data.

An overview of the types of data required to run the loss study, as well as a description of the default databases is found in Chapter 4.

Chapter 5 contains information about what data are needed to complete a loss study, sources of inventory, how to collect inventory, how to convert data to the correct format for the methodology, and how to enter data into **HAZUS**. The user is provided with estimated costs (in terms of labor) to collect the inventory.

Chapter 6 includes instructions for entering data, editing records and geocoding addresses.

Chapter 7 provides the user with a discussion of how to display, modify and print databases.

Chapter 8 discusses The Building Data Import Tool (BIT). This utility is designed to help the user analyze and query existing databases to develop general building stock inventory information.

Chapter 9 provides a detailed step-by-step description of how to run an analysis using **HAZUS,** including analysis with user-supplied data**.**

Chapter 10 discusses how to view results and provides suggestions about putting together a report.

Chapter 11 contains a general discussion of vulnerability to natural hazards and key factors that should be considered in estimating losses as well as brief discussions of supplemental data that are available with **HAZUS.**

Chapter 12 covers QASEM, the Quick Assessment Event Monitoring tool.

The *User's Manual* is written in language that should be easily understood by a user of the methodology. Highly technical terms are avoided where possible, but a glossary of terms is provided in Appendix H to supplement any definitions that are needed. A compilation of relevant references is found in References Section.

The appendices contain detailed information about the structure of the methodology. Appendix A lists all of the classification systems that are used.

Appendices B and C provide descriptions of the model building types and lifeline components that are used in the methodology.

Appendix D describes the content and origin of the default databases.

Appendix E is a database dictionary containing details about the format of all of the databases used by **HAZUS**.

Appendix F includes a sample questionnaire that was used for assessing characteristics of regional building stock.

Appendix G describes the hazardous materials that are covered under SARA Title III, including their Chemical Abstracts Service (CAS) registry numbers, and the threshold quantities for reporting purposes.