Chapter 5. Collecting Inventory Data

A limiting factor in performing a loss estimation study is the cost and quality of the inventory. Collection of inventory is without question the most costly part of performing the study. Crude estimates of damage do not require extensive inventory data and can be performed on a modest budget. As the damage estimates become more precise, the need for inventory information increases, as does the cost to obtain this information. Since many municipalities have limited bud gets for performing an earthquake loss estimation study, HAZUS accommodates different users with different levels of resources. It should be understood, however, that the uncertainty of the loss estimates increases with less detailed inventory, and that there are uncertainties associated with modules other than inventory. For example, even with a perfectly accurate inventory of soils and buildings in the study area, **HAZUS** or any other loss estimation methodology cannot infallibly predict damage and associated losses.

Inventory information will come from and/or be collected in databases compatible with the GIS technology. Once collected and entered into the database, the data will also be available to users for other applications. For example, data collected for an earthquake loss estimation model in San Bernardino County, California is now being used for city planning purposes.

5.1 Sources of Information

As discussed in Chapter 3, the use of default parameters and default inventory in performing a loss study introduces a great deal of uncertainty. Loss studies performed with only default data may be best for preliminary assessments to determine where more information is needed. For example, if the analysis using only default information suggests that the scenario earthquake will cause a great deal of damage in a particular part of your community, you may want to collect more detailed inventory for that area to have a better understanding of the types of structures, the essential facilities and businesses that will be affected. Similarly, your default analysis may indicate that components of your electrical system are vulnerable. Based on this outcome, you may wish to perform walk-downs of the substations to see how they are really configured. In short, it is likely that you will want to augment and update the default data that are supplied with **HAZUS**.

Regional building inventories can be built up from a variety of sources including federal government, state government, local government and private sector databases. These databases may be useful for obtaining facility-specific information. Following are examples of sources of inventory data that can be accessed to enhance the **HAZUS** building data.

- Locations of government facilities such as military installations and government offices
- Databases of hazardous buildings such as the California Safety Commission database of unreinforced masonry buildings
- Tax assessor's files
- School district or university system facilities
- Databases of fire stations or police stations
- Databases of historical buildings
- Databases of churches and other religious facilities
- Postal facilities (ATC-26, 1992)
- Hospitals (The AHA Guide of the American Hospital Association; ATC-23A, 1991A)
- Public and private utility facility databases
- Department of transportation bridge inventory
- Dun and Bradstreet database of business establishments
- Insurance Services Office's files of large buildings that is used for fire assessment real estate databases

It should be kept in mind that each of these databases includes only a portion of the building stock, and none is complete. For example, the tax assessor's files do not include untaxed properties such as government buildings, public works and tax-exempt private properties. School district databases probably will not include private schools. A good discussion of available databases is found in ATC-13 (1985) and Vasudevan et al. (1992), although some of the databases discussed in these two references are specific to California.

Another possible source of inventory information is previous loss or hazard studies. An example is "Earthquake Hazard Mitigation of Transportation Facilities" (Allen et al., 1988), which contains a listing of all "seismically significant" points along priority routes surrounding the New Madrid Seismic Zone. This listing includes dams, pipelines, high fills, cut slopes, signs, tanks, mines, buildings subject to collapse, faults and bridges. This type of list could certainly be used as a starting point for developing a complete lifeline inventory. Unfortunately many regional loss studies do not contain a listing (either hard copy or electronic) of the inventory that was used.

The following sections contain more detailed information about sources of information for specific modules of the earthquake loss estimation methodology.

5.1.1 Potential Earth Science Hazards (PESH)

5.1.1.1 Soil Maps

In order to account for the effects of local soil conditions for estimating ground motion and landslide and liquefaction potential, you need to enter a soil map into **HAZUS**. High-resolution (1:24,000 or greater) or lower resolution (1:250,000) geologic maps are generally available from geologists or regional U. S. Geological Survey offices, state geological agencies, regional planning agencies or local government agencies. There are

a variety of schemes available for classifying soils. The geologic maps typically identify the age, depositional environment, and material type for a particular mapped geologic unit. You will require the services of a geologist or geotechnical engineer to convert the classification system on your map to the one used in this methodology (see Table A.1 in Appendix A).

If a previous regional loss study has been conducted, you may find that the study contains soil maps. Once again, for use with **HAZUS** you may need to convert the classification to the one described in Table A.1.

5.1.1.2 Liquefaction Susceptibility

Liquefaction susceptibility maps, which may be utilized in the hazard analysis, have been produced for a few selected regions, i.e., greater San Francisco region (ABAG, 1980); San Diego (Power, et. al., 1982); Los Angeles (Tinsley, et. al., 1985); San Jose (Power, et. al., 1991); Seattle (Grant, et. al., 1991); among others. Applied Technology Council published a summary of available regional liquefaction hazard maps (Power and Holtzer, 1996).

If no liquefaction susceptibility maps are available, and liquefaction is a potential hazard, a geologist or geotechnical engineer will be required to develop one. The level of effort required depends on the size of the region and the desired resolution of the contours. A crude map with a great deal of uncertainty can be developed in one week using the procedure outlined in Chapter 4 of the *Technical Manual*. An experienced geotechnical engineer with knowledge of the region can develop a simple map in about one month. A detailed map can require a separate study that could take several months to years. Digitizing a map can take a day to a week depending on the size and complexity of the region.

5.1.1.3 Landslide Susceptibility

If no landslide susceptibility maps are available, and landslides are potential hazards, a geologist or geotechnical engineer will be required to develop one. The level of effort required depends on the size of the region, and the desired resolution of the contours.

5.1.2 General Building Stock

Developing the inventory for general building stock most likely will require combining information from several sources. As mentioned earlier, there is no complete single source of general building stock information. In addition, you will find that the quality and format of the information varies dramatically from county to county. Furthermore, since general building stock inventory is not normally compiled by counting individual buildings, but instead is developed using various assumptions and inferences, you may find that you need input from local engineers and building officials to ensure that you have captured unique aspects of the region.

5.1.2.1 County Tax Assessor Files

County Tax Assessor files may or may not be a source of general building stock information. Since Tax Assessor files are kept for the purposes of collecting property taxes, they may contain little or no useful structural information. The quality of the data varies widely from county to county. The most useful data will contain occupancy,

structural type, square footage, height, and age. Generally, the files contain good information on the use (occupancy) of the building, since tax rates often depend on building use; therefore, either a land use code and/or a specific occupancy of the building is included. Ideally, if good information is available, you can use the Building Data Import Tool (BIT) described in Chapter 8 to develop region-specific occupancy to model building type relationships. However, several problems generally occur:

- Many Tax Assessor files do not contain building square footage information. In some counties, square footage is not recorded at all. In other cases, it is only sometimes recorded. You should ask the Tax Assessor before you buy the records as to what percentage of the records contain square footage information.
- Many Tax Assessor files contain square footage information that may be difficult to interpret. For example, a property that is owned by several owners (such as an office building) may appear several times in the files. Perhaps Owner #1 owns two floors of the building and Owner #2 owns eight floors. The Tax Assessor's records may not reflect the fact that Owner #1 owns 20% of the Building and Owner #2 owns 80%. In fact, sometimes both property entries will show the total building square footage instead of Owner #1 with 20% of the square footage and Owner #2 with 80%. Without going through the files record by record, this is difficult to fix.
- Since some occupants that do not pay taxes (e.g., schools, churches, and government buildings) are not usually well represented in the Tax Assessor's files. Often these types of properties include an entry and an Assessor's Parcel Number, but omit assessed value, square footage, structural type, height or age.
- Structural type may not be recorded at all in the files. You need to ask the Tax Assessor what percentage of the records has structural information before you buy the files.
- Similar comments about missing data can be made about age and height.
- Some or all of the properties in the Tax Assessor's files may contain no address information. In some counties, the Assessor's Parcel Number is the only identifier in the database. While this can be mapped to location, it is not an easy task. The file may contain a mailing address of the owner, but this is not a reliable address to locate properties. In other cases, selected properties are missing addresses. Address information is important because you can use addresses to see how the types and occupancies of buildings vary geographically.
- Perhaps one of the most difficult problems is that, in many cases, the Tax Assessors use a system of classifying structures that is difficult to map to the model building types defined in Table A.2. For example, there may only be five building types, such as steel frame, wood frame, fire resistant, masonry and other. It is difficult from this very simple classification system to determine whether masonry structures are reinforced or unreinforced. Similarly, it is impossible to distinguish braced steel frames from moment resisting steel frames. Fire resistant construction could include a variety of structural types consisting of concrete or masonry. In these cases you will need to use local experts to help define the mix of construction.

5.1.2.2 Commercial Sources of Property Data

There are a variety of on-line services that maintain databases of real property that are designed to assist realtors and other commercial enterprises in gathering property sales data and owner information, and to assist in generating mailing lists and labels. The databases are developed from County Tax Assessor's files and updated as properties are sold or as other information becomes available.

You can subscribe to one of these services and download records over a telephone line, or you can order CDs of selected counties and use software supplied by the service to

extract the records on your own computer. It seems that different services tend to focus their efforts in different parts of the United States. Therefore, one service may not maintain a database on the county you wish to study while another service may. Typical costs for a county are $300 to $1000, depending on its size. Addresses and phone numbers of several on-line services are listed below. (Note: While these are California addresses, they carry data from around the country. There may be local offices for these companies.) If one of these services does not have the counties in your study region you may find that there is a service in your own community that maintains these types of records. Local real estate agencies or the local Board of Realtors would probably know about this. Alternatively, you could try calling local Tax Assessors and see if they have sold their data to this type of service.

Some of the Commercial Sources of Property Data are:

Experian Property Data (formally known as TRW)
3610 Central Avenue
Riverside, CA 92506
(800) 345-7334

Transamerica Information Management (offer a program called MetroScan)
1860 Howe Avenue, Suite 455
Sacramento, CA 98525
(800) 866-2783

DataQuick Information Services
9171 Towne Centre Drive, #404
San Diego, CA 92122
(800) 950-9171

The commercially available databases contain the same type of problems found in the County Assessor's data since they were obtained from them. Perhaps one of the main advantages of the commercially available data is that you can get some technical support in trying to put the data into databases. The software they provide enables you to look at individual properties or to sort properties in a variety of ways such as by zip code, or by census tract, or by age, or by occupancy to name a few. On the other hand, assessor's data are often stored on 9-track tape and little instruction is provided about how to extract the data.

One note of caution: The software that commercial services provide is limited in that you cannot extract the entire county at once. You are limited to extracting a certain number of records (for example 9000) at a time. A large county such as Los Angeles contains over two million records. Thus extracting all of the records for the county can be a tedious task, sometimes taking several days.

5.1.3 Occupancy to Model Building Type Relationships

Developing occupancy to model building type mapping schemes that accurately reflect your study region will require combining available data with input from local experts. The Building Data Inventory Tool (BIT) discussed in Chapter 8 has a utility that develops occupancy to model building type mapping schemes from the assessor's files or other

commercially available property data. Collecting supplemental information about local building practices through the use of a questionnaire and/or a workshop is recommended.

A questionnaire that was used to collect region specific information for developing some of the default mapping schemes in **HAZUS** is found in Appendix F. This questionnaire was used in a one-day workshop that was attended by about ten individuals with significant experience with local construction that included design engineers, building officials and a university professor. Workshop participants were presented with preliminary occupancy to model building type relationships that were developed from County Assessor's files. Using the questionnaire to focus on the workshop, participants modified preliminary schemes based on their own experience. The advantage of using a workshop instead of sending the questionnaires out was that participants were able to discuss their different opinions and come to a consensus on a reasonable representation of local practices.

5.1.4 Essential Facilities

Essential facilities, to a great degree, are owned or licensed by government agencies. Consequently, lists of these facilities often have been compiled for a region. Therefore, the time associated with collecting inventory on essential facilities may be relatively small; perhaps a day or two, if no building type information is collected and default occupancy to building type mappings are used. However, more detailed building type information may require a site visit for each facility.

Some essential facilities are subject to special design and construction considerations that may help these structures perform better than the typical building when subjected to an earthquake. Data you collect with respect to special seismic design and construction considerations may be useful later on in identifying whether structures are high-code, moderate-code or low-code design. The criteria for determining how essential facilities fit in these categories are summarized in Table 5.1. An additional bias can also be defined for essential facilities to reflect the potential for different damage and losses based on the vintage of the design code. This is described in Section 6.7.1 of the *Technical Manual*.

Table 5.1 Suggested seismic design levels for essential facilities

Seismic Design Level (I = 1.5)	Seismic Zone (1994 Uniform Building Code)	Map Area (1994 NEHRP Provisions)
High-Code	4	7
Moderate-Code	2B	5
Low-Code	1	3

5.1.4.1 Medical Care Facilities

Sources of inventory information for medical care facilities include the yellow pages of the telephone book, city and county emergency response offices, the American Hospital Association and previous loss studies. The default medical facilities database included with **HAZUS** was developed from a FEMA database and contains the number of beds for many of the facilities. Determining the number of beds for other facilities may require

the user to contact facilities on an individual basis. In some cases, county guides, such as the McCormack Guides in California, provide a listing of all health care facilities, their addresses, phone numbers and the number of beds. The State Department of Public Health in California (and its equivalent in other states) licenses health care facilities and may publish a directory of licensed facilities.

5.1.4.2 Fire Stations, Police Stations and Emergency Operations Centers

Locations of fire stations, police stations and emergency operations centers can be obtained from city and county emergency response offices. In addition, many city maps show locations of police and fire stations. Determining the number of fire trucks may require the user to contact an administrator in the fire department.

5.1.4.3 Schools

Locations of public schools and their enrollments can be obtained from district offices. The Board of Education in some states compiles a directory of all schools (public and private) in the state with names, addresses, phone numbers and enrollments. The yellow pages of the phone book can be used as an initial listing. Regional governments may compile directories of local educational institutions (including colleges and universities).

5.1.5 High Potential Loss Facilities

While High Potential Loss Facilities include nuclear power plants, dams and military installations, default data are currently provided only for nuclear power plants and dams.

5.1.5.1 Nuclear Power Plants

HAZUS does not include damage and loss estimates for nuclear power plants. These structures are so complex that estimating losses would require a dedicated study; therefore, **HAZUS** restricts the treatment of these facilities to mapping them in the study region. Since a default database is included with **HAZUS,** you will only have to add those nuclear power plants that are not listed in the default database. Utilities that operate these facilities will have information on their locations, though they may not be willing to share it. Local, state and Federal regulatory agencies should also have inventories of power plants (nuclear as well as fossil fuel plants).

5.1.5.2 Dams

The methodology does not include damage and loss estimates for dams. The default dam database provided with **HAZUS** is a modified version of the NATDAM database supplied by the National Inventory of Dams. It contains over 80,000 entries and includes most of the dams of any significance in a study region along with a great deal of descriptive information about each dam. The criteria for inclusion in the database are found in Table 5.2 and the list of fields is found in Section 2.2 of Appendix E. The default classes that are included in this database were assigned by converting the rather complex classification system used by NATDAM to the twelve classes used in this methodology. Cities, counties, states, the Army Corps of Engineers, the U.S. Soil Conservation Service, other federal agencies, water districts, flood control districts, or private parties may own dams or levees. Thus obtaining more detailed information on dams may require contacting a number of different sources. In addition to the above-

mentioned agencies, you may wish to contact the State Office of Emergency Services, local emergency services, fire protection services, or regulatory agencies.

Table 5.2 Criteria for inclusion in the NATDAM database

Characteristic	Criterion	Excluded
Dam Height	Dam height greater than 25 feet	Dam height < 6 feet, regardless of reservoir capacity
Reservoir Size	Reservoir impoundment capacity greater than 50 acre-feet	Reservoir impoundment capacity less than 15 acre-feet maximum capacity regardless of dam height
Hazard	Any dam that poses a significant threat to human life or property in the event of its failure	N/A

5.1.5.3 Levees

Users are responsible for developing their own inventory of levees since **HAZUS** doesn't supply default levee inventory. Levees are defined in terms of endpoints of levee segments (latitude and longitude). There are a number of fields defined in the levee database structure (see Appendix E, Section 2.2) including:

- Levee design basis (for example 100 year flood)
- Levee crest elevation
- Water elevation during most of the year
- Levee owner/operator

Since some levees are designed only to provide protection during flooding, they may be dry during most of the year. These levees do not pose a significant inundation hazard.

5.1.5.4 Military Installations

The methodology includes the capability to estimate damage and loss for facilities on military bases that can be modeled as one of the 36 model building types. Locations of military installations can be obtained from maps or Topologically Integrated Geographic Encoding and Referencing (TIGER) files. These sources give locations of installations but no breakdown as to the number or type of structures. FEMA maintains databases of major Army, Navy and Air Force installations, although they are not included in **HAZUS**.

5.1.6 User-Defined Structures

User-defined structures are those structures, other than essential facilities or high potential loss facilities, which the user may wish to analyze on a site-specific basis. For example, you may wish to identify all of the unreinforced masonry buildings in the community or all of the pharmacies. You can collect data about these types of structures

using the same sources you would use for general building stock or essential facilities, namely: specific databases that may be available to you through some agency, commercial sources of property data, the phone book, interviews with owners and site visits.

5.1.7 Lifelines

Developing a lifeline inventory or improving the inventories supplied with **HAZUS** most likely will require the cooperation of local utilities or government agencies that operate and maintain the systems. It is difficult to estimate how much time will be required to collect and organize lifeline information because it depends on the size of the region, the level of detail required, the quality of existing data and the degree of cooperation from agencies within the region.

Previous loss estimation or hazard studies may be sources of information on all types of lifelines. For example, the planning scenarios developed by the California Division of Mines and Geology (CDMG) provide detailed inventories of lifelines and essential facilities (See Davis et al., 1982). In the Davis study, addresses and the number of beds for all hospital facilities are provided. A limitation of the CDMG planning scenarios is that the inventory is only for the area around the epicenter of the scenario earthquake. Another example of a previous loss study is the study performed for the Portland, Oregon water and sewer systems (Kennedy/ Jenks/Chilton et al., 1989). It should be noted that a detailed lifeline study such as the one performed for Portland might provide information in addition to component inventory. This study contains values of facilities and loss curves (based on MMI) for some components. A source of loss studies that have been performed is FEMA Report 249 (FEMA, 1994).

In some communities, government agencies such as the Association of Bay Area Governments in the San Francisco area and Metro in Portland, have been studying hazard mitigation policies and procedures for quite some time. In some cases their studies have involved developing inventories of local lifeline and essential facilities.

5.1.7.1 Transportation Lifelines

The default databases of highways and bridges included with **HAZUS** were created from data obtained from Federal Highway Administration (FHWA) and the Census Bureau's TIGER files. You may find that the locations of these lifeline components contain inaccuracies; however, the locations can easily be modified based on more accurate information obtained by the user. Street maps are an excellent source for locating streets and highways. Although they provide no information about the width of streets or the average daily traffic, they do generally give the route number and usually classify the roads according to some simple scheme such as freeways, expressways, main highways, and surface streets. A potential drawback, however, is that to use street maps, you must digitize them.

Some cities and counties have invested in GIS systems and may already have computerized databases that you can use. You may find that the GIS files have to be converted into a format that is compatible with ArcView (see Section 6.1). To obtain cost and structural information about roads, bridges and tunnels that is not included in the default inventory, local and state transportation agencies maintain lists of bridges and

tunnels and may also have detailed information about their design, construction and configuration. You may find that you need to perform a survey to collect cost per mile data for roads (surveys are discussed in Section 5.2.)

To obtain information about traffic on road segments you may wish to consult the default bridge database included with **HAZUS**. This database, obtained from the FHWA includes average daily traffic counts. As a first step you can assume that the average daily traffic on a bridge is the same as that on a highway leading to that bridge. Alternatively, the public works departments or the city, county, state or the federal agencies that own and operate the roads likely have performed studies with respect to the daily traffic and capacities of the roads.

The Federal Railway Administration maintains a database of all railways. It is unclear as to whether you will be able to access such a database. Rail companies that operate in a region maintain lists of rail yards and other rail facilities. These sources should be able to provide structural information as well as cost data.

Light rail, ferry and bus inventory information may be obtained from the agencies operating these systems. Maps of the light rail system can be digitized or scanned and entered into the GIS database to inventory track segments.

While the locations of ports and airports are provided in the default inventories, no information is provided about the types of buildings, cranes, tanks, etc. that are at these facilities. The Federal Aviation Administration maintains a database of airports along with information about the number of runways and the average daily traffic. It is unclear if you will be able to access this information. Facility maps may be obtained from the agencies that operate these ports and harbors. However, it is likely that a meeting or phone call with the owner will be required to get structural and cost information.

5.1.7.2 Utilities Lifelines

Developing a lifeline inventory or improving the default inventories supplied with **HAZUS** generally requires the cooperation of local utilities or government agencies that operate and maintain the systems. In some cases utilities and government agencies are already maintaining databases on GIS systems or in CAD systems. However, the data may have to be converted to a format that is compatible with the ArcView GIS software.

More than one supplier may supply water to a region. Suppliers may be either government owned or they may be private companies. Systems may already be mapped in a GIS or CAD system. In this case, the data files may need to be converted to an ArcView format. If the water system is not maintained in a GIS, a map of the pipe network can be digitized or scanned for input into **HAZUS**. Similar comments apply to wastewater systems.

A rather crude analysis of water and wastewater systems can be performed by knowing the number of kilometers of different types of pipes for each census tract. Owners of these systems can typically provide this information.

Oil and gas systems consist of not only the pipelines but also refineries, tank farms, pumping plants and compressor stations. In addition to inventories available from suppliers, databases of hazardous waste sites can serve as a locator of fuel storage facilities.

5.1.8 Inundation

Sources of existing inundation studies due to dam failure, levee failure or tsunami include state and federal agencies that regulate dams, dam or lake owners, the State Office of Emergency Services (OES), the U.S. Geological Survey (USGS), etc. The availability of such studies may be limited.

If inundation maps are available, they may be digitized and entered into **HAZUS** (see Section 9.5). Digitizing a map for display may take a day to a week. If an inundation map is not available, development of an inundation map for a particular earthquake scenario requires an analysis of the response of the dam to the earthquake and the involvement of a hydrologist to define the extent of flooding. This is a detailed study requiring up to several months.

5.1.9 Fire Following Earthquake

Aside from the locations of fire stations, and the number of trucks that should be available from fire departments or regional emergency response organizations, there is little inventory information available to investigate fire following earthquake. Typical wind speeds and wind directions can be obtained from the weather service, and average fire engine speeds should be available from the fire department.

5.1.10 Hazardous Materials

Due to the considerations of limiting the methodology to those hazardous materials whose release could have regional consequences, the default database contains only those chemicals that are considered highly toxic, flammable or highly explosive. In addition, it is limited to those facilities where large quantities of these materials are stored. The (Environmental Protection Agency) EPA compiles an annual inventory of manufacturing facilities that release toxic chemicals into the air, water and ground. This inventory focuses on 305 chemicals that may cause chronic health problems and serious environmental effects. The default database was built from the 1993 EPA Toxic Release Inventory (TRI) database of hazardous materials sites. The latest version of the TRI database may be obtained from the EPA. You may opt to use only the information contained in the default database provided with **HAZUS**. This database, however, is limited and you are urged to collect additional inventory for a better representation of the types of chemicals stored in your study region.

The ease with which information regarding hazardous materials storage and usage is available varies from jurisdiction to jurisdiction. Some jurisdictions have this information available in the form of a computer database/printout, whereas other jurisdictions do not. Most likely the format of the database will vary from place to place, and even if hazardous materials inventories are easy to get, there will be some effort required to combine databases from several cities in a region.

At the present time, users and handlers of hazardous materials have to meet two primary reporting requirements. One is the requirement mandated by the Uniform Fire Code, and the other is required by SARA Title III (Superfund Amendments and Reauthorization Act of 1986, Title III). The reporting requirements for each of these are rather different. The Uniform Fire Code is very comprehensive in its coverage. It covers materials that pose

any physical or health hazard. The SARA Title III reporting requirements, on the other hand, are restricted to 360 hazardous materials that are known to be particularly toxic. These chemicals have been termed Acutely Hazardous Materials (AHM). For either of these reporting specifications, based upon the hazard posed by each material, there are minimum (threshold) hazardous material quantities below that the user/handler may store without a permit. The information contained in the application for a permit is a matter of public record, and the agency granting the permit is able to provide that information to the community, if deemed necessary. 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, are listed in Appendix G.

The user should contact the local Fire Department in the case of cities, or the County Health Department in the case of unincorporated areas, to obtain a list of facilities that have obtained permits to store, handle or use hazardous materials. It appears that most jurisdictions within the United States require all users and handlers of hazardous materials to obtain permits from the proper local authority.

The user should also be cognizant of the dynamic nature of hazardous materials data. This will be particularly true of areas that are undergoing economic and industrial growth. For best results, it is strongly recommended that the data be periodically updated, with the update interval being dependent on the rate of growth of the region.

5.1.11 Demographics

Population statistics are used in estimating several different losses such as casualties, displaced households and shelter needs. Population location, as well as ethnicity, income level, age and home ownership is needed to make these estimates. The 1990 Census data are included with **HAZUS**. Population migration patterns, based on place of employment, were developed from Dun and Bradstreet data as described in Section 3.6 of the Technical Manual. The user may be able to obtain updated information from the Census Bureau or from a regional planning agency.

5.1.12 Direct Economic Loss Parameters

Direct economic losses begin with the cost of repair and replacement of damaged or destroyed buildings. However, building damage results in a number of consequential losses that are defined as direct economic losses. Thus, building-related direct economic losses (which are all expressed in dollars) comprise two groups. The first group consists of losses that are directly derived from building damage:

- Cost of repair and replacement of damaged and destroyed buildings
- Cost of damage to building contents
- Losses of building inventory (contents related to business activities)

The second group consists of losses that are related to the length of time the facility is non-operational (or the immediate economic consequences of damage):

- Relocation expense (for businesses and institutions)
- Capital-related income loss (a measure of the loss of services or sales)
- Wage loss (consistent with income loss)
- Rental income loss (to building owners)

Damage to lifeline and transportation systems causes direct economic losses analogous to those caused by building damage. In this methodology, direct economic loss for lifelines and transportation systems are limited to the cost of repairing damage to the systems and business losses due to cessation of electrical power supply. A large part of the data required to estimate direct economic losses is concerned with the cost of repair and replacement, the value of lost inventory, wages and rent. Many of these types of economic parameters are documented by government agencies.

5.1.12.1 County Business Patterns

County Business Patterns is an annual series published by the United States Census Bureau that presents state and county-level employment, annual payrolls, total number of establishments, and establishments by employee size. The data are tabulated by industry as defined by the Standard Industrial Classification (SIC) Code. Most economic divisions are covered, which include agricultural services, mining, construction, manufacturing, transportation, public utilities, wholesale trade, retail trade, finance, insurance, real estate and services.

The data generally represents the types of employment covered by the Federal Insurance Contributions Act (FICA). Data for employees of establishments totally exempt from FICA are excluded, such as self-employed persons, domestic service employees, railroad employees, agricultural production employees and most government employees.

County Business Patterns is the only complete source of sub-national data based on the four digit SIC system. The series, therefore, is useful in making basic economic studies of small areas (counties), for analyzing the industrial structure of regions, and as a benchmark for statistical series, surveys and other economic databases. The data can serve a variety of business uses as well as being used by government agencies for administration and planning.

County Business Patterns data are extracted from the Standard Statistical Establishment List, a file of known single- and multi-establishment companies maintained and updated by the Bureau of the Census every year. The Annual Company Organization provides individual establishment data for multi-location firms. Data for single-location firms are obtained from various programs conducted by the Census Bureau as well as from administrative records of the Internal Revenue Service (Census Bureau, 1991).

5.1.12.2 Means Square Foot Costs

The default replacement costs supplied with the methodology (damage state = complete) were derived from Means Square Foot Costs 1994 for Residential, Commercial, Industrial, and Institutional buildings (Jackson, 1994). The Means publication is a nationally accepted reference on building construction costs, which is published annually. This publication provides cost information for a number of low-rise residential model buildings, and for 70 other residential, commercial, institutional and industrial buildings.

These are presented in a format that shows typical costs for each model building, showing variations by size of building, type of building structure, and building enclosure. One of these variations is chosen as "typical" for this model, and a breakdown is provided that shows the cost and percentages of each building system or component. The methodology also allows the user to adjust costs for location of the structure (i.e., San Francisco versus Dallas). A description of how to estimate costs from the Means publication is found in Sections 15.2.1.1 and 15.2.1.2 of the *Technical Manual*. Since Means is published annually, fluctuations in typical building cost can be tracked and the user can insert the most up-to-date Means typical building cost into the default database. This procedure is outlined in Section 15.2.1.3 of the *Technical Manual*.

For **HAZUS**, selected Means models have been chosen from the more than 70 models that represent the 28 occupancy types. The wide range of costs shown, even for a single model, emphasize the importance of understanding that the dollar values shown should only be used to represent costs of large aggregations of building types. If costs for single buildings or small groups (such as a college campus) are desired for more detailed loss analysis, then local building specific cost estimates should be used.

5.1.12.3 Dun and Bradstreet

Dun and Bradstreet is an organization that tracks all businesses that are incorporated. Dun and Bradstreet maintains data on the type of business, the number of employees, the square footage of the business, the annual sales and a variety of other information. The default square footage for the occupancy classes and for all the census tracts was created from the 2 and 4 digit (Standard Industrial Classification) SIC 1995-1996 Dun and Bradstreet data. This mapping scheme is listed in Table 3.20 of the *Technical Manual*. Dun and Bradstreet will provide aggregated information for a specific region on total number of employees, total annual sales and total square footage by census tract. They can also provide information on specific businesses. Dun and Bradstreet has multiple offices in the United States and can be located using the local telephone directory assistance.

5.1.12.4 Capital-Related Income

The U. S. Department of Commerce's Bureau of Economic Analysis reports regional estimates of capital-related income by economic sector. Capital-related income per square foot of floor space can then be derived by dividing income by the floor space occupied by a specific sector. Income will vary considerably depending on regional economic conditions. Therefore, default values need to be adjusted for local conditions.

5.1.13 Indirect Economic Loss Parameters

To estimate long-term economic losses (indirect economic losses), you need to supply the variables summarized in Table 5.3. Other inputs will need to be estimated as described below.

Estimates of Supplemental Imports, Inventories (Supplies), Inventories (Demand), and New Export Markets are perhaps the most difficult parameters to estimate. If you have had an earthquake in your region, you will need both pre-quake and post-quake estimates in order to calculate percents as defined in Table 5.3. There are County Development Corporations (CDC) that can provide estimates of local economic activities. However, it

is likely you will have to develop estimates of these parameters through discussions with individuals in the local community. One option is to perform a telephone survey. Another option is to create a panel of individuals from all of the sectors in the local community, ask them these same questions and reach some sort of consensus.

Table 5.3 User supplied inputs for indirect economic module

Variable	Definition	Units[(a)]	Default Value
Current Level of Employment	The number of people gainfully employed, by place of work (not residence).	Employed persons	Region-specific[(b)]
Current Level of Income	Total personal income for the study region.	Million dollars	Region-specific[(b)]
Composition of the Economy (Level I only)	1. Primarily manufacturing 2. Primarily service, secondarily manufacturing. 3. Primarily service secondarily trade.	1, 2, or 3	1
Supplemental Imports	In the event of a shortage, the amount of a good/service that was supplied from within the region that can be imported from elsewhere.	Percent of current annual imports (by industry)	Defaults for "distinct region"[(c)]
Inventories (Supplies)	In the event of a shortage, the amount of a good that was supplied from within a region that can be drawn from inventories within the region.	Percent of current annual sales (by industry)	0 (for all industries)
Inventories (Demand)	In the event of a surplus, the amount of a good placed in inventory for future sale.	Percent of current annual sales (by industry)	0 (for all industries)
New Export Markets	In the event of a surplus, the amount of a good which was once sold within the region that is now exported elsewhere.	Percent of current annual exports (by industry)	Defaults for "distinct region"[(c)]
Percent Rebuilding	The percent of damaged structures that are repaired or replaced	Percent	95%
Unemployment Rate	The pre-event unemployment rate as reported by the U.S. Bureau of Labor Statistics	Percent	6%
Outside Aid/Insurance	The percentage of reconstruction expenditures that will be financed by Federal/State aid (grants) and insurance payouts.	Percent	50%
Interest Rate	Current market interest rate for commercial loans.	Percent	5%
Restoration of function	The percent of total annual production capacity that is lost due to direct physical damage, taking into account reconstruction progress.	Percent (by industry, by year for 5 years)	Defaults for "moderate-major" event[(c)]
Rebuilding (buildings)	The percent of total building repair and reconstruction that takes place in a specific year.	Percent (by year for 5 years)	70% (yr. 1), 30% (yr. 2)
Rebuilding (lifelines)	The percent of total transportation and utility lifeline repair and reconstruction that takes place in a specific year.	Percent (by year for 5 years)	90% (yr. 1), 10% (yr. 2)
Stimulus	The amount of reconstruction stimulus anticipated in addition to buildings and lifelines repair and reconstruction.	Percent (by industry, by year for 5 years)	0% (for all)

NOTES:

(a) Percent data should be entered as percentage points, e.g. 60 for 60%.
(b) **HAZUS** provides a default value for the counties in the study region.

(c) See Section 16.5.2.2 of the *Technical Manual*.

5.1.13.1 Current Level of Employment

You can usually obtain data about current levels of employment from the CDC or the U.S. Bureau of Labor Statistics. The U.S. Bureau of Labor Statistics can be contacted at:

Bureau of Labor Statistics
2 Massachusetts Ave., N.E.
Washington, D.C. 20212
Phone: 202-606-7800
Fax: 202-606-7797

5.1.13.2 Current Level of Income

You can usually obtain data about current levels of income from the County Development Corporation or from the U.S. Bureau of Labor Statistics.

5.1.13.3 Composition of the Economy

Information about the composition of the economy may be obtained through the County Development Corporation, Chamber of Commerce, County Commissioner's Office or the Mayor's office of the largest city in the county.

5.1.13.4 Percent Rebuilding

The percent of destroyed property that is reconstructed will depend on the health of the economy of the region when the earthquake occurs. If there are many vacant properties, there are places for displaced companies and households to move. Thus it is likely that not all of the damaged and destroyed properties will be rebuilt. On the other hand, if the economy is booming and the vacancy rate was very low, then there will be a great deal of competition for space. In this case you can expect that most of the damage will be repaired. There is no source of data that will directly tell you the percent of destroyed property that will be reconstructed. As suggested above you might use vacancy rates to get a feel for the extra building capacity in your region. However, you will probably want to run the analysis using several values to see how the analysis changes. Reasonable values rebuilding estimates would be in the range of 95% to 100%.

5.1.13.5 Unemployment Rates

You can obtain pre-event unemployment rates from the U.S. Bureau of Labor Statistics.

5.1.13.6 Outside Aid and Insurance Payouts

Many state governments have an Insurance Commissioner who will most likely have compiled insurance payout statistics for previous disasters in the region. If you have not had a disaster in your region, you may have to contact someone from some other location in the country to ask about payouts resulting from a natural disaster in that region. In the absence of data, you can run the model twice, once with outside aid set to 100% and once with outside aid set to 0%. This will provide you with lower and upper bounds on the indirect economic impacts.

For state aid statistics, contact the state governor's chief economist at the Office of the Governor.

For federal aid statistics contact FEMA either at the main office (in address below) or at a regional office (see Table 5.4):

Federal Emergency Management Agency
500 C. Street S.W., Federal Center Plaza
Washington, D.C. 20472
Phone: 202-646-4600
Fax: 202-646-2531

Table 5.4 Addresses of regional offices of FEMA

FEMA Region	Address		Phone
Region 1	JW McCormack POCH Room 442	Boston, MA 02109	617-223-9540
Region 2	26 Federal Plaza Room 1337	New York, NY 10278	212-225-7209
Region 3	105 S 7th St. Liberty Square Bldg. 2nd floor	Philadelphia, PA 19106	215-931-5608
Region 4	3003 Chamblee-Tucker Road	Atlanta, GA 30341	770-220-5200
Region 5	175 W Jackson Blvd. 4th floor	Chicago, IL 60604	312-408-5501
Region 6	800 N Loop 288	Denton, TX 76201	817-898-5104
Region 7	2323 Grand Blvd. Suite 900	Kansas City, MO 64106	816-283-7061
Region 8	Denver Federal Center, Building 710, P. O. Box 25267	Denver, CO 80225	303-235-4812
Region 9	Presidio Bldg. 105	San Francisco, CA 94129	415-923-7100
Region 10	130 228th St. SW Federal Regional Center	Bothell, WA 98021	206-487-4604

5.1.13.7 Interest Rate

The current market interest rate for commercial loans should be available from a bank, a local newspaper or the Board of Realtors.

5.2 Collecting Inventory Data

It should be understood that many available databases do not contain all of the information that is needed to perform a loss study. For example, they may contain street addresses, the size of the facility, or the value of the facility, but may not contain information about structural type or age. A discussion of inferring missing attributes in inventory databases is found in King and Kiremidjian (1994). Databases may be out of date and may not contain all of the facilities in the region. Another problem the user can encounter is that databases may be in a paper rather than electronic format, making them

difficult or impossible to use. Combining multiple databases can also be problematic. Issues such as double counting facilities and eliminating unnecessary information need to be addressed (King and Kiremidjian, 1994).

In general, the majority of the building inventory used in the regional loss estimation will not be collected or kept on a facility-by-facility basis. Resource limitations make it difficult to collect such detailed information. Management and storage of such a large amount of information, while possible, is beyond the state-of-practice for many municipalities and government agencies. Maintaining facility-specific databases will be most useful for important or hazardous facilities such as hospitals, fire stations, emergency operation centers, facilities storing hazardous materials, and high occupancy facilities, to name a few. Procedures exist for supplementing facility-specific databases with area-specific inventory information. An example of an area specific inventory is the number of square feet of commercial space in a census tract or zip code. These area-specific inventories are often based on economic or land use information that is augmented using inference techniques. For example, the user may have available the number of commercial establishments in a region. Assuming an average size (in square feet) per establishment, the user can infer the total square footage of that occupancy. Similarly, a land use map may be converted to building square footage by multiplying land use area by percent of area covered by buildings (see Section 5.2.2 on Land Use Data).

Techniques for developing inventories by using sidewalk surveys, land use data and aerial photography are briefly discussed below.

5.2.1 Sidewalk/Windshield Survey

5.2.1.1 What's Needed:

- Data Collection Sheet
- Map
- Clip Board
- Camera (optional)
- Pre-field Planning
- Your Feet or an Automobile

A sidewalk survey is a technique that can be used to rapidly inventory and identify characteristics of buildings without entering or performing any engineering analyses of the structure. Essentially, most of the inventory collection is done from the sidewalk or the street. An individual uses a pre-defined data collection sheet, a map and possibly a camera and walks or drives through an area to identify buildings and specified characteristics. A critical aspect of the sidewalk survey is the data collection sheet. An example of a data collection sheet is found in Figure 5.1. This particular data sheet was used for ranking buildings for potential seismic hazards and a scoring system is also included. However, the data sheet could be modified for the needs of the particular region being evaluated.

5.2.1.2 How the Information is used:

- Develop Inventories of Specific Building Types or Occupancy Classes
- Develop or Check Inferencing Rules
- Check Accuracy of Available Inventories

Sidewalk surveys have been performed in a number of cities. In Oakland (Arnold and Eisner, 1984) and Redlands California (County of San Bernardino, 1987), studies were performed to identify unreinforced masonry or other "seismically suspicious" buildings. In Portland Oregon, a sidewalk survey was used to collect building inventory (about 9000 buildings) for all commercial occupancies in the downtown and surrounding areas. An excellent overview of studies that have been performed using sidewalk surveys or rapid visual screening techniques is found in FEMA 155 (1988).

A sidewalk survey can be used to develop or check inference rules that are used to characterize that region. An example of such rules might be that 90% of all low-rise residential buildings are wood frame and 10% are unreinforced masonry. Data collected in a residential portion of the study region can be compared with the rule to check validity. Similarly, different areas within a region will have different building and occupancy patterns depending on when structures were built, zoning laws and land use. Sampling of different areas within the study region can be used to identify these variations.

Finally, the user may have access to previously collected inventories such as tax assessors files. A sidewalk survey can be used to determine if structural information in the assessors file are accurate.

ATC-21/ (NEHRP Map Areas 5,6,7 High)

Rapid Visual Screening of Seismically Hazardous Buildings

Address _____

_____ Zip _____

Other Identifiers _____

No. Stories _____ Year Built _____

Inspector _____ Date _____

Total Floor Area (sq. ft) _____

Building Name _____

Use _____

(Peel-off label)

INSTANT PHOTO

Scale:

OCCUPANCY

Residential	No. Persons
Commercial	0–10
Office	11–100
Industrial	100+
Pub. Assem.	
School	
Govt. Bldg.	
Emer. Serv.	
Historic Bldg.	

Non Structural Falling Hazard ☐

DATA CONFIDENCE

* = Estimated, Subjective, or Unreliable Data

DNK = Do Not Know

STRUCTURAL SCORES AND MODIFIERS

BUILDING TYPE	W	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RC SW)	C1 (MRF)	C2 (SW)	C3/S5 (URM INF)	PC1 (TU)	PC2	RM	URM
Basic Score	**4.5**	**4.5**	**3.0**	**5.5**	**3.5**	**2.0**	**3.0**	**1.5**	**2.0**	**1.5**	**3.0**	**1.0**
High Rise	N/A	-2.0	-1.0	N/A	-1.0	-1.0	-1.0	-0.5	N/A	-0.5	-1.0	-0.5
Poor Condition	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Vert. Irregularity	-0.5	-0.5	-0.5	-0.5	-0.5	-1.0	-0.5	-0.5	-1.0	-1.0	-0.5	-0.5
Soft Story	-1.0	-2.5	-2.0	-1.0	-2.0	-2.0	-2.0	-1.0	-1.0	-2.0	-2.0	-1.0
Torsion	-1.0	-2.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
Plan Irregularity	-1.0	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-1.0	-1.0	-1.0	-1.0
Pounding	N/A	-0.5	-0.5	N/A	-0.5	-0.5	N/A	N/A	N/A	-0.5	N/A	N/A
Large Heavy Cladding	N/A	-2.0	N/A	N/A	N/A	-1.0	N/A	N/A	N/A	-1.0	N/A	N/A
Short Columns	N/A	N/A	N/A	N/A	N/A	-1.0	-1.0	-1.0	N/A	-1.0	N/A	N/A
Post Benchmark Year	+2.0	+2.0	+2.0	+2.0	+2.0	+2.0	+2.0	N/A	+2.0	+2.0	+2.0	N/A
SL2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
SL3	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
SL3 & 8 to 20 stories	N/A	-0.8	-0.8	N/A	-0.8	-0.8	-0.8	-0.8	N/A	-0.8	-0.8	-0.8
FINAL SCORE												

COMMENTS

ATC87H
30032.01

Figure 4-1a Data collection form

Detailed Evaluation Required?

YES NO

54 RSP Method and the Data Collection Form *ATC-21*

Figure 5.1 Example of a data collection sheet for sidewalk survey from FEMA 154 (1988).

5.2.1.3 Steps Followed to Perform a Sidewalk Survey

- Define survey objectives
- Develop survey data sheet
- Identify area where survey is to be performed
- Examine map of survey area looking at density of building construction, and other characteristics that would affect how the area is surveyed
- Perform pre-field data collection (e.g. building age)
    - Train individuals who will perform survey

As discussed earlier, a sidewalk survey can be performed for a variety of purposes. Examples of survey objectives are:

- Inventory building stock according to occupancy
- Inventory building stock according to model building type
- Identify specific occupancies (e.g. # of buildings on a school campus)
- Identify specific model building types (e.g. unreinforced masonry)
- Identify characteristics of the building stock (e.g. age, height)
- Identify potential seismic hazards (e.g. unbraced parapets, overhangs, unusual geometry)

The design of the survey data sheet will depend on the objectives that are defined. As discussed in FEMA 154, the survey data sheet should include a minimum amount of information as listed below:

- Complete address or other identifier of building (i.e. tax assessor's parcel number)
- Name of surveyor
- Number of stories
- Estimate of building plan dimensions

The above minimum information is needed so that the survey can be updated or used again at a later time. It is also useful for directing any survey related questions to the surveyor. It is also useful to have:

- Sketch of building plan
- Photo of building

A good data sheet will be in a check off format so that 1) all buildings will be in the same format, and 2) the inspector will not forget to mark certain information. One suggestion is to develop data labels from some pre-existing database such as Assessor's files or building department files with street addresses, building type and other information that may be determined before going into the field. Using an Assessor's map to mark down relevant information can also be useful.

Identifying structural types from the street can be extremely difficult. Structural frames and walls are often covered with finishes that mask their characteristics. However, building practices can be associated with certain eras, architectural styles or occupancies. This will likely vary by region. FEMA 154 devotes a whole chapter to inferring model building type from architectural styles. Training of surveyors should include instruction in building practices of the region and characteristics that might be used to identify certain building types. Surveyors should train together on the same group of buildings to improve consistency in survey results.

5.2.2 Land Use Data

Land use data can be combined with a series of inferences to develop a building inventory. This approach has been used in many previous loss studies and is described in some detail in Scawthorn and Gates (1983) and ABAG (1986). Land Use data provides information about the location and area of different land use categories in a region. Several steps are required to convert the land use areas to building inventory:

- Land use must be converted to building type
- Land use area must be converted to square feet of building

To convert land use to building type, inferencing rules about the proportion of model building types in each land use category must be developed. An example of these inferences taken from a loss study for Los Angeles County (Scawthorn and Gates, 1983) is shown in Table 5.5. From this table it can be inferred that if the land use is General Commercial (Code 129) then 23% of the land has 1 to 4 story concrete block construction, 9 % has 1 to 2 story tilt-up, 58% has 1 to 2 story wood, 2% has unreinforced masonry and 8% has reinforced masonry. This table was developed based on interviews with experienced engineers and personnel from local building departments. (Note: Using the standardized model building types developed in this methodology, concrete block would be classified as reinforced or unreinforced masonry. You will need to discuss with a local building official or other expert whether or not the concrete block construction contains reinforcing.)

To estimate square footage of each building type, one needs to make inferences about the ratio of building square footage to total land. An example of this type of inference is found in Table 5.6. This table, also taken from Scawthorn and Gates (1983), was developed with the help of real estate consulting services, the local school district, and experienced engineers. Table 5.6 shows that for land containing high-rise apartments (Code 119), the square footage of the apartment is equal to 184% of the land area, whereas for single family dwellings (Code 112), the square footage of these dwellings is only 18% of the land area. For example, if 4 acres of land contain high-rise apartments and 3 acres contained single-family dwellings, the following inventory results:

4 acres x 43,560 sq. ft/acre x 1.84 bldg. sq. ft/sq. ft = 320,600 sq. ft high rise apartments
3 acres x 43,560 sq. ft/acre x 0.18 bldg. sq. ft/sq. ft = 23,522 sq. ft single family residences

These numbers can then be proportioned among building types using the inferences in Table 5.5. The results are shown in Table 5.7.

Table 5.5 Land Use to Building Type Conversion - Proportion by Percent

(from Scawthorn and Gates, 1983)

CODE	LAND USE CATEGORY	BUILDING TYPE - STRUCTURAL MATERIAL AND NUMBER OF FLOORS												
		CONC. BLOCK 1-4	TILT-UP 1-2	WOOD 1-2	WOOD 3-4	CONCRETE 1-2	STEEL 1-2	CONCRETE 3-4	STEEL 3-4	CONCRETE 5-19	STEEL 5-19	URM**	REINFORCED MASONRY	STEEL ≥20
111	ESTATE	3		85								4	8	
112	SINGLE FAMILY			87								5	8	
113	DUPLEX / ROW HOUSING			84								11	5	
114	LOW RISE APARTMENTS / CONDOMINIUMS			84								11	5	
115	MEDIUM RISE APARTMENTS / CONDOMINIUMS			75								13	12	
116	RURAL CLUSTERED			89								6	8	
117	RURAL DISPERSED			96								7	4	
118	MOBILE HOMES / TRAILER PARKS	4		92									4	
119	HIGH RISE APARTMENTS / CONDOMINIUMS									69	21		10	
121	MAJOR OFFICE USE	12		10	3	38	7		5		10	3	12	
122*	MAJOR OFFICE USE -- 8 OR MORE FLOORS													
123	REGIONAL SHOPPING CENTER	13	27	4		44		3					9	
124	NEIGHBORHOOD SHOPPING CENTER	13	7	72								1	7	
125	STRIP/ ROADSIDE COMMERCIAL	6		82								6	6	
127	COMMERCIAL RECREATION	18	3	62		6	2						9	
128	HOTEL / MOTEL	16		61	8							3	12	
129	GENERAL COMMERCIAL	23	9	58								2	8	
132	OIL AND GAS EXTRACTIVE	6				3	91							
133	RESEARCH AND DEVELOPMENT	24	18	9		24	18							
134	MOTION PICTURE	27	15	49									7	
135	MANUFACTURING AND ASSEMBLY	15	34	35		7							9	
136	PETROLEUM REFINING / PROCESSING	10	9			4	46	12	13			1	5	
138	MAJOR METALS	5	5			25	65							
139	WHOLESALING AND WAREHOUSING	19	45	5		13	10			3		1	5	
141	AIRPORT	14	15	27		10	15	10				16	8	
142	RAILROAD	7		33		28	11					7	5	
144	HARBOR FACILITIES	4		32		24	28						5	
150	ELECTRIC POWER FACILITIES	10	5			50	25						10	
152	LIQUID WASTE DISPOSAL FACILITIES	25				50	25							
156	COMMUNICATION FACILITIES	32	5	10		40			4		3		6	
160	SPECIALIZED USE INSTITUTION	22		40		19	4	4	4				7	
161	GOVERNMENT OFFICES AND FACILITIES	21		50	3	12						4	10	
162	EMERGENCY RESPONSE FACILITIES	27		27		28							18	
163	MAJOR HEALTH CARE FACILITIES	6		17		47		10	5				15	
164	ELEMENTARY SCHOOL	7		49		16	15						13	
165	JUNIOR HIGH SCHOOL	13		29		37	3						18	
166	HIGH SCHOOL	13		19		38	6	7					17	
167	COLLEGE / UNIVERSITY / OTHER SCHOOL	16	3	5		48	7	4					17	
168	TRADE SCHOOL	16		27		32	3					1	21	
169	RELIGIOUS FACILITIES	16		42		21	3					2	16	

* Code 122 was distributed amongst building types concrete, 5-19; steel, 5-19; and steel ≥ 20 using a method described in Section 2.4.1.3.1.
Land Use Code 122 was the only one with any of its total area assigned to the steel ≥ 20 building type.

** All of the area assigned to Unreinforced Masonry (URM) was distributed according to a method described in Section 2.4.1.3.2.

Table 5.6 Site coverage for different land use categories (from Scawthorn and Gates, 1983)

CODE	LAND USE CATEGORY	FLOOR AREA RATIO (%)
111	ESTATE	23
112	SINGLE FAMILY	18
113	DUPLEX / ROW HOUSING	25
114	LOW RISE APARTMENTS / CONDOMINIUMS	48
115	MEDIUM RISE APARTMENTS / CONDOMINIUMS	100
116	RURAL CLUSTERED	4
117	RURAL DISPERSED	5
118	MOBILE HOMES / TRAILER PARKS	25
119	HIGH RISE APARTMENTS / CONDOMINIUMS	184
121	MAJOR OFFICE USE	80
122*	MAJOR OFFICE USE -- 8 OR MORE FLOORS	200
123	REGIONAL SHOPPING CENTER	30
124	NEIGHBORHOOD SHOPPING CENTER	28
125	STRIP/ ROADSIDE COMMERCIAL	40
127	COMMERCIAL RECREATION	35
128	HOTEL / MOTEL	70
129	GENERAL COMMERCIAL	35
132	OIL AND GAS EXTRACTIVE	2
133	RESEARCH AND DEVELOPMENT	35
134	MOTION PICTURE	20
135	MANUFACTURING AND ASSEMBLY	65
136	PETROLEUM REFINING / PROCESSING	5
138	MAJOR METALS	50
139	WHOLESALING AND WAREHOUSING	60
141	AIRPORT	5
142	RAILROAD	5
144	HARBOR FACILITIES	30
150	ELECTRIC POWER FACILITIES	10
152	LIQUID WASTE FACILITIES	2
156	COMMUNICATION FACILITIES	5
160	SPECIALIZED USE INSTITUTION	15
161	GOVERNMENT OFFICES AND FACILITIES	60
162	EMERGENCY RESPONSE FACILITIES	50
163	MAJOR HEALTH CARE FACILITIES	80
164	ELEMENTARY SCHOOL	25
165	JUNIOR HIGH SCHOOL	23
166	HIGH SCHOOL	33
167	COLLEGE / UNIVERSITY / OTHER SCHOOL	25
168	TRADE SCHOOL	30
169	RELIGIOUS FACILITIES	30

*The amount of area in Land Use Code 122 was distributed according to a method described in Section 2.4.1.3.1 and this Floor Area Ratio was used only as a check against the estimate.

Table 5.7 Square footage of each building type for study region

	Wood (1-2 stories)	Unreinforced Masonry	Reinforced Masonry	Concrete (5-19 stories)	Steel (5-19 stories)
High Rise Apartments	-	-	32,060	221,214	67,326
Single Family Residential	20,464	1,176	1,882	-	-

Land use information can be obtained from Land Use and Land Cover maps and digital data available from the USGS or from maps developed by local counties and cites. It should be understood that the resolution of USGS maps (1/100,000 or 1/250,000 scale) might not be adequate. Furthermore, these maps are based on aerial photography from the mid-1970s and have not been updated. As a result they will not contain newer developments. An index of available maps and digital data can be obtained from the USGS. Some municipalities maintain their own land use maps or computerized land use databases. A few select regions may maintain land use in a GIS.

5.2.3 Aerial Photography

Aerial photography may be most useful for developing land use maps in areas where they do not exist. A great deal of research has been done on how to convert aerial photographs to land use maps (Gauchet and Schodek, 1984; Johnson, 1986; Jones et al., 1987). The effort involved is significant and therefore other methods of collecting inventory may be more appropriate.

5.2.4 Discussions with Local Engineers and Building Officials

Valuable information, particularly on age and type of construction, can be collected from discussions with engineers, building officials and inspectors. Past experience has shown that the best data collection occurs if interviews are conducted in an organized and consistent manner. In a loss study by the Association of Bay Area Governments (ABAG, 1986) typical interviews lasted 1 to 3 hours and involved filling out a form such as the one shown in Figure 5.2. It was discovered in the interview process that building officials who had been working and living in the region for a number of years could provide much more information than those who were new to the region. In addition, building officials could provide little information about facilities for which they have no jurisdiction - these included public schools, hospitals, state colleges and universities, state penitentiaries and federal military installations.

To develop the occupancy to model building type relationships used in this methodology, several one-day workshops were performed around the country. These workshops were comprised of building officials, engineers and academics. Appendix F contains an example of a questionnaire that was used to better understand the characteristics of the regional building stock.

Figure 5.2 Association of Bay Area Governments (ABAG) survey

TABLE B-1-
PERCENTAGE OF SELECTED BUILDING TYPES
WITHIN LAND USE CLASSIFICATIONS

IS TRACT SPLIT?_____ TRACT POPULATION:_____

CENSUS TRACT NO._____ OTHER JURISDICTIONS: TRACT POPULATION IN JURISDICTION:_____

JURISDICTION:_____ _____ TRACT EMPLOYMENT:_____

_____

LAND USE	WOOD FRAME (%)	LIGHT METAL (%)	MASONRY (%)	CONCRETE AND STEEL (%)	PRE-CAST CONCRETE (%)	MOBILE HOME-TYPE (%)
11 RESIDENTIAL						
(111) 1 or less Du/hectare						
(112) 2-8 Du/hectare						
(113) 9 or more Du/hectare						
(114) Mobile Home Parks						
12 COMMERCIAL & SERVICES						
(121) Retail & Wholesale						
(122) Commercial Outdoor Recreation						
(123) Education						
(1231) Elementary & Secondary						
(1232) Colleges & Universities						
(1233) Stadium						
(124) Hospitals, Rehab. Centers, Other Public Facilities						
(125) Military Installations						
(126) Other Public Institutions and Facilities						
(1261) Stadium						
(1262) Church						
(127) Research Centers						
(128) Office						
(129) Hotels						
13 INDUSTRIAL						
(131) Heavy Industrial						
(132) Light Industrial						
14 TRANSPORTATION UTILITIES						
(141) Highways						
(142) Railways						
(143) Airports						
(144) Ports						
(145) Power Lines						
(146) Sewage treatment plants						
15 COMMERCIAL AND INDUSTRIAL						
16 MIXED URBAN OR BUILT-UP LAND						
(161) Transitional						
(162) Mixed use in buildings						
17 OTHER URBAN OR BUILT-UP						
(171) Extensive recreation						
(1711) Golf Courses						
(1712) Racetracks						
(172) Cemeteries						
(173) Parks						
(174) Open space-urban						
NON URBAN						
(233) Greenhouses						
(55) Sedimentation ponds						
(75) Mines, quarries and gravel pits						
(761) Sanitary land fills						

Comments: