Chapter 3.
Inventory Data: Collection and Classification

3.1 Introduction

An important requirement for estimating losses from floods is the identification and valuation of the building stock, infrastructure, and population exposed to flood hazard *i.e.*, an inventory. Consequently, the HAZUS®MH Flood Model uses a comprehensive inventory in estimating losses. This inventory serves as the default when the users of the model do not have better data available. The inventory consists of a proxy for the general building stock in the continental United States, Hawaii and the US held Territories. Additionally, the model contains national data for essential facilities, high potential loss facilities, selected transportation and lifeline systems, demographics, agriculture, and vehicles. This inventory is used to estimate damage, and the direct economic losses for some elements (*i.e.*, the general building stock) or the associated impact to functionality for essential facilities.

The Earthquake Model's general building stock is currently available at the census tract level but increased resolution is needed to support the Flood Model. The census block was chosen as the level of aggregation due to its relatively small geographic size and the capability of the census to identify data at that level of detail. The census only provides information for the development of the residential structures data. Similar to the Earthquake Model, Dun & Bradstreet (D&B) has provided data for non-residential structures at the census block level.

3.2 Direct Damage Data – Buildings and Facilities

3.2.1 General Building Stock

The General Building Stock (GBS) includes residential, commercial, industrial, agricultural, religious, government and education buildings. Damage is estimated in percent and is weighted by the area of inundation at a given depth for a given census block. The entire composition of the general building stock within a given census block is assumed to be evenly distributed throughout the block. The inventory information necessary for determining a given percent damage for the inundated area is given by relationships between the specific occupancy classifications and the building types. The square foot occupancy table is the table from which all the other tables are based.

All three models (Earthquake, Wind and Flood) use key common data to ensure that the users do not have inventory discrepancies when switching from hazard to hazard. Generally the Flood Model displays GBS data at the census block while the Hurricane and Earthquake Model displays GBS data at the census tract level. In order to allow for future alignment between the Hurricane and Flood Models, the Hurricane Model will display and perform analysis at the census block level if the user has included the Flood Model in the study region. Whenever the Flood Model is included in the study region, all three models require the user to edit the common inventory data at the census block level. The key GBS databases include the following:

- **Square footage by occupancy.** These data are the estimated floor area by specific occupancy (e.g., COM1). For viewing by the user, these data are also rolled up to the general occupancies (e.g., Residential).

- **Full Replacement Value by occupancy.** These data provide the user with estimated replacement values by specific occupancy (e.g., RES1). For viewing by the user, these data are also rolled up to the general occupancies (e.g., Commercial).

- **Building Count by occupancy.** These data provide the user with an estimated building count by specific occupancy (e.g., IND1). For viewing by the user, these data are also rolled up to the general occupancies (e.g., Government).

- **General Occupancy Mapping.** These data provide a general mapping for the GBS inventory data from the specific occupancy to general building type (e.g., Wood). Generally, all three models will agree, however, a user can modify the general occupancy mapping at the census block level in the Flood Model thereby requiring them to select an "average" value at the tract level in the other two models, which will result in variances. This should not be an issue for users making this type of change.

- **Demographics.** This table provides housing and population statistics for the study region.

3.2.1.1 Classification

In previous versions of HAZUS, 28 specific occupancy classifications were used in the baseline inventory. The primary purpose of building classifications is to group buildings with similar valuation, damage and loss characteristics into a set of pre-defined groups for analysis. For example, the damage and loss models represent a typical response of the occupancy classification to inundation. During the development of the Flood Model, it was recommended that the number of specific occupancy classifications increase from 28 to 33 to allow for an enhanced classification of the multi-family dwellings. This was accepted by all three HAZUS$^{®MH}$ contractors and therefore, all three models are using the same specific occupancy classifications.

With respect to classifying buildings by their construction types, where Earthquake Model uses 36 specific construction types (e.g., S1L), the Flood Model uses the five general construction classifications: Wood, Concrete, Masonry, Steel, and Manufactured Housing (aka Mobile Home). Table 3.1 shows the resulting specific occupancy classifications and the label used throughout the HAZUS$^{®MH}$ Flood Model. The table also shows the SIC code classification used in the development of the non-residential facilities.

Table 3.1 HAZUS$^{®MH}$ Building Occupancy Classes

HAZUS Label	Occupancy Class	Standard Industrial Codes (SIC)
Residential		
RES1	Single Family Dwelling	
RES2	Mobile Home	
RES3A	Multi Family Dwelling - Duplex	
RES3B	Multi Family Dwelling – 3-4 Units	
RES3C	Multi Family Dwelling – 5-9 Units	
RES3D	Multi Family Dwelling – 10-19 Units	
RES3E	Multi Family Dwelling – 20-49 Units	
RES3F	Multi Family Dwelling – 50+ Units	
RES4	Temporary Lodging	70
RES5	Institutional Dormitory	
RES6	Nursing Home	8051, 8052, 8059
Commercial		
COM1	Retail Trade	52, 53, 54, 55, 56, 57, 59
COM2	Wholesale Trade	42, 50, 51
COM3	Personal and Repair Services	72, 75, 76, 83, 88
COM4	Business/Professional/Technical Services	40, 41, 44, 45, 46, 47, 49, 61, 62, 63, 64, 65, 67, 73, 78 (except 7832), 81, 87, 89
COM5	Depository Institutions	60
COM6	Hospital	8062, 8063, 8069
COM7	Medical Office/Clinic	80 (except 8051, 8052, 8059, 8062, 8063, 8069)
COM8	Entertainment & Recreation	48, 58, 79 (except 7911), 84
COM9	Theaters	7832, 7911
COM10	Parking	
Industrial		
IND1	Heavy	22, 24, 26, 32, 34, 35 (except 3571, 3572), 37
IND2	Light	23, 25, 27, 30, 31, 36 (except 3671, 3672, 3674), 38, 39
IND3	Food/Drugs/Chemicals	20, 21, 28, 29
IND4	Metals/Minerals Processing	10, 12, 13, 14, 33
IND5	High Technology	3571, 3572, 3671, 3672, 3674
IND6	Construction	15, 16, 17
Agriculture		
AGR1	Agriculture	01, 02, 07, 08, 09
Religion/Non-Profit		
REL1	Church/Membership Organizations	86

Table 3.1 HAZUS$^{®MH}$ Building Occupancy Classes (Continued)

HAZUS Label	Occupancy Class	Standard Industrial Codes (SIC)
Government		
GOV1	General Services	43, 91, 92 (except 9221, 9224), 93, 94, 95, 96, 97
GOV2	Emergency Response	9221, 9224
Education		
EDU1	Schools/Libraries	82 (except 8221, 8222)
EDU2	Colleges/Universities	8221, 8222

The Earthquake Model provided the initial guidelines for the development of the building classifications by building type. As stated earlier, the Flood Model does not require the two-dimension matrix for the building types as seen in the Earthquake Model. With the exception of the velocity damage, for which the damage functions utilize the general building type, all of the Flood Model damage and loss calculations are performed based on the 33 specific occupancies and the foundation distribution that is discussed later in this Chapter. Results for by building type are post-processed from the specific occupancy results.

Table 3.2 shows the general building types as defined in the three models and the range of heights (number of stories) for these building types. Because the damage functions are only marginally dependent on the number of floors, the typical floor information provided in the Earthquake Model Technical Manual is not provided here.

Table 3.2 HAZUS$^{®MH}$ Building Occupancy Classes

Number	Label/Description	Height Name	Height Range
1	Wood Frame	All	All
2	Steel Frame	Low-Rise	1 –3
3		Mid-Rise	4 – 7
4		High-Rise	8 and up
5	Concrete Frame	Low-Rise	1 – 3
6		Mid-Rise	4 – 7
7		High-Rise	8 and up
8	Masonry	Low-Rise	1 –3
9		Mid-Rise	4-7
10		High-Rise	8 and up
11	Manufactured Housing		All

3.2.1.2 The Default General Building Stock Database

The general building stock inventory was developed from the following information:

- Census of Population and Housing, 2000: Summary Tape File 1B Extract on CD-ROM / prepared by the Bureau of Census.
- Census of Population and Housing, 2000: Summary Tape File 3 on CD-ROM / prepared by the Bureau of Census.
- Dun & Bradstreet, Business Population Report aggregated by Standard Industrial Classification (SIC) and Census Block, May 2002.
- Department of Energy, Housing Characteristics 1993. Office of Energy Markets and End Use, DOE/EIA-0314 (93), June 1995.
- Department of Energy, A Look at Residential Energy Consumption in 1997, DOE/EIA-0632(97), November 1999.
- Department of Energy, A Look at Commercial Buildings in 1995: Characteristics, Energy Consumption, and Energy Expenditures, DOE/EIA-0625(95), October 1998.

The US Census and the Dun & Bradstreet data were used to develop the general building stock inventory. The three reports from the Department of Energy (DOE) helped in defining regional variations in characteristics such as number and size of garages, type of foundation, and number of stories. The inventory's baseline floor area is based on a distribution contained in the DOE's Energy Consumption Report. An approach was developed using the same report for determining the valuation of single-family residential homes by accounting for income as a factor on the cost of housing.

Initially the methodology created the opportunity for the user to develop conflicting or discrepant square footage totals for single-family residential structures within a census block between the inventory database and the valuation database. The solution was to integrate the regional DOE distributions with the income factors developed for determining valuation. To do this, default values for typical square footage per single-family home were developed from Energy Information Administration (EIA) data on heated floor space. These default data, shown in Table 3.3, are provided by region and income group. The breakdown reflects not only how typical housing size varies across the U.S., but also how in general, higher income areas tend to contain larger single-family homes.

Consequentially, the default typical square footage data was derived from a detailed, unpublished database provided by the EIA. Only information on families in single-family residences, aggregated across all foundation/basement types, was used. The raw database included information on the number of households by region, income category, and housing floor space. Regional data were available by 9 multi-state census divisions (e.g., New England).

The very nature of the default data, both in occupancy classifications and extent of coverage (national) requires the use of a baseline database collected in a consistent manner for the nation. The data source changes depending on the general use of the inventory being explored. For example, to determine the total floor area (square feet) of single-family residences by census block, one uses a data source like the Census data. While sufficient for residential occupancy, the Census data does not address non-residential occupancy classifications.

The development of the default inventory required two major datasets for the two main elements of the built environment. To create the default inventory for residential structures, the US Department of Commerce's Census of Housing was used. For commercial and industrial structures, a commercial supplier, Dun & Bradstreet (D&B) was contacted. The project team performed the aggregation to the census data, while D&B performed the aggregation to their own data (due to its proprietary nature).

The STF1B census extract at the census block level allows for the quick quantification of the single-family residential environment. When combined with the STF3A census extract at the census block group level, the STF1B can provide a better proxy of the multi-family environment than using one extract alone. In both the single-family and multi-family proxies, the proposed methodology represents an improvement over using single "average" values similar to the existing HAZUS99 data.

The STF3A extract also provides information that is useful in developing distributions for the age of buildings within each census block group as well as valuable demographic data. The age distribution, for example, can be used to infer the Pre-FIRM and Post-FIRM distribution which has an impact on the loss estimation.

The D&B provides a realistic representation of the non-residential environment. Based on the site specific data contained within their database, D&B's data is used to provide a reasonable assessment of the non-residential environment. The processing of the D&B data is discussed in more detail in Section 3.2.1.2.1.

3.2.1.2.1 Specific Occupancy Square Footage by Census Block

Single-Family Residences (RES1)

The following discussion highlights the data development effort for the RES1 square foot values by block. The Census Extract STF1B provides estimates of the single family attached and detached housing units on a block-by-block basis. Several other sources of information were used to develop distributions of square footage relative to the income of the census block group. The DOE distributions of income factors was used to develop a ratio of the census block group income (STF3A field P08A001) and the average income for the region (the nine multi-state census divisions.

The EIA data provided information regarding the heated floor area in relationship to income. Income was reported in 25 categories (e.g., $20,000-$22,499) that were converted into five relative income groups for consistency with the inventory valuation methodology. Housing floor space data were provided in 7 categories (e.g., 2,000-2,399 sq. ft.), which, for purposes of computing typical floor space, were represented by the midpoint of the range (e.g., 2,200 sq. ft.). This enabled average floor space to be calculated for the 9 census divisions and 5 relative income categories.

Table 3.3 Typical Square Footage Per Unit (Main Living Area) by Census Division (R)[1]

***R* = New England**

Income Ratio:	Basement	
	No (j=1)	***Yes[2] (j=2)***
$I_k < 0.5$	1300	975
$0.5 \le I_k < 0.85$	1500	1125
$0.85 \le I_k < 1.25$	1800	1350
$1.25 \le I_k < 2.0$	1900	1425
$I_k \ge 2.0$	2200	1650

***R* = Middle Atlantic**

Income Ratio:	Basement	
	No (j=1)	***Yes[2] (j=2)***
$I_k < 0.5$	1300	975
$0.5 \le I_k < 0.85$	1500	1125
$0.85 \le I_k < 1.25$	1700	1275
$1.25 \le I_k < 2.0$	1900	1425
$I_k \ge 2.0$	2200	1650

***R* = East North Central**

Income Ratio:	Basement	
	No (j=1)	***Yes[2] (j=2)***
$I_k < 0.5$	1300	975
$0.5 \le I_k < 0.85$	1600	1200
$0.85 \le I_k < 1.25$	1700	1275
$1.25 \le I_k < 2.0$	1800	1350
$I_k \ge 2.0$	2500	1875

Table 3.3 Typical Square Footage Per Unit (Main Living Area) by Census Division (R)[1] (Continued)

R **= West North Central**

Income Ratio:	Basement	
	No (j=1)	***Yes[2] (j=2)***
$I_k < 0.5$	1300	975
$0.5 \le I_k < 0.85$	1500	1125
$0.85 \le I_k < 1.25$	1800	1350
$1.25 \le I_k < 2.0$	1800	1350
$I_k \ge 2.0$	2300	1725

R **= South Atlantic**

Income Ratio:	Basement	
	No (j=1)	***Yes[2] (j=2)***
$I_k < 0.5$	1400	1050
$0.5 \le I_k < 0.85$	1600	1200
$0.85 \le I_k < 1.25$	1700	1275
$1.25 \le I_k < 2.0$	2000	1500
$I_k \ge 2.0$	2300	1725

R **= East South Central**

Income Ratio:	Basement	
	No (j=1)	***Yes[2] (j=2)***
$I_k < 0.5$	1300	975
$0.5 \le I_k < 0.85$	1400	1050
$0.85 \le I_k < 1.25$	1700	1275
$1.25 \le I_k < 2.0$	1900	1425
$I_k \ge 2.0$	2500	1875

R **= West South Central**

Income Ratio:	Basement	
	No (j=1)	***Yes[2] (j=2)***
$I_k < 0.5$	1300	975
$0.5 \le I_k < 0.85$	1700	1275
$0.85 \le I_k < 1.25$	1800	1350
$1.25 \le I_k < 2.0$	1900	1425
$I_k \ge 2.0$	2500	1875

Table 3.3 Typical Square Footage Per Unit (Main Living Area) by Census Division (R)[1] (Continued)

***R* = Mountain**

Income Ratio:	Basement	
	No (j=1)	***Yes[2] (j=2)***
$I_k < 0.5$	1200	900
$0.5 \le I_k < 0.85$	1500	1125
$0.85 \le I_k < 1.25$	1700	1275
$1.25 \le I_k < 2.0$	1800	1350
$I_k \ge 2.0$	2600	1950

***R* = Pacific**

Income Ratio:	Basement	
	No (j=1)	***Yes[2] (j=2)***
$I_k < 0.5$	1300	975
$0.5 \le I_k < 0.85$	1500	1125
$0.85 \le I_k < 1.25$	1700	1275
$1.25 \le I_k < 2.0$	1900	1425
$I_k \ge 2.0$	2100	1575

Notes:

1 based on data from the Energy Information Administration, Housing Characteristics 1993;

2 (Area of main living area if basement present) = 0.75 x (Area of main living area if no basement). This adjustment allows consistent application of the Means cost models, in which basement areas are added-on, and are assumed to be 1/3 of main living area.

While the US Census data does have data defining the median income for each census block, there is data for the median income for each census block group. This value will be applied to each block within the block group. With the a median income for each census block, and the median income for the census region, it is possible to define an Income Ratio that can be used to determine the square footage for buildings with and without basements. Table 3.4 below shows the 9 census regions, the states within those regions and the values used to compute the Income Ratio. The value from the Census STF3A field P08A001 is the median income for the census block group that will be applied to every census block within the group. The distribution of basements is a summation or roll-up of the foundation type distribution discussed later in this section.

Table 3.4 Income Ratio and Basement Distribution by Census Region

Region (States)	Income Ratio	Percent with Basement	Percent without Basement
AL	P053001 / 36,268	25	75
AK	P053001 / 52,492	13	87
AZ	P053001 / 39,653	32	68
AR	P053001 / 30,082	5	95
CA	P053001 / 45,070	13	87
CO	P053001 / 49,216	32	68
CT	P053001 / 50,647	81	19
DE	P053001 / 47,438	23	77
DC	P053001 / 38,005	23	77
FL	P053001 / 37,305	23	77
GA	P053001 / 41,481	23	77
HI	P053001 / 45,657	13	87
ID	P053001 / 37,760	32	68
IL	P053001 / 46,649	68	32
IN	P053001 / 41,315	68	32
IA	P053001 / 41,560	75	25
KS	P053001 / 38,393	75	25
KY	P053001 / 36,826	25	75
LA	P053001 / 32,500	5	95
ME	P053001 / 39,815	81	19
MD	P053001 / 52,846	23	77
MA	P053001 / 45,769	81	19
MI	P053001 / 46,034	68	32
MN	P053001 / 50,088	75	25
MS	P053001 / 31,963	25	75
MO	P053001 / 44,247	75	25
MT	P053001 / 32,553	32	68
NE	P053001 / 39,029	75	25
NV	P053001 / 43,262	32	68
NH	P053001 / 48,029	81	19
NJ	P053001 / 51,739	76	24
NM	P053001 / 34,035	32	68
NY	P053001 / 40,822	76	24
NC	P053001 / 38,413	23	77
ND	P053001 / 33,769	75	25

Table 3.4 Income Ratio and Basement Distribution by Census Region (Continued)

Region (States)	Income Ratio	Percent with Basement	Percent without Basement
OH	P053001 / 41,972	68	32
OK	P053001 / 34,020	5	95
OR	P053001 / 41,915	13	87
PA	P053001 / 41,394	76	24
RI	P053001 / 43,428	81	19
SC	P053001 / 36,671	23	77
SD	P053001 / 35,986	75	25
TN	P053001 / 35,874	25	75
TX	P053001 / 39,296	5	95
UT	P053001 / 46,539	32	68
VT	P053001 / 40,908	81	19
VA	P053001 / 47,701	23	77
WA	P053001 / 46,412	13	87
WV	P053001 / 29,217	23	77
WI	P053001 / 45,441	68	32
WY	P053001 / 38,291	32	68

Once the parameters above had been defined, it is possible to develop an algorithm that allows for the estimation of the RES1 or single-family residential square footage for the entire nation. This algorithm is:

> RES1 (sq. ft.) = Total Single Family Units (STF1B H1BX0002) *[(Percent of units with basement) * (floor area w/basement based on income ratio and region) + (Percent of units without basement)*(floor area w/o basement based on income ratio and region] where Income Ratio = STF3A P08A001/regional income

For a sample New England census block, 81% Basement 19% no basement and an I_k of 0.67:

> RES1 (sq. ft.) = [STF1BX0002] * [(0.81)*(1,125) + (0.19)*(1,500)]

<u>Multi-Family and Manufactured Housing (RES3 and RES2)</u>

Developing the multi-family (RES3A through RES3F) and manufactured housing (RES2) inventory requires additional information and effort compared to the single-family occupancy classification. In the 1999 census extract, the STF1B (census block data) extract identifies only those housing units within the 10 or more unit classification, unfortunately, the 2000 census extract no longer provided that information. Therefore in order to define of the multi-family units, it is necessary to utilize the STF3A extract. The multi-family definition in the STF3A extract identifies Duplex, 3-4 Unit, 5-9 unit, 10-19 unit, 20-49 unit, and 50+ dwellings. Additionally the STF3A census data provides a definition of the Manufactured Housing (MH) units within a block group and therefore the RES2 was processed at the same time. The census data has an "other" classification for that will be ignored since this classification represent a very small portion of the universe of housing units and there is no "other" damage functions that can be assigned to these facilities. Examples of the "Other" Census classification include vans and houseboats.

Unlike the single family residential that used the Housing Characteristics 1993 to define heated floor area, assessor data from around the United States, including that from the six Proof-of-Concept (POC) communities, was reviewed to develop preliminary estimates of average floor area for multi-family housing. This data was then peer reviewed by engineering experts to develop an average floor area per number of units for the unit ranges provided by the census data. Table 3.5 shows the distribution of the floor area by unit. The associated equations provide an example of the calculations that have taken place.

Table 3.5 Floor Areas for Multi-Family Dwellings (RES2 & RES3A-RES3F)

Units	Duplex	3-4	5-9	10-19	20-49	50+	Manufactured Housing	Other
Floor Area	1,500	750	800	750	700	650	Single Wide – 950 Double Wide – 1,350	Not Required

Previously, the flood model team had a complex process that allowed for a more accurate block level distribution. However, when the US Census Bureau modified the SF1 extract to eliminate information regarding the single-family and large multi-family fields, it became necessary to modify the data manipulation process. The multi-family data was still available in the SF3 extract at the census block group level. The only available process was to distribute the census block group data homogeneously throughout the census blocks. The distribution process is facilitated by finding the ratio of total housing units per census block (H1BX0001) with respect to the total housing units per census block group (H0010001). This ratio was then used to as a multiplier to distribute the census block group level multi-family data into each census block.

<u>Step 1</u>: Develop the ratio of total housing units for each census block"

Unit Ratio = (H1BX0001)/(H0010001)

<u>Step 2</u>: Distribute the multi-family housing units throughout each census block

For example:

Duplex units per block = H0200003*Unit Ratio

<u>Step 3</u>: Derive Floor area per occupancy classification

Manufactured Housing (sq. ft.) = Census Block RES2 (from Step 2)* (0.75 * 950 + 0.25 * 1,400)

Duplex (sq. ft.) = (Census Block Duplex from Step 2) * 1,500

3-4 Units (sq. ft.) = (Census Block 3-4 units from Step 2) * 750

5-9 Units (sq. ft.) = (Census Block 5-9 units from Step 2) * 800

10-19 Units (sq. ft.) = (Census Block 10-19 units from Step 2) * 750

20-49 Units (sq. ft.) = (Census Block 20-49 units from Step 2) * 700

50+ Units (sq. ft.) = (Census Block 50+ units from Step 2) * 700

By using the above distribution, the valuation can be more specifically tailored to each floor plan. This has the potential future benefit of allowing the user to modify the floor area for multi-family units. For example in future releases, it may be possible to provide the user the capability to modify the average floor area for duplexes to 2,000 Sq Ft per unit if this more closely reflected the users community. This should then lead to a net decrease in the total number of units for the RES3A occupancy classification.

The floor areas presented for manufactured housing are based on review of various internet websites for manufactured housing sales (new and used), housing manufacturers, and finally additional US Census Bureau data. There was a great deal of information regarding sales and shipment of manufactured housing since the 1970’s, but there was very little information regarding the attrition rate experienced over the same 30-year span. Charting information from the Manufactured Housing Institute, Figure 3.1 shows that there has been a general growth trend in the size of the units since the 1980’s for both the single wide and doublewide (also known as single-section and multi-section) manufactured housing.

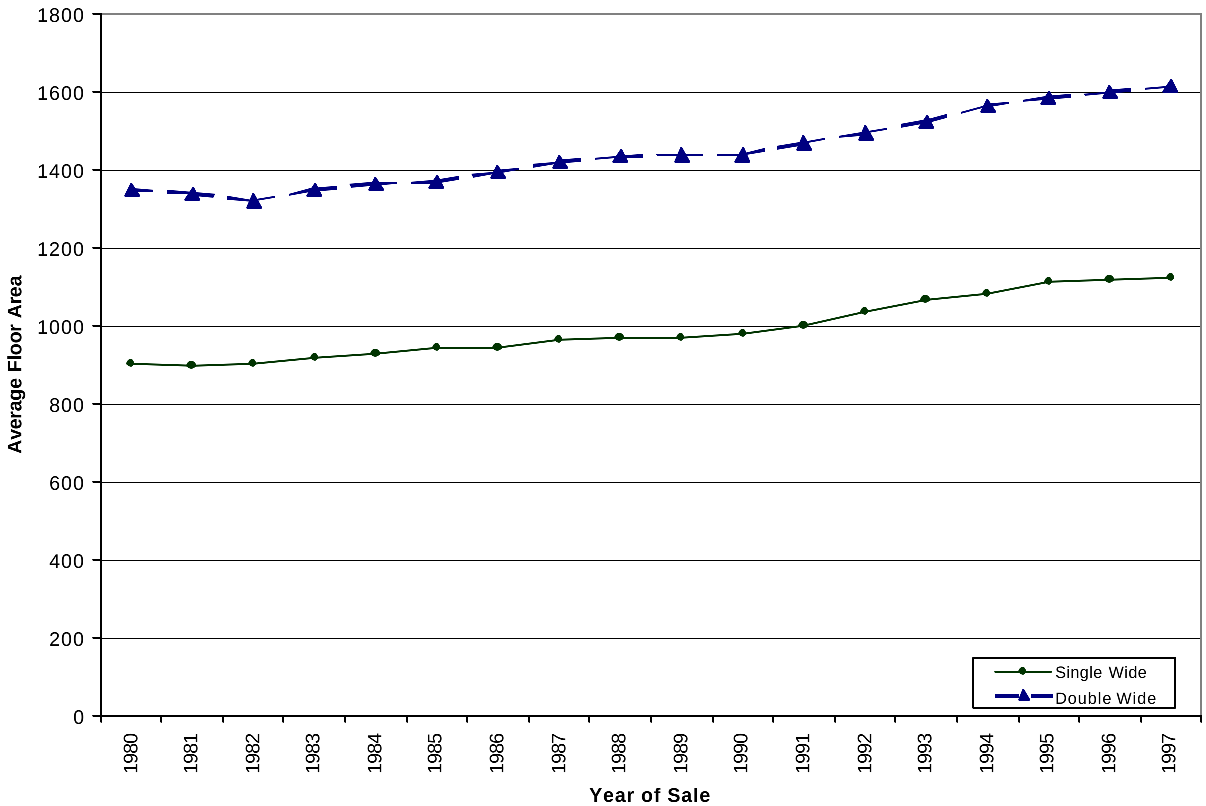

Figure 3.1 Manufactured Housing Growth Over Time

The recently released American Housing Survey for the US, 1997[1] (September, 1999) contained estimated floor areas for manufactured housing (labeled Mobile Home in the Census tables) based on a surveyed population of over 8 million manufactured homes across the United States. The survey does not differentiate between single-section and multi-section units, but when the values are charted the distribution presents natural points to estimate these dimensions. Figure 3.2 shows the distribution of floor area by number of structures from the survey. Using this distribution, it is possible to estimate representative values for single-section and multi-section units of 950 Square Feet and 1,400 Square Feet respectively.

1 US Department of Housing and Urban Development and US Census Bureau, American Housing Survey for the United States H150/97, Office of Policy Development an Research and the US Census Bureau, September 1999.

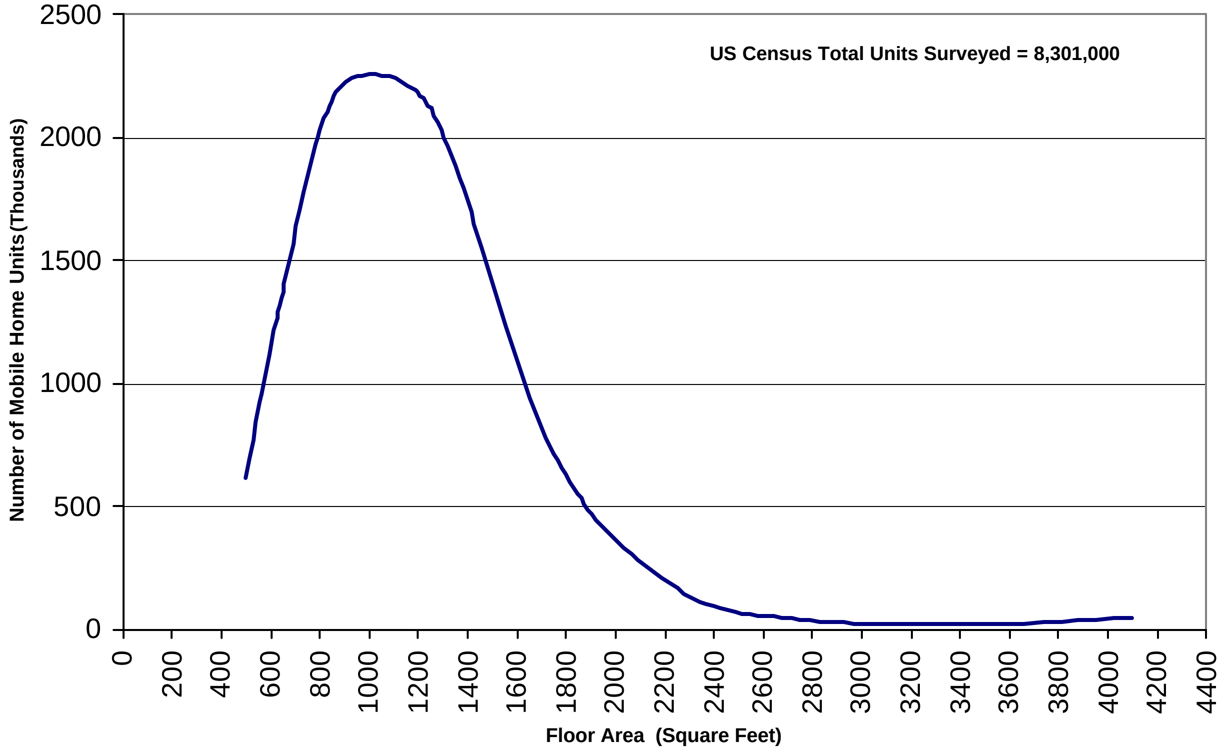

Figure 3.2 Number of Mobile Home Units by Floor Area – 1990 US Census Data Housing Characteristics

Non-Residential Occupancy Classifications

The HAZUS99 Earthquake Model inventory used the D&B business inventory at the census tract level for all non-residential structures and those facilities that are commercial in nature but provide housing for people such as hotels (RES4) and nursing homes (RES6). The D&B data represents approximately 76 percent (approximately 14 million) of the total estimated businesses in the United States (approximately 19 million). While initially this might seem like a low representation, the D&B database accounts for 98 percent of the gross national product. D&B states that the remaining businesses are likely to be smaller and home-based. If true, the proxy inventory established for the residential dwellings will account for these businesses in the total damage estimates.

D&B provided the data aggregated on the SIC definitions used previously in the development of the HAZUS99 Earthquake Model (HAZUS99 Users Manual, 1997 Table Appendix A.19, page A-23). The D&B data obtained for the Flood Model provided floor area for businesses at the census block level. It should be noted that D&B performs regular random sampling of businesses in their database to obtain the actual floor area. D&B then utilizes proprietary algorithms to estimate the floor area for the remaining businesses. According to D&B, floor area is sampled for approximately 25 percent of their business database and the remainder is modeled.

With their data, D&B provided a count of businesses, the total floor area (modeled and sampled), and the total number of employees. During a review of the data, it was discovered that D&B had some data aggregated at the census block groups and tracts level. Review of the data determined that these errors were consistent with automated georeferencing processes and are likely to represent those businesses where the addresses did not match directly with D&B's reference street base. D&B performed an additional review and ascertained that this was in fact the cause of this aggregation. It was felt, however, that the tract and block group data could be safely distributed to the census blocks based on weighted averages of commercial development within the blocks. Review of the results of this effort showed little net impact and continued agreement with ground truth data.

The D&B data contained information on all non-residential uses including some agricultural facilities, general government offices, schools, and churches. Again, comparison with POC data and other available data showed relatively good agreement.

Building Height (Number of Stories)

Table 3.6 provides a distribution of the single-family residential structures by census region. When reviewing the new data within the Residential Energy Consumption 1997 report, there was sufficient data to develop the distributions in Table 3.5. As can be seen in this table, the Northeast region has a larger percentage of 2-story single-family homes than any other census region with the South and West having a preponderance of 1-story single-family homes.

Table 3.6 Distribution of Floors for Single Family Residences

US Census Region	States within the Region	Number of Stories (% of Structures)			
		1-Story	2-Story	3-Story	Split Level
Northeast	CT, MA, ME, NH, NJ, NY, PA, RI, VT	29	61	8	2
Midwest	IA, IL, IN, KS, MI, MN, MO, NE, ND, OH, SD, WI	44	45	5	6
South	AL, AR, DE, DC, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV	72	23	3	2
West	AK, AZ, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA, WY	68	26	3	3

Data Source – A Look at Residential Energy Consumption in 1997 (Nov 1999) Table HC1-13a converted to percent of total single family dwellings.

For the multi-family residences, the Housing Characteristics 1993 report did not provide any distribution by number of floors. This information was enhanced in the Residential Energy Consumption 1997 report with a broad distribution of number of floors that is best represented in Table 3.7. The actual data is provides a little more detail than that seen in the table, but based on the current damage functions available, there is no real value in providing additional definition above 5 floors.

Table 3.7 Distribution of Floors for Multi-Family Residences

US Census Region	States within the Region	Number of Stories (% of Structures)		
		1-2 Stories	3-4 Stories	5+ Stories
Northeast	CT, MA, ME, NH, NJ, NY, PA, RI, VT	29	26	45
Midwest	IA, IL, IN, KS, MI, MN, MO, NE, ND, OH, SD, WI	49	29	22
South	AL, AR, DE, DC, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV	66	21	13
West	AK, AZ, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA, WY	58	25	17

Data Source – A Look at Residential Energy Consumption in 1997 (Nov 1999) Table HC1-13a converted to percent of total multi-family dwellings.

For commercial and industrial structures it is possible to develop a distribution of floors based on the Commercial Building Characteristics[2] (1997). **The Commercial Building Characteristics Table 10 – Year Constructed, Number of Buildings,** 1995 provides for Low, Medium and High rise ranges (approximately consistent with the current HAZUS distributions) based on year built. The range of dates provided do not align exactly with the US Census ranges, but when aligned as seen in Table 3.8 it is possible to create a working relationship that will allow for the creation of a distribution of low, medium and high rise.

Table 3.8 Association of US Census "Year Built" with Commercial Building Characteristics "Year Constructed"

US Census Year Built Ranges for Residential Units	Corresponding Commercial Building Characteristics Year Constructed Ranges
1939 or Earlier and 1940-1949	1919 or Before and 1920-1945
1950-1959	1946-1959
1960-1969	1960-1969
1970-1979	1970-1979
1980-1988	1980-1989
1989-Mar 1990	1990-1992 1993-1995

When using Table 3.8 as the basis for relating the commercial development with the physical characteristic of number of floors, Table 3.9 is developed.

[2] Department of Energy, 1995. A Look At Commercial Buildings in 1995 DOE/EIA-0625(97), Washington, D.C., Energy Information Administration Office of Energy Markets and End Use, US Department of Energy, October, 1998.

Table 3.9 Distribution of Number of Floors by Year Built Commercial Buildings

Census Year Built	Low Rise	Mid-Rise	High Rise
1939 or Earlier and 1940-1949	92	7	1
1950-1959	98	1	1
1960-1969	96	3	1
1970-1979	98	1	1
1980-1989	96	3	1
Post 1990	96	3	1

Data Source - Commercial Building Characteristics Table 10 – Year Constructed, Number of Buildings, 1995

3.2.1.2.2 Building Foundation Type

The distribution of foundations, the associated first floor heights, and the Pre/Post-FIRM relationships are the key controlling parameters affecting flood damage within the model. The flood model allows the user to define or control these parameters in the Flood Specific Occupancy Mapping dialogs, which are discussed in further detail in Section 5.2 of this Technical Manual. This section will focus on the process by which the foundation distributions and the first floor heights were defined.

To properly develop a distribution of foundation types, the following foundation definitions are used:

- **Slab-on-Grade:** Concrete slab resting on the ground. It may have its edges thickened or turned down, but does not rely on other walls or footings for support.

- **Fill:** Soil built up above the natural ground elevation and used to support a slab or shallow footings.

- **Crawlspace:** Usually short (less than 4 ft high), load bearing, masonry or concrete walls around the perimeter of the building footprint, supported on shallow footings. Floor beams or joists rest atop the walls and may also rest on interior piers.

- **Basement or Garden Level Basement:** Any level or story, which has its floor subgrade on all sides. Usually load bearing, masonry or concrete walls around the perimeter of the building, supported on shallow footings. Floor beams or joists rest atop the walls. Shallow basements with windows slightly above grade are defined as a garden level basement.

- **Pier:** An open foundation (no load-bearing perimeter walls), usually built of masonry units and supported by shallow footings. Piers usually range from approximately 2 ft to 8 ft in height.

- **Solid Wall:** Load-bearing perimeter walls greater than 4 ft in height, usually supported by shallow footings. Floor beams or joists usually rest atop the walls, and may or may not be supported by interior piers or columns.

- **Pile:** An open foundation, composed of tall and slender members, embedded deeply into the ground. A pile is a single element, not built-up on site like a pier. For our purposes, cast-in-place columns supported by a deep foundation (pile cap, or mat or raft below the anticipated scour depth) will be classified as a pile foundation. In some pile-supported buildings, shear walls may be used to transfer shear from the upper building to the embedded foundation elements.

Riverine Building Foundation Types

Foundation type can be determined from either the Housing Characteristics report (1993) or the Residential Energy Consumption report (1997) with the exception of those areas subjected to coastal flood hazards. Foundation types such as pilings are not considered or mentioned in the either report, but this information can be derived from the H. John Heinz III Center data collected for their report "The Hidden Cost of Coastal Hazards" (2000). Coastal hazard areas will be discussed later in this section.

When the two reports were compared there seemed to be only moderate differences in the total percentages. For this reason, the Residential Energy Consumption (1997) census division reporting was used to enhance accuracy of the foundation distributions available to the user. While the Residential Energy Consumption report does not consider multi-family residences of five units or less, it will be assumed that this distribution can be applied to these structures since the numbers are so similar to the distributions found in the Housing Characteristics.

For non-coastal development Table 3.10 provides the recommended distribution of foundation types (basement, crawlspace, or slab on grade) for single family and multi-family residences of less than 5 units.

Table 3.10 Distribution of Foundation Types for Single Family and Multi-Family* Residences

US Census Region	States within the Region	Foundation Types						
		Pile	Solid Wall	Pier/ post	Basement/ Garden Level	Crawl-space	Fill	Slab-on-Grade
Northeast – New England	CT, MA, ME, NH, RI, VT	0	0	0	81	10	0	9
Northeast – Mid Atlantic	NJ, NY, PA	0	0	0	76	10	0	14
Midwest – East North Central	IL, IN, MI, OH, WI	0	0	0	68	21	0	11
Midwest – West North Central	IA, KS, MN, MO, NE, ND, SD	0	0	0	75	13	0	12
South – South Atlantic	DE, DC, FL, GA, MD, NC, SC, VA, WV	0	0	0	23	35	0	42

Table 3.10 Distribution of Foundation Types for Single Family and Multi-Family* Residences (Continued)

US Census Region	States within the Region	Foundation Types						
		Pile	Solid Wall	Pier/ post	Basement/ Garden Level	Crawl-space	Fill	Slab-on-Grade
South – East South Central	AL, KY, MS, TN	0	0	0	25	49	0	26
South – West South Central	AR, LA, OK, TX,	0	0	0	5	38	0	57
West-Mountain	AZ, CO, ID, MT, NV, NM, UT, WY	0	0	0	32	29	0	39
West – Pacific	AK, CA, HI, OR, WA	0	0	0	13	45	0	42

Data Source: – A Look at Residential Energy Consumption in 1997 (Nov 1999) Table HC1-9b through HC1-12b as percent of single-family housing units.

Riverine Building Floor Height Above Grade

With the distribution of default foundation types determined it is necessary to determine what this means in terms of first floor elevation. For the sake of consistency, it was determined that the measurement of floor height from grade to the top of the finished floor for both Pre-FIRM and Post-FIRM would be a good basis for default values. Table 3.11 provides the default elevations for each foundation type in riverine flood hazard areas. This table also shows the changes in foundation type and height by flood hazard zone and pre-FIRM or Post-FIRM.

Table 3.11 Default Floor Heights Above Grade to Top of Finished Floor (Riverine)

Foundation Type	Pre-FIRM	Post-FIRM
Slab	1 ft	1 ft[1]
Fill	2 ft	2 ft
Crawlspace	3 ft	4 ft
Basement (or Garden Level)	4ft	4 ft[1]
Pier (or post and beam)	5 ft	6 ft
Solid Wall	7 ft	8 ft
Pile	7 ft	8 ft

Source Data: Expert Opinion

Notes:

1 *Typically not allowed, but may exist*

Note the heights shown here are default values. In most cases, regulations are written to include a freeboard above the Base Flood Elevation (BFE). Additionally typical engineering design will shift from one foundation type to another depending on the height necessary to elevate the structure above BFE. Therefore the user is recommended to use the following guidelines for Post-FIRM foundation distributions:

- **Slab-on-Grade:** Typically not allowed in Post-FIRM development. The user should establish the Post-FIRM distribution to match what is actually occurring in the regulated areas.

- **Fill:** Utilized when the BFE plus freeboard is less than 2-feet. If the BFE plus freeboard is greater than 2-feet, typical construction practice is to use other foundation types such as crawlspace, piers, solid walls, or piles.

- **Crawlspaces:** Utilized when the BFE plus freeboard is less than 4-feet. If BFE plus freeboard is greater than 4-feet, typical construction practice is to use other foundation types such as piers, solid walls, or piles.

- **Basements:** Typically not allowed in Post-FIRM development. The user should establish the Post-FIRM distribution to match what is actually occurring in the regulated areas.

- **Piers:** Utilized when the BFE plus freeboard is less than 6-feet. If BFE plus freeboard is greater than 6-feet, typical construction practice is to use other foundation types such as solid walls or piles.

- **Solid Walls:** Utilized when the BFE plus freeboard is less than 8-feet. If the BFE plus freeboard is greater than 8-feet, typical construction practice is to use piles.

- **Piles:** Utilized when the BFE plus freeboard is 8 feet or greater.

<u>Coastal Building Foundation Types</u>

The H. John Heinz III Center for Science, Economics and the Environment has developed a report discussing coastal erosion along the US coastline. Part of this effort entailed collecting data from several coastal communities for the areas that front the actual coastline. Their study included site visits to survey the areas of interest. While the data they developed was collected for a different task, it contained detailed information on the structures that front coastlines from around the US. For additional information regarding the methodology of data collection and the complete metadata discussion, please refer to the Heinz Center's report[3].

The Heinz Center's data was supplied with the necessary metadata to allow for analysis to identify potential usefulness for the HAZUS$^{®MH}$ Flood Model. The data contained information regarding foundation types and the structures flood zone (i.e., A Zone, V Zone, etc.). The data was graphically plotted in order to find distinct construction features by geographic region and

[3] The Heinz Center. 2000. Evaluation of Erosion Hazards. Washington, D.C.: The H. John Heinz III Center for Science, Economics and the Environment.

flood zone appropriate for the development of a modifier table. Table 3.12 shows the table for Pre-FIRM structures that is applied to those census blocks that are within or intersect with the coastal FIRM zones.

Table 3.12 Distribution of Pre-FIRM Foundation Types

Coastline	Pile	Pier	Solid Wall	Basement	Crawl	Fill	Slab
Pacific	7	7	1	2	46	0	37
Great Lakes	0	1	0	0	29	0	70
North Atlantic	47	7	2	0	34	0	10
South Atlantic	34	7	2	0	20	0	37
Gulf of Mexico	34	7	1	1	21	0	36

Source Data: The H. John Heinz III Center for Science, Economics and the Environment study data, and expert opinion

Table 3.12 shows that the Heinz Center did not find any structures that were located on elevated fill in any of their sample communities. The field for elevated fill was kept so users could modify the foundation types to include this classification if it exists within their community. The flood team felt that the communities investigated by the Heinz Center had an unusually high number of pile foundations due to modern hurricane experiences. To accommodate this concern, the North Atlantic, South Atlantic and Gulf Coast V-zones were modified slightly to increase the use of pier foundations and reduce the pile foundations. The team also reduced the slab-on-grade foundations and increased the use of the crawlspace foundations for the Great Lake A-zone.

For Post-FIRM structures, Table 3.13 provides the default distribution for the flood model. It should be noted that the Heinz Center data includes some foundation types that should not have been utilized within the flood zones indicated. For example, the North Atlantic V-zone data includes some slab-on-grade structures. This may be an indication that some of the structures were built just before or were under construction while the ordinances were being put in place.

It is important to note that the flood model will apply the A-zone and V-zones throughout a given census block based on the zone information available in the Q3.

Table 3.13 Distribution of Post-FIRM Foundation Types by Coastal Zones

Coastline	Post-FIRM Distribution of Coastal Foundation Type						
	Pile	Solid Wall	Pier	Basement	Crawlspace	Fill	Slab on Grade
V-Zone							
Pacific	69	0	15	0	10	0	6
Great Lakes	5	0	10	0	30	0	55
North Atlantic	90	0	6	0	0	0	4
South Atlantic	90	0	6	0	1	0	3
Gulf of Mexico	90	0	6	0	1	0	3
A-Zone							
Pacific	20	0	5	0	55	0	20
Great Lakes	5	0	10	0	30	0	55
North Atlantic	67	0	0	0	20	0	13
South Atlantic	62	0	15	0	10	0	13
Gulf of Mexico	62	0	15	0	10	0	13

Source Data: The H. John Heinz III Center for Science, Economics and the Environment study data

Coastal Building Floor Height Above Grade

For coastal flood areas a consistent measure of floor height from grade to the top of the finished floor was selected for both A-zone and V-zone heights. While the FIA looks to the bottom of the lowest horizontal member it is believed that utilizing a constant reference point in the structures made the table clearer and easier for the user. Within the flood model the floor height will automatically be adjusted to reference the lowest horizontal floor member to make the height consistent with the damage curves, which all follow the FEMA coastal approach.

Table 3.14 provides the default elevations for each foundation type in coastal flood hazard areas. This table also shows the changes in foundation type and height by flood hazard zone and pre-FIRM or Post-FIRM. Typically, foundations like slab-on-grade, fill, and crawlspaces are not allowed in V-zone construction, but there will be occasions within communities that these foundations exist in some numbers due to map revisions or delays in compliance enforcement. For this reason V-zone elevations are provided for these foundation types.

Table 3.14 Default Floor Heights Above Grade to Top of Finished Floor (Coastal)

Foundation Type	Pre-FIRM	Post-FIRM	
		A zone	V zone
Slab	1 ft	1 ft[1]	1 ft[1]
Fill	2 ft	2 ft	2 ft[1]
Crawlspace	3 ft	4 ft	4 ft[1]
Basement (or Garden Level)	4ft	4 ft[1]	4 ft[1]
Pier (or post and beam)	5 ft	6 ft	8 ft
Solid Wall	7 ft	8 ft	8 ft
Pile (or column)	7 ft	8 ft	8 ft

Source Data: Expert Opinion

Notes:

1 Typically not allowed, but may exist

3.2.1.2.3 Building Year Built and Pre-FIRM/Post-FIRM Designation

Note, the heights shown here are default values for coastal areas. In most cases, regulations are written to include a freeboard above the Base Flood Elevation (BFE). Additionally typical engineering design will shift from one foundation type to another depending on the height requirements to elevate the structure above BFE. Therefore the user is recommended to use the following guidelines for Post-FIRM foundation distributions:

- **Slab-on-Grade:** This is typically not allowed in Post-FIRM development. The user should establish the Post-FIRM distribution to match what is actually occurring in the regulated areas.

- **Fill:** Typically this foundation is utilized when the BFE plus freeboard is less than 2-feet. If the BFE plus freeboard is greater than 2-feet, typical construction practice is to use other foundation types such as crawlspace, piers, solid walls, or piles. This foundation type is typically not allowed in areas identified as V-zone.

- **Crawlspace:** Typically this foundation is utilized when the BFE plus freeboard is less than 4-feet. If BFE plus freeboard is greater than 4-feet, typical construction practice is to use other foundation types such as piers, solid walls, or piles. This foundation type is typically not allowed in areas identified as V-zone.

- **Basement:** This is typically not allowed in Post-FIRM development. The user should establish the Post-FIRM distribution to match what is actually occurring in the regulated areas.

- **Pier:** Typically this foundation is utilized when the BFE plus freeboard is less than 6-feet (A-zone) and 8-feet (V-zone). If BFE plus freeboard is greater than these heights, typical construction practice is to use other foundation types such as solid walls or piles.

- **Solid Wall:** Typically this foundation is utilized when the BFE plus freeboard is less than 8 feet. If the BFE plus freeboard is greater than 8-feet, typical construction practice is to use piles.

- **Pile:** Typically this foundation is utilized when the BFE plus freeboard is 8-feet or greater.

As with the values in Table 3.11, the foundation results in Table 3.12 were slightly modified to account for the unusually high percentage of pile foundations.

3.2.1.2.4 Garage Distributions

The development of a distribution of garages within a census block assists in the assignment of valuation functions to the dwellings. These valuation functions determine whether or not the structure is luxury, custom, average home, or economy. Once again, both DOE reports were reviewed to determine if the data provided differed and if changes in the methodologies impacted the reporting of this information. This review showed that percentages presented in the report are slightly different, but the methodology did not seem to have an impact on the quality of the reporting and therefore the data from the Residential Energy Consumption Report (1997) will be used. Initially it was hoped that the census divisions could be utilized, but upon review of the data it showed that some data was not reported because either not enough units were interviewed to properly report results or the Relative Standard of Error was greater than 50%. It was therefore determined that Census regions would be used as seen in Table 3.15. The user will have the option to modify the results.

As with some of the other housing characteristics tables, multi-family housing units were not asked about garages, but the totals are reported as a portion of the universe of housing. It is therefore necessary to adjust the table to represent a percentage of single family and small multi-family homes. Again, the housing characteristics tables provide the percentages of multi-family units not asked so this adjustment could be made.

Table 3.15 Distribution of Garages for Single Family Residential Structures

US Census Region	States within the Region	Garage Types				
		1-Car	2-Car	3-Car	Covered Carport	None
Northeast	CT, MA, ME, NH, NJ, NY, PA, RI, VT	32	30	3	2	33
Midwest	IA, IL, IN, KS, MI, MN, MO, NE, ND, OH, SD, WI	21	47	6	3	23
South	AL, AR, DE, DC, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV	16	29	1	13	41
West	AK, AZ, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA, WY	17	45	5	10	23

Data Source: – A Look at Residential Energy Consumption in 1997 (Nov 1999) Table HC1-9b through HC-12b as percent of single-family housing units.

3.2.1.3 Specific Occupancy-to-Model Building Type Mapping

PBS&J should provide the text for this section.

Default mapping schemes for specific occupancy classes to model building types by floor area percentage are provided in Table 3A-X through 3A-Y (PBS&J to provide tables) of Appendix 3A.

3.2.2 Essential Facilities

Essential facilities are those facilities that provide services to the community and should be functional after a flood. Essential facilities include hospitals, police stations, fire stations and schools. The damage for essential facilities is determined on a site-specific basis (i.e., the depth of flooding at the location of the facility based on the latitude and longitude provided). The purpose of the essential facility module is to determine the expected loss of functionality for these critical facilities. Economic losses associated with these facilities are computed as part of the analysis of the general building stock (general building stock occupancy classes GOV2). The data required for the analysis include mapping of essential facility's occupancy classes to model building types or a combination of essential facilities building type and design level. The Flood Model has attempted to mirror the Earthquake Model as much as possible with this approach. Since the Flood Model does provide results in damage states, rather the inventory is simplified and the user can define the construction classification of the building to improve the model.

3.2.2.1 Classification

The essential facilities are also classified based on the building structure type and occupancy class. The building structure types of essential facilities are the same as those for the general building stock presented in Table 3.1. The occupancy classifications are broken into general occupancy and specific occupancy classes. For the methodology, the general occupancy classification system consists of three groups (medical care, emergency response, and schools). Specific occupancy consists of fourteen classes. The occupancy classes are given in Table 3.16, where the general occupancy classes are identified in over each section.

Table 3.16 Essential Facilities Classification

HAZUS Label	Occupancy Class	Description
Medical Care Facilities		
MDFLT	Default Hospital	Assigned features similar to EFHM
EFHS	Small Hospital	Hospital with less than 50 Beds
EFHM	Medium Hospital	Hospital with beds between 50 & 150
EFHL	Large Hospital	Hospital with greater than 150 Beds
EFMC	Medical Clinics	Clinics Labs Blood Banks
Emergency Response		
FDFLT	Default Fire Station	
EFFS	Fire Station	
PDFLT	Default Police Station	
EFPS	Police Station	
EDFLT	Default EOC	
EFEO	Emergency Operation Centers	
Schools		
SDFLT	Default School	Assigned features similar to ESF1
EFS1	Grade Schools Primary/ High Schools	
EFS2	Colleges/Universities	

Unlike the Earthquake Model, which had to deal with damage states and probabilities of having a certain building type, the Flood Model methodology is designed to allow the user to select he general building type for the facility and control the critical input for the estimation of losses. At Level 1, the model will use the basic location information (name, latitude, longitude, general facility information) and identify the depth of flooding at the site. The Flood Model has assigned a default building type, which the user can easily modify. Additionally, an assumed foundation type is also presented to the user for their review and modification.

Since the user can easily modify the foundation type, building type and other key parameters to match the actual facility, the Flood Model does not define a facility as Pre- or Post-FIRM. The user can, however, identify if there is any flood protection surrounding the facility such as floodgates that prevent water from entering a basement.

Critical assumptions are as follows:

- **Basement (Y/N):** The assumption developed from expert opinion is that EFFS, EFS1, and EFS2 do not have basements. All other essential facilities are assumed to have basements. The user can modify this field if their facility is incorrect using the table dialog.

- **First Floor Elevation:** Assume EFEO, EFFS, EFS1, and EFS2 are at grade. Assume all other facilities are 3 feet above grade. The user can adjust this field using the table dialog.

- **Number of Stories:** Assume all ESF1, EFHS, EFMC, EFFS, EFPS, and EFEO are all low rise structures, and the EFHM, and EFHL are mid rise. The user can adjust this field using the table dialog.

- **Damage Functions:** Comparable damage functions from the General Building Stock should be used to determine the estimated damage (percent) from which a loss of function for essential facilities can be developed. The user can change the damage functions in the analysis parameters dialogs.

Using the information presented in Table 3.17 below, it is possible to determine an estimated damage for the facility in the baseline inventory. Unlike earthquake damage, where the facility may remain functional even after some damage has been sustained, the depth of flooding dictates whether a facility remains in operation or not and then clean-up time dictates when functionality is restored. As Table 3.17 shows, the general assumption is that when the depth of flooding at the facility reaches half a foot, typically the facility is closed and people evacuated. In the case of some hospitals, this does not always mean the patients are evacuated, but the trauma center will typically refuse new patients.

Since the essential facility is a point site, the depth can be determined from the grid cell in which the facility falls. Based on the first floor elevation and the existence of a basement, the damage can be estimated and the functionality determined. The user can override the basement, number of stories, and use an alternative damage function by changing the assignment. This approach removes the need for an occupancy mapping for essential facilities.

Table 3.17 Essential Facilities Inventory Occupancy Classification and Flood Model Default Parameters

HAZUS Label	Occupancy Class	Default Building Type	Base-ment	First Floor Height (ft)	No. of Stories	Functionality Depth (ft)
Medical Care Facilities						
MDFLT	Default Hospital	Concrete	Yes	3	Mid	0.5
EFHS	Small Hospital	Concrete	Yes	3	Low	0.5
EFHM	Medium Hospital	Concrete	Yes	3	Mid	0.5
EFHL	Large Hospital	Concrete	Yes	3	Mid	0.5
EFMC	Medical Center	Concrete	Yes	3	Low	0.5
Emergency Centers						
FDFLT	Default Fire Station	Concrete	No	0	Low	0.5
EFFS	Fire Station	Concrete	No	0	Low	0.5
PDFLT	Default Police Station	Concrete	Yes	0	Low	0.5
EFPS	Police Station	Concrete	Yes	0	Low	0.5
EDFLT	Default Emergency Center	Concrete	Yes	0	Low	0.5
EFEO	Emergency Center	Concrete	Yes	0	Low	0.5
Schools						
SDFLT	Default School	Masonry	No	0	Low	0.5
EFS1	School	Masonry	No	0	Low	0.5
EFS2	University	Concrete	No	0	Low	0.5

3.2.3 High Potential Loss Facilities

High potential loss facilities were defined during the development of the Earthquake Model as those facilities that are likely to cause heavy earthquake losses if damaged. For the earthquake methodology, high potential loss (HPL) facilities include nuclear power plants, dams, and some military installations. The inventory data required for HPL facilities include the geographical location (latitude and longitude) of the facility.

The dam classifications are based on the National Inventory of Dams (NATDAM) database (FEMA 1993).

Table 3.18 High Potential Loss Facilities Classifications

HAZUS Label	General Occupancy	Specific Occupancy
Dams		
DDFLT	Dam Default	Default
HPDA	Dams	Arch
HPDB	Dams	Buttress
HPDC	Dams	Concrete
HPDE	Dams	Earth
HPDG	Dams	Gravity
HPDM	Dams	Masonry
HPDR	Dams	Rock fill
HPDS	Dams	Stone
HPDT	Dams	Timber Crib
HPDU	Dams	Multi-Arch
HPDZ	Dams	Miscellaneous
Nuclear Power Plants		
NDFLT	Nuclear Plant Default	Default
HPNP	Nuclear Power Facilities	Nuclear Power Facilities
Military Installations		
MDFLT	Military Default	Default
HPMI1	Military Installations	Barracks/Group Quarters
HPMI2	Military Installations	Officer/Enlisted Quarters - Multi-Unit
HPMI3	Military Installations	Officer/Enlisted Quarters - Detached
HPMI4	Military Installations	Maintenance/Operations Shops
HPMI5	Military Installations	Administrative Offices
HPMI6	Military Installations	Mess Halls
HPMI7	Military Installations	Officer/Enlisted Clubs
HPMI8	Military Installations	Gymnasiums/Armory
HPMI9	Military Installations	Gas/Services Stations
HPMI10	Military Installations	PX/Retail Stores
HPMI11	Military Installations	Arsenals
HPMI12	Military Installations	Other

Damage and loss estimation calculation for high potential loss facilities are not performed as part of the flood methodology. The user can map the locations of the facilities over the flood hazard grid and ascertain the potential for problems associated with the scenario flood conditions and the facility.

3.2.4 User Defined Facilities

By default, there is no baseline inventory for User Defined facilities within HAZUS$^{®MH}$. The user will be provided with a table definition and structure and the opportunity to either import a table that matches that structure, or to add individual records within the data table. Within the Flood Model, the Flood Model will use the damage function from the General Building Stock damage library. The user will can selected another damage function from the Flood Model damage function library or the user can build a function and assign it to the user-defined facility. It is recommended that the user utilize this functionality when they have facilities that do not fall within the normal occupancy classifications. An example of this might be those users who would like to perform a more detailed analysis on structures related to a railway system. The user could create a listing of railway stations, assign the appropriate damage functions and perform the analysis. It is recommended that the user utilize the User Defined facilities feature when the InCAST Tool has been used to collect the inventory data.

Damage and loss estimation calculation for User Defined facilities are performed as part of this methodology and are displayed in results tables, but are not aggregated in a summary report.

3.3 Direct Damage Data - Transportation Systems

The inventory classification scheme for lifeline systems separates components that makeup the system into a set of pre-defined classes. The classification system used in this methodology was developed to provide an ability to differentiate between varying lifeline system components with substantially different damage and loss characteristics. Transportation systems addressed in the methodology include highways, railways, light rail, bus, ports, ferries and airports. The classification of each of these transportation systems is discussed in detail in the following sections. The inventory data required for the analysis of each system is also identified in the following sections.

Effort has been made to classify the components based on their vulnerability to flooding. At this time, the Flood Model does not account for flood borne debris impact or the loads resulting from flood borne debris trapped against transportation features such as bridges. The initial release of the Flood Model will estimate the level of damage to the bridge network and the subsequent functionality of the bridge, but other transportation components have been deferred to later versions.

The Flood Model comes with a baseline bridge database compiled from the National Transportation Atlas and was last updated in 2001. The Flood Model uses the scour field within the database as discussed later in Section 7 of this document. The user can add or remove bridges from this database.

3.3.1 Highway Systems

A highway transportation system consists of roadways, bridges and tunnels. The inventory data required for analysis include the geographical location, classification, and replacement cost of the system components. The Flood Model has tailored the classification system to meet the needs of the flood community and reduce the overall data collection effort.

The Flood Model has delayed the assessment of losses to street segments and other highway components, but will produce an estimate of the percent damage to a bridge and the probability of the bridge being functional depending on the estimated damage.

3.3.1.1 Classification

The classes of highway systems are presented in Table 3.18. The table also provides a comparison of the Flood Model classification scheme to the Earthquake Model classification scheme to allow those users who have an earthquake database to aggregate the data appropriately into the flood requirements.

Table 3.19 Highway System Classifications

Flood Label	Earthquake Label	General Occupancy	Specific Occupancy	HAZUS Valuation[1]
HRD1	HRD1	Highway Roads	Major Roads (1km 4 lanes))	10,000
HRD2	HRD2	Highway Roads	Urban Roads (1 km 2 lanes)	5,000
HTU	HTU1, 2	Highway Tunnel	Highway Tunnel	20,000
HWBM	HWB1, 2	Highway Bridge	Major Bridge	20,000
HWBO	HWB3, 4, 28	Highway Bridge	Other Bridge (include all wood)	1,000
HWBCO	HWB5, 6, 7, 17, 18	Highway Bridge	Other Concrete Bridge	1,000
HWBCC	HWB8, 9, 10, 11, 20, 21, 22, 23	Highway Bridge	Continuous Concrete Bridge	5,000
HWBSO	HWB12, 13, 14, 24, 25	Highway Bridge	Other Steel Bridge	1,000
HWBSC	HWB15, 16, 26, 27	Highway Bridge	Continuous Steel Bridge	5,000

Notes:

1 All dollar amounts are in thousands of dollars.

3.3.2 Railway Systems

A railway transportation system consists of tracks, bridges, tunnels, stations, fuel, dispatch and maintenance facilities. The inventory data required for analysis include the geographical location, classification and replacement cost of the system components. The Flood Model has tailored the classification system to meet the needs of the flood community and reduce the overall data collection effort.

The Flood Model has delayed the assessment of losses to railway segments and other railway components, but will produce an estimate of the percent damage to a bridge and the probability of the bridge being functional depending on the estimated damage.

3.3.2.1 Classification

The classes of railway systems are presented in Table 3.19. The table also provides a comparison of the Flood Model classification scheme to the Earthquake Model classification scheme to allow those users who have an earthquake database to aggregate the data appropriately into the flood requirements.

Table 3.20 Railway System Classifications

Flood Label	Earthquake Label	General Occupancy	Specific Occupancy	HAZUS Valuation[1]
RTR	RTR1, 2	Railway Tracks	Railway Tracks (per km)	1,500
RBRU	RBR1, RBR2	Railway Bridge	Railway Bridge Unknown	5,000
RBRC	RBR1, RBR2	Railway Bridge	Concrete Railway Bridge	5,000
RBRS	RBR1, RBR2	Railway Bridge	Steel Railway Bridge	5,000
RBRW	RBR1, RBR2	Railway Bridge	Wood Railway Bridge	5,000
RTU	RTU1, RTU2	Railway Tunnel	Railway Tunnel	10,000
RSTS	RST2L, RST3L, RST2M, RST3M, RST2H, RST3H	Railway Urban Station	Steel Railway Urban Station	2,000
RSTC	RST1L, RST5L, RST1M, RST5M, RST1H, RST5H	Railway Urban Station	Concrete Railway Urban Station	2,000
RSTW	RST7L, RST7M, RST7H	Railway Urban Station	Wood Railway Urban Station	2,000
RSTB	RST4L, RST6L, RST4M, RST6M, RST4H, RST6H	Railway Urban Station	Brick Railway Urban Station	2,000
RFF	RFF1, RFF2, RFF3, RFF4, RFF5	Railway Fuel Facility	Railway Fuel Facility (Tanks)	3,000
RDF	RDF1, RDF2, RDF3, RDF4	Railway Dispatch Facility	Railway Dispatch Facility (Equip)	3,000
RMFS	RMF2L, RMF3L, RMF2M, RMF3M, RMF2H, RMF3H,	Railway Maintenance Facility	Steel Railway Maintenance Facility	2,800
RMFC	RMF1L, RMF5L, RMF1M, RMF5M, RMF1H, RMF5H	Railway Maintenance Facility	Concrete Railway Maintenance Facility	2,800
RMFW	RMF7L, RMF7M, RMF7H	Railway Maintenance Facility	Wood Railway Maintenance Facility	2,800
RMFB	RMF4L, RMF6L, RMF4M, RMF6M, RMF4H, RMF6H	Railway Maintenance Facility	Brick Railway Maintenance Facility	2,800

Notes:

1 All dollar amounts are in thousands of dollars.

3.3.3 Light Railway Systems

A light railway transportation system consists of tracks, bridges, tunnels, stations, fuel, dispatch and maintenance facilities. The major difference between light rail and rail systems is the power supply, where light rail systems operate with DC power substations. The inventory data required for analysis include the geographical location, classification and replacement cost of the system components. The Flood Model has tailored the classification system to meet the needs of the flood community and reduce the overall data collection effort.

The Flood Model has delayed the assessment of losses to railway segments and other light rail components, but will produce an estimate of the percent damage to a bridge and the probability of the bridge being functional depending on the estimated damage.

3.3.3.1 Classification

The classes of light rail systems are presented in Table 3.20. The table also provides a comparison of the Flood Model classification scheme to the Earthquake Model classification scheme to allow those users who have an earthquake database to aggregate the data appropriately into the flood requirements.

Table 3.21 Light Rail System Classifications

Flood Label	Earthquake Label	General Occupancy	Specific Occupancy	HAZUS Valuation[1]
LTR	LTR1	Light Rail Track	Light Rail Track (per km)	1,500
LBRU	LBR1, LBR2	Light Rail Bridge	Light Rail Bridge Unknown	5,000
LBRC	LBR1, LBR2	Light Rail Bridge	Concrete Light Rail Bridge	5,000
LBRS	LBR1, LBR2	Light Rail Bridge	Steel Light Rail Bridge	5,000
LBRW	LBR1, LBR2	Light Rail Bridge	Wood Light Rail Bridge	5,000
LTU	LTU1, LTU2	Light Rail Tunnel	Light Rail Tunnel	10,000
LDC	LDC1, LDC2	DC Substation	DC Substation (equip)	2,000
LDF	LDF1, LDF2, LDF3, LDF4	Dispatch Facility	Dispatch Facility (equip)	3,000
LMFS	LMF2L, LMF3L, LMF2M, LMF3M, LMF2H, LMF3H	Maintenance Facility	Steel Maintenance Facility	2,600
LMFC	LMF1L, LMF5L, LMF1M, LMF5M, LMF1H, LMF5H	Maintenance Facility	Concrete Maintenance Facility	2,600
LMFW	LMF7L, LMF7M, LMF7H	Maintenance Facility	Wood Maintenance Facility	2,600
LMFB	LMF4L, LMF6L, LMF4M, LMF6M, LMF4H, LMF6H	Maintenance Facility	Brick Maintenance Facility	2,600

Notes:

1 All dollar amounts are in thousands of dollars.

3.3.4 Bus Systems

A bus transportation system consists of urban stations fuel facilities, dispatch and maintenance facilities. The inventory data required for analysis include the geographical location, classification and replacement cost of the system components. The Flood Model has tailored the classification system to meet the needs of the flood community and reduce the overall data collection effort.

The Flood Model has delayed the assessment of losses to bus systems.

3.3.4.1 Classification

The classes of bus systems are presented in Table 3.21. The table also provides a comparison of the Flood Model classification scheme to the Earthquake Model classification scheme to allow those users who have an earthquake database to aggregate the data appropriately into the flood requirements.

Table 3.22 Bus System Classifications

Flood Label	Earthquake Label	General Occupancy	Specific Occupancy	HAZUS Valuation[1]
BPTS	BPT2L, BPT3L, BPT2M, BPT3M, BPT2H, BPT3H	Bus Urban Station	Steel Bus Urban Station	1,000
BPTC	BPT1L, BPT5L, BPT1M, BPT5M, BPT1H, BPT5H	Bus Urban Station	Concrete Bus Urban Station	1,000
BPTB	BPT4L, BPT6L, BPT4M, BPT6M, BPT4H, BPT6H	Bus Urban Station	Brick Bus Urban Station	1,000
BPTW	BPT7L, BPT7M, BPT7H	Bus Urban Station	Wood Bus Urban Station	1,000
BFF	BFF1, BFF2, BFF3, BFF4, BFF5	Bus Fuel Facility	Bus Fuel Facility (tanks)	150
BDF	BDF1, BDF2, BDF3, BDF4	Bus Dispatch Facility	Bus Dispatch Facility (equip)	400
BMFW	BMF7L, BMF7M, BMF7H	Bus Maintenance Facility	Wood Bus Maintenance Facility	1,300
BMFS	BMF2L, BMF3L, BMF2M, BMF3M, BMF2H, BMF3H	Bus Maintenance Facility	Steel Bus Maintenance Facility	1,300
BMFC	BMF1L, BMF5L, BMF1M, BMF5M, BMF1H, BMF5H	Bus Maintenance Facility	Concrete Bus Maintenance Facility	1,300
BMFB	BMF4L, BMF6L, BMF4M, BMF6M, BMF4H, BMF6H	Bus Maintenance Facility	Brick Bus Maintenance Facility	1,300

Notes:

1 All dollar amounts are in thousands of dollars.

3.3.5 Ports and Harbors

Port and harbor transportation systems consist of waterfront structures, cranes/cargo handling equipment, warehouses and fuel facilities. The inventory data required for analysis include the geographical location, classification and replacement cost of the system components. The Flood Model has tailored the classification system to meet the needs of the flood community and reduce the overall data collection effort.

The Flood Model has delayed the assessment of losses to ports and harbors.

3.3.5.1 Classification

The classes of ports and harbors are presented in Table 3.22. The table also provides a comparison of the Flood Model classification scheme to the Earthquake Model classification scheme to allow those users who have an earthquake database to aggregate the data appropriately into the flood requirements.

Table 3.23 Ports and Harbors Classifications

Flood Label	Earthquake Label	General Occupancy	Specific Occupancy	HAZUS Valuation[1]
PWS	PWS1	Waterfront Structures	Waterfront Structures	1,500
PEQ	PEQ1, PEQ2	Cranes/Cargo Handling Equipment	Cranes/Cargo Handling Equipment	2,000
PWHW	PWH7L, PWH7M, PWH7H	Warehouses	Wood Port Warehouses	1,200
PWHS	PWH2L, PWH3L, PWH2M, PWH3M, PWH2H, PWH3H	Warehouses	Steel Port Warehouses	1,200
PWHC	PWH1L, PWH5L, PWH1M, PWH5M, PWH1H, PWH5H	Warehouses	Concrete Port Warehouses	1,200
PWHB	PWH4L, PWH6L, PWH4M, PWH6M, PWH4H, PWH6H	Warehouses	Brick Port Warehouses	1,200
PFF	PFF1, PFF2, PFF3, PFF4, PFF5	Fuel Facility	Port Fuel Facility	2,000

Notes:

1 All dollar amounts are in thousands of dollars.

3.3.6 Ferry Transportation Systems

A ferry transportation systems consists of waterfront structures, passenger terminals, warehouses, fuel facilities, and dispatch and maintenance facilities. The inventory data required for analysis include the geographical location, classification and replacement cost of the system components. The Flood Model has tailored the classification system to meet the needs of the flood community and reduce the overall data collection effort.

The Flood Model has delayed the assessment of losses to ferry transportation systems.

3.3.6.1 Classification

The classes of ferry transportation systems are presented in Table 3.23. The table also provides a comparison of the Flood Model classification scheme to the Earthquake Model classification scheme to allow those users who have an earthquake database to aggregate the data appropriately into the flood requirements.

Table 3.24 Ferry System Classifications

Flood Label	Earthquake Label	General Occupancy	Specific Occupancy	HAZUS Valuation[1]
FWS	FWS1	Water Front Structures	Ferry Waterfront Structures	1,500
FPTW	FPT7L, FPT7M, FPT7H	Ferry Passenger Terminals	Wood Ferry Passenger Terminals	1,000
FPTS	FPT2L, FPT3L, FPT2M, FPT3M, FPT2H, FPT3H	Ferry Passenger Terminals	Steel Ferry Passenger Terminals	1,000
FPTC	FPT1L, FPT5L, FPT1M, FPT5M, FPT1H, FPT5H	Ferry Passenger Terminals	Concrete Ferry Passenger Terminals	1,000
FPTB	FPT4L, FPT6L, FPT4M, FPT6M, FPT4H, FPT6H	Ferry Passenger Terminals	Brick Ferry Passenger Terminals	1,000
FFF	FFF1, FFF2, FFF3, FFF4, FFF5	Ferry Fuel Facility	Ferry Fuel Facility	400
FDF	FDF1, FDF2, FDF3, FDF4	Ferry Dispatch Facility	Ferry Dispatch Facility	200
FMFW	FMF7L, FMF7M, FMF7H	Piers and Dock Facilities	Wood Piers and Dock Facilities	520
FMFS	FMF2L, FMF3L, FMF2M, FMF3M, FMF2H, FMF3H	Piers and Dock Facilities	Steel Piers and Dock Facilities	520
FMFC	FMF1L, FMF5L, FMF1M, FMF5M, FMF1H, FMF5H	Piers and Dock Facilities	Concrete Piers and Dock Facilities	520
FMFB	FMF4L, FMF6L, FMF4M, FMF6M, FMF4H, FMF6H	Piers and Dock Facilities	Brick Piers and Dock Facilities	520

Notes:

1 All dollar amounts are in thousands of dollars.

3.3.7 Airports

A airport transportation systems consists of control towers, runways, terminal buildings, parking structures, fuel facilities, and maintenance and hanger facilities. The inventory data required for analysis include the geographical location, classification and replacement cost of the system components. The Flood Model has tailored the classification system to meet the needs of the flood community and reduce the overall data collection effort.

The Flood Model has delayed the assessment of losses to airports.

3.3.7.1 Classification

The classes of airport transportation systems are presented in Table 3.24. The table also provides a comparison of the Flood Model classification scheme to the Earthquake Model classification scheme to allow those users who have an earthquake database to aggregate the data appropriately into the flood requirements.

Table 3.25 Airports Classifications

Flood Label	Earthquake Label	General Occupancy	Specific Occupancy	HAZUS Valuation[1]
ACTW	ACT7L, ACT7M, ACT7H	Airport Control Towers	Wood Airport Control Towers	5,000
ACTS	ACT2L, ACT3L, ACT2M, ACT3M, ACT2H, ACT3H	Airport Control Towers	Steel Airport Control Towers	5,000
ACTC	ACT1L, ACT5L, ACT1M, ACT5M, ACT1H, ACT5H	Airport Control Towers	Concrete Airport Control Towers	5,000
ACTB	ACT4L, ACT6L, ACT4M, ACT6M, ACT4H, ACT6H	Airport Control Towers	Brick Airport Control Towers	5,000
APTR	ARW1	Airport Runway	Airport Runway (total)	28,000
AFF	AFF1, AFF2, AFF3, AFF4, AFF5	Fuel Facilities	Fuel Facilities	5,000
AFO	AFO1	Seaport/Stolport/Gliderport/etc.	Seaport/Stolport/Gliderport/etc.	500
AFH	AFH1	Heliport Facilities	Heliport Facilities	2,000
APS	ALL	Airport Parking Structure	Airport Parking Structure	1,400
AMFW	AMF7L, AMF7M, AMF7H	Airport Maintenance & Hangar Facility	Wood Airport Maintenance & Hangar Facility	3,200
AMFS	AMF2L, AMF3L, AMF2M, AMF3M, AMF2H, AMF3H	Airport Maintenance & Hangar Facility	Steel Airport Maintenance & Hangar Facility	3,200
AMFC	AMF1L, AMF5L, AMF1M, AMF5M, AMF1H, AMF5H	Airport Maintenance & Hangar Facility	Concrete Airport Maintenance & Hangar Facility	3,200
AMFB	AMF4L, AMF6L, AMF4M, AMF6M, AMF4H, AMF6H	Airport Maintenance & Hangar Facility	Brick Airport Maintenance & Hangar Facility	3,200
ATBW	ATB7L, ATB7M, ATB7H	Airport Terminal Buildings	Wood Airport Terminal Buildings	8,000
ATBS	ATB2L, ATB3L, ATB2M, ATB3M, ATB2H, ATB3H	Airport Terminal Buildings	Steel Airport Terminal Buildings	8,000
ATBC	ATB1L, ATB5L, ATB1M, ATB5M, ATB1H, ATB5H	Airport Terminal Buildings	Concrete Airport Terminal Buildings	8,000
ATBB	ATB4L, ATB6L, ATB4M, ATB6M, ATB4H, ATB6H	Airport Terminal Buildings	Brick Airport Terminal Buildings	8,000
ATBU	ATBU1	Airport Terminal Unknown	Airport Terminal Buildings Unknown	8,000

Notes:

1 *All dollar amounts are in thousands of dollars.*

3.4 Direct Damage Data – Lifeline Utility Systems

The inventory classification scheme for lifeline systems separates components that makeup the system into a set of pre-defined classes. The classification system used in this methodology was developed to provide an ability to differentiate between varying lifeline system components with substantially different damage and loss characteristics. Utility systems addressed in the methodology include potable water, wastewater, oil, natural gas, electric power and communication systems. The classification of each of these utility systems is discussed in detail in the following sections. The inventory data required for the analysis of each system is also identified in the following sections.

Effort has been made to classify the components based on their vulnerability to flooding. At this time, the Flood Model does not account for flood borne debris impact, or water borne debris loads, which can cause significant clean-up efforts for utility systems. The Flood Model is analyzing those system components that are more vulnerable or costly to clean-up, repair or replace since they are likely to control the overall recovery costs and time.

3.4.1 Potable Water Systems

A potable water system consists of pipelines, water treatment plants, control vaults and control stations, wells, storage tanks and pumping stations. The inventory data required for potable water systems analysis include the geographical location and classification of system components. The analysis also requires the replacement cost for facilities and the repair cost for pipelines.

The Flood Model will estimate damage, losses and functionality for select vulnerable components of the potable water system. These include treatment plants, control vaults and control stations, and pumping stations.

3.4.1.1 Classification

The classes of potable water systems are presented in Table 3.25. The table also provides a comparison of the Flood Model classification scheme to the Earthquake Model classification scheme to allow those users who have an earthquake database to aggregate the data appropriately into the flood requirements.

Table 3.26 Potable Water System Classifications

Flood Label	Earthquake Label	General Occupancy	Specific Occupancy	HAZUS Valuation[1]
PWPE	PWP1, PWP2	Pipelines	Exposed Transmission Pipeline Crossing	1
PWPB	PWP1, PWP2	Pipelines	Buried Transmission Pipeline Crossing	1
PWP	PWP1, PWP2	Pipelines	Pipelines (non-crossing)	1
PWSO	PWT1, PWT2	Water Treatment Plants	Small Water Treatment Plants Open/Gravity	30,000
PWMO	PWT3, PWT4	Water Treatment Plants	Medium Water Treatment Plants Open/Gravity	100,000
PWLO	PWT5, PWT6	Water Treatment Plants	Large Water Treatment Plants Open/Gravity	360,000
PWSC	PWT1, PWT2	Water Treatment Plants	Small Water Treatment Plants Closed/Pressure	30,000
PWMC	PWT3, PWT4	Water Treatment Plants	Medium Water Treatment Plants Closed/Pressure	100,000
PWLC	PWT5, PWT6	Water Treatment Plants	Large Water Treatment Plants Closed/Pressure	360,000
PPSB	PPP1, PPP2	Pumping Plants	Pumping Plants (Small) Below Grade	150
PPMB	PPP3, PPP4	Pumping Plants	Pumping Plants (Med/Large) Below Grade	525
PPSA	PPP1, PPP2	Pumping Plants	Pumping Plants (Small) Above Grade	150
PPMA	PPP3, PPP4	Pumping Plants	Pumping Plants (Med/Large) Above Grade	525
PCVS	N/A	Control Vaults and Stations	Control Vaults and Stations	50
PSTC	PST1, PST2	Water Storage Tanks	Water Storage Tanks At Grade Concrete	1,500
PSTS	PST3, PST4	Water Storage Tanks	Water Storage Tanks At Grade Steel	800
PSTW	PST6	Water Storage Tanks	Water Storage Tanks At Grade Wood	30
PSTE	PST5	Water Storage Tanks	Water Storage Tanks Elevated	800
PSTB	N/A	Water Storage Tanks	Water Storage Tanks Below Grade (all)	1,500
PWE	PWE1	Wells	Wells	400

Notes:

1 All dollar amounts are in thousands of dollars.

3.4.2 Wastewater Systems

A wastewater system consists of pipelines, wastewater treatment plants, control vaults and control stations, and lift stations. The inventory data required for wastewater systems analysis include the geographical location and classification of system components. The analysis also requires the replacement cost for facilities and the repair cost for pipelines.

The Flood Model will estimate damage, losses, and functionality for select vulnerable components within the wastewater system including treatment plants, control vaults and stations, and lift stations.

3.4.2.1 Classification

The classes of wastewater systems are presented in Table 3.26. The table also provides a comparison of the Flood Model classification scheme to the Earthquake Model classification scheme to allow those users who have an earthquake database to aggregate the data appropriately into the flood requirements.

Table 3.27 Wastewater System Classifications

Flood Label	Earthquake Label	General Occupancy	Specific Occupancy	HAZUS Valuation[1]
WWPE	WWP1, WWP2	Sewers & Interceptors	Exposed Collector River Crossings	1
WWPB	WWP1, WWP2	Sewers & Interceptors	Buried Collector River Crossings	1
WWP	WWP1, WWP2	Sewers & Interceptors	Pipes (non-crossings)	1
WWTS	WWT1, WWT2	Wastewater Treatment Plants	Small Wastewater Treatment Plants	60,000
WWTM	WWT3, WWT4	Wastewater Treatment Plants	Medium Wastewater Treatment Plants	200,000
WWTL	WWT5, WWT6	Wastewater Treatment Plants	Large Wastewater Treatment Plants	720,000
WWCV	N/A	Control Vaults and Control Stations	Control Vaults and Control Stations	50
WLSW	WLS1, WLS2	Lift Stations	Lift Station (Small) Wet Well/Dry Well	300
WLMW	WLS3, WLS4	Lift Stations	Lift Station (Med/Large) Wet Well/Dry Well	1,050
WLSS	WLS1, WLS2	Lift Stations	Lift Station (Small) Submersible	300
WLMS	WLS3, WLS4	Lift Stations	Lift Station (Med/Large) Submersible	1,050

Notes:

1 All dollar amounts are in thousands of dollars.

3.4.3 Oil Systems

An oil system consists of pipelines, refineries, control vaults and control stations, and tank farms. The inventory data required for oil systems analysis include the geographical location and classification of system components. The analysis also requires the replacement cost for facilities and the repair cost for pipelines.

The Flood Model will estimate damage, losses and functionality for select vulnerable system components within the oil system. This is limited to refineries and control vaults and stations.

3.4.3.1 Classification

The classes of oil systems are presented in Table 3.27. The table also provides a comparison of the Flood Model classification scheme to the Earthquake Model classification scheme to allow those users who have an earthquake database to aggregate the data appropriately into the flood requirements.

Table 3.28 Oil System Classifications

Flood Label	Earthquake Label	General Occupancy	Specific Occupancy	HAZUS Valuation[1]
OIPE	OIP1, OIP2	Pipelines	Exposed Transmission Pipelines River Crossings	1
OIPB	OIP1, OIP2	Pipelines	Buried Transmission Pipelines River Crossings	1
OIP	OIP1, OIP2	Pipelines	Pipelines (non-crossing)	1
OPP	OPP1, OPP2	Pumping Plant	Pumping Plant	1,000
OTF	OTF1, OTF2	Tank Farm	Tank Farm	2,000
OCV	N/A	Oil Control Vault & Control Station	Oil Control Vault & Control Station	50
ORFS	ORF1, ORF2	Oil Refinery	Small Oil Refinery	175,000
ORFM	ORF3, ORF4	Oil Refinery	Medium Oil Refinery	750,000
ORFL	ORF3, ORF4	Oil Refinery	Large Oil Refinery	750,000

Notes:

1 All dollar amounts are in thousands of dollars.

3.4.4 Natural Gas Systems

A natural gas system consists of pipelines, control vaults and control stations, and compressor stations. The inventory data required for natural gas systems analysis include the geographical location and classification of system components. The analysis also requires the replacement cost for facilities and the repair cost for pipelines.

The Flood Model will estimate loses to select vulnerable system components within the natural gas system. This includes the control vaults, control stations and compressor stations.

3.4.4.1 Classification

The classes of natural gas systems are presented in Table 3.28. The table also provides a comparison of the Flood Model classification scheme to the Earthquake Model classification scheme to allow those users who have an earthquake database to aggregate the data appropriately into the flood requirements.

Table 3.29 Natural Gas System Classifications

Flood Label	Earthquake Label	General Occupancy	Specific Occupancy	HAZUS Valuation[1]
NGPE	NGP1, NGP2	Pipelines	Exposed Transmission Pipelines River Crossings	1
NGPB	NGP1, NGP2	Pipelines	Buried Transmission Pipelines River Crossings	1
NGP	NGP1, NGP2	Pipelines	Pipelines (Non-crossing)	1
NGCV	N/A	Control Valves and Control Stations	Control Valves and Control Stations	50
NGC	NGC1, NGC2	Compressor Stations	Compressor Stations	1,000

Notes:

1 *All dollar amounts are in thousands of dollars.*

3.4.5 Electric Power Systems

An electric power system consists of generating plants, substations, distribution circuits, and transmission towers. The inventory data required for electric power systems analysis include the geographical location and classification of system components. The analysis also requires the replacement cost for facilities and the repair cost for transmission lines.

The Flood Model will perform a limited analysis on select vulnerable electric power system components. These components include the generating plants and substations.

3.4.5.1 Classification

The classes of electric power systems are presented in Table 3.29. The table also provides a comparison of the Flood Model classification scheme to the Earthquake Model classification scheme to allow those users who have an earthquake database to aggregate the data appropriately into the flood requirements.

Table 3.30 Electric Power System Classifications

Flood Label	Earthquake Label	General Occupancy	Specific Occupancy	HAZUS Valuation[1]
ESSL	ESS1, ESS2	Substations	Low Voltage Substation	10,000
ESSM	ESS3, ESS4	Substations	Medium Voltage Substation	20,000
ESSH	ESS5, ESS6	Substations	High Voltage Substation	50,000
EDCE	EDC1, EDC2	Distribution Circuits	Distribution Circuits Elevated Crossings	3
EDCB	EDC1, EDC2	Distribution Circuits	Distribution Circuits Buried Crossings	3
EDC	EDC1, EDC2	Distribution Circuits	Distribution Circuits (non-crossing)	3
EPPS	EPP1, EPP2	Generation Plants	Small Power Plants	100,000
EPPM	EPP3, EPP4	Generation Plants	Medium Power Plants	500,000
EPPL	EPP3, EPP4	Generation Plants	Large Power Plants	500,000

Notes:

1 *All dollar amounts are in thousands of dollars.*

3.4.6 Communication Systems

A communication system consists of communications facilities, communications lines, control vaults, switching stations, Radio/TV station, weather station, or other facilities. The inventory data required for communications systems analysis include the geographical location and classification of system components. The analysis also requires the replacement cost for facilities and the repair cost for communications lines.

The Flood Model has deferred estimating damage and losses for communications facilities.

3.4.6.1 Classification

The classes of communications systems are presented in Table 3.30. The table also provides a comparison of the Flood Model classification scheme to the Earthquake Model classification scheme to allow those users who have an earthquake database to aggregate the data appropriately into the flood requirements.

Table 3.31 Communication System Classifications

Flood Label	Earthquake Label	General Occupancy	Specific Occupancy	HAZUS Valuation[1]
CCTE	N/A	Communications Lines	Exposed Communications Lines River Crossings	Need Value
CCTB	N/A	Communications Lines	Buried Communications Lines River Crossings	Need Value
CCT	N/A	Communications Lines	Communications Lines (non-crossings)	Need Value
CCSV	N/A	Control Vault	Control Vault	50
CCS1	CCO1, CCO2, CCO3, CCO4	Switching Stations	Central Offices/Switching Stations Below Grade	5,000
CCS2	CCO1, CCO2, CCO3, CCO4	Switching Stations	Central Offices/Switching Stations At or Above Grade	5,000
CBR	CBR1, CBT1	Radio/TV Station	Radio Station/TV Station	2,000
CBW	CBW1	Weather Station	Weather Station	2,000
CBO	CBO1	Other Communication Facility	Other Communication Facility	2,000

Notes:

1 All dollar amounts are in thousands of dollars.

3.5 Direct Damage Data Agricultural Products

Based on the results from the proof-of-concept exercise and direction from the HAZUS Flood Model Oversight Committee, the methodology for developing the agriculture products inventory has been established. Additionally, the flood model project team took the opportunity to review additional crop loss estimation approaches currently used by the US Army Corps of Engineers (USACE). This includes the current development within the Hydraulic Engineering Center's (HEC) Flood Impact Analysis (FIA) and Flood Damage Assessment (FDA) models. The project team also reviewed a program called Computerized Agricultural Crop Flood Damage Assessment System (CACFDAS). None of these models varied significantly from the Agriculture Flood Damage Analysis (AGDAM) approach tested in the proof-of-concept effort, which has been selected for implementation. The methodology discussed in the Final Task 2 report combines two nationally available datasets that provide sufficient data to develop a general distribution of crops by type, average yield by NRI polygon, the unit price, and the harvest price. As mentioned in the report, the two datasets are the National Resources Inventory (NRI) and the National Agriculture Statistical Service (NASS).

The NRI dataset was created to allow the US Department of Agriculture (USDA) to "…assess the status, conditions and trends of resources at 5-year intervals." The NRI has conducted their survey in 1977, 1982, 1987, 1992 and 1996 and 2001. The data for 2001 is not available for inclusion into the HAZUS®*MH* Flood Model, but this does not pose any issue for the model based on the chosen approach. The NRI data is compiled and presented at the sub-county level. The NRI data consists of point sample data taken throughout the county. This is associated with soils data and "expansion factors" that identify what each sample point represents in terms of acres.

The 1992 NRI dataset was used to develop sub-county polygons (essentially an intersection of the county boundary with the USGS 8-digit Hydrologic Unit codes or HUCS). For example Story County, Iowa and the county is subdivided into six polygons (one of which had no data). For the entire nation, this resulted in an average of six polygons per county. The NRI data also provides sample points taken throughout the county. Each sample point is associated with specific HUC and county polygon, soils data and "expansion factors", statistical weighting factors that establish the total crop acreage and yields represented by the sample point. The NRI data is averaged over each collection interval (5 intervals since 1977) to smooth variations in agriculture yields. These variations include changes in crop types, crop rotation and seasonal or weather related changes in yield. As with every inventory dataset within HAZUS, the user can modify or adjust the values based on more accurate local information. The total yields for each polygon are then summed over the 5 collection intervals and averaged to produce the "average yield" that will be supplied to the user. The user will be able to edit the value to account for their estimated or actual yields. The NRI data provides definition of the units of measure for each crop type (such as bushels). Due to data limitations, the agriculture inventory will not be available for Alaska and the US territories, however the Flood Model is being developed such that users in those areas could easily input locally available data as needed.

The NASS data is compiled annually by the NASS, a branch of the USDA, and covers nearly every aspect of the agriculture industry. This rigorous collection of data is used primarily to assess and estimate crop yields and future industry planting. The data is collected through a variety of sources. The key limitation of this data is that the crop yields are developed for the entire county and do not assess regional variations in crop types or yields. It is believed that the NASS data is more perishable due to the variations in crop yields from year to year. Additionally, the countywide distribution limits the accuracy of the data. The NASS data, however, provides the most up to date estimate on the unit price for each crop type since the data is collected annually. With the strong variations in crop price this field can easily be updated by the user with data from the NASS website. The User Manual will recommend that the user check the NASS website prior to performing an agriculture loss assessment.

By associating the crop types from the NASS data to the NRI, the project team was able to obtain the crop price per unit (e.g., $ per bushel). The NASS data is compiled annually, and the most recent values were used. It is anticipated that the crop price per unit will be the data field most likely modified by users since this value fluctuates annually. The software will make this data field easy to locate, identify, and modify.

Based on conversations with various districts within the USACE and based on review of the previously mentioned crop loss models (FIA, AGDAM, and CACFDAS) used by the USACE, crop losses are substantially affected by the duration of the flood. Since the flood model is not developing a hazard duration factor, the solution is to provide a table of results to the user for a range of durations. The USACE has a set of duration functions with factors for 0, 3, 7, and 14 days of duration. The flood model will provide a single table of losses by crop type for each duration period.

The USACE has provided damage functions for several different crop types and the flood model will use many of these functions as the default. A damage function library is being developed based on curves collected from the various USACE Districts. Damage and duration curves have been obtained from the Sacramento, St. Paul, and Vicksburg Districts. All the curves are based on a Julian calendar to account for the changing potential to loss from planting to harvest. The user will need to provide a date for the flood scenario, and the flood model will determine the Julian date and identify the loss potential from the damage function. The loss will be increased by the duration factors as discussed above.

3.6 Direct Damage Data – Vehicles

In order to utilize HAZUS®*MH* to estimate flood damage of motor vehicles, procedures are required to: 1) calculate vehicle inventory within a study area, 2) allocate vehicles by time of day to different locations, 3) estimate the value of vehicles, and 4) apply a percent loss damage function according to the flood depth. These steps are divided into two parts. The first part is a vehicle location estimator, and the other part is the value of damage calculator. The vehicle location estimator is summarized in Figure 3.3.

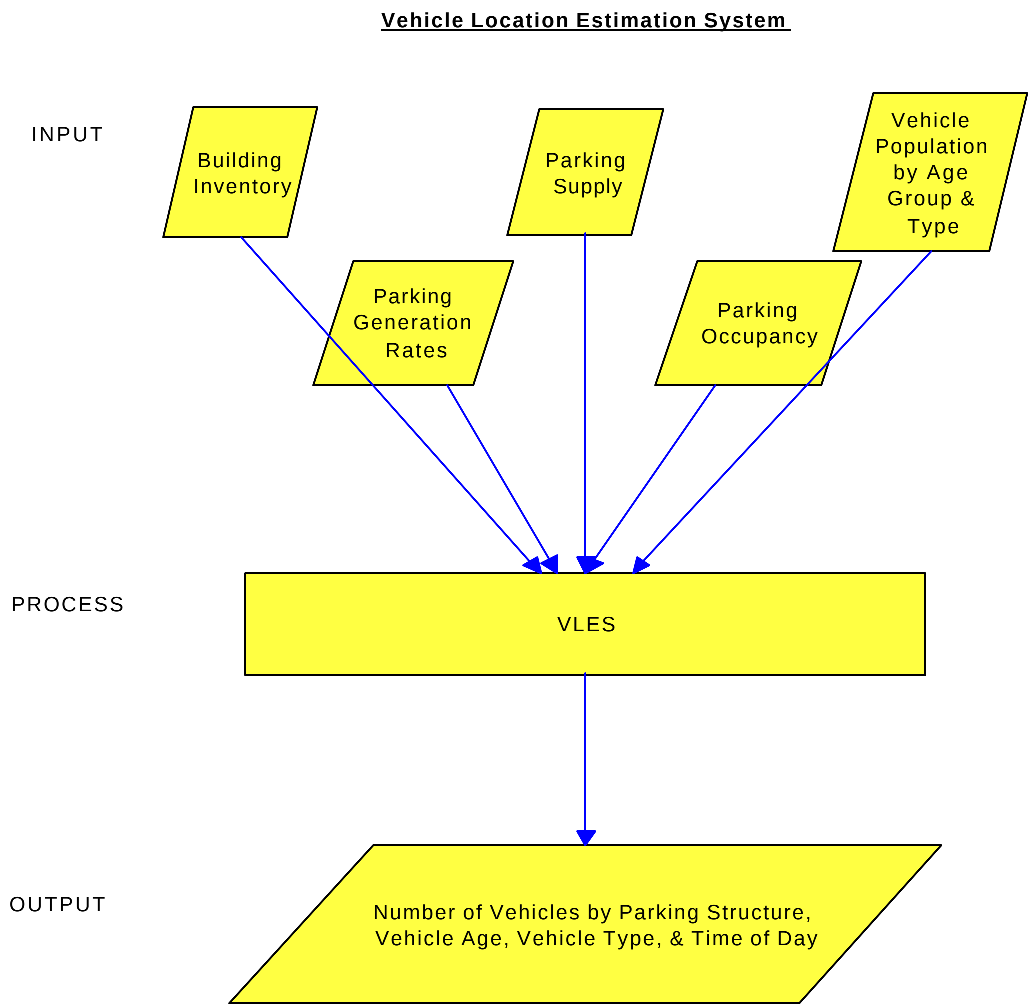

Figure 3.3 Vehicle Location Estimation System

3.6.1 Building inventory

Building inventory in a study area is provided in HAZUS$^{®MH}$, which categorizes all building structures into 28 occupancy groups. Among those major occupancy groups, 6 are residential, 10 are commercial, and 6 are industrial.

3.6.1.1 Parking Generation Rates

Parking generation rates are used to associate number of parked vehicles to square footages of different types of occupancy groups in HAZUS during a flood event. Vehicle distributions are estimated for daytime and nighttime, with daytime assumed to be normal business hours. The Institute of Transportation Engineers (ITE) has compiled the most comprehensive parking generation study. The latest version of the ITE Parking Generation manual was dated 1987, however, and a new edition is expected in early 2002. Another comprehensive source of parking in relation to land use is the Off-Street Parking Requirements manual compiled by the American Planning Association (APA). For the purpose of this report, various regional parking studies are referenced to update the ITE study and help determine the parked vehicle distribution according to time of day. These regions include Austin, Denver, Indianapolis, Seattle, and Westfield.

The following examples illustrate the process of assigning parked vehicles to specific occupancy groups. The first example is related to retail trade, which belongs to the HAZUS occupancy group COM1. The ITE parking generation report devotes land use code 810-850 and 870-890 to retail trade, which includes shopping centers, restaurants, supermarkets, and so on. The ITE updated parking generation rate (data through April 2001) for shopping centers is available in a report from DKS Associates that utilizes results of 940 parking studies to characterize generalized retail trade activities. During regular business hours, average vehicles per 1,000 square feet of shopping center space generally fall between 3-4; during nighttime, observations are limited and the rate falls sharply to between 0-1 vehicles per 1,000 square feet. Corresponding numbers for the 85 percentile are between 4.5-6 for the daytime and also between 0-1 during nighttime, as seen in Figure 3.4.

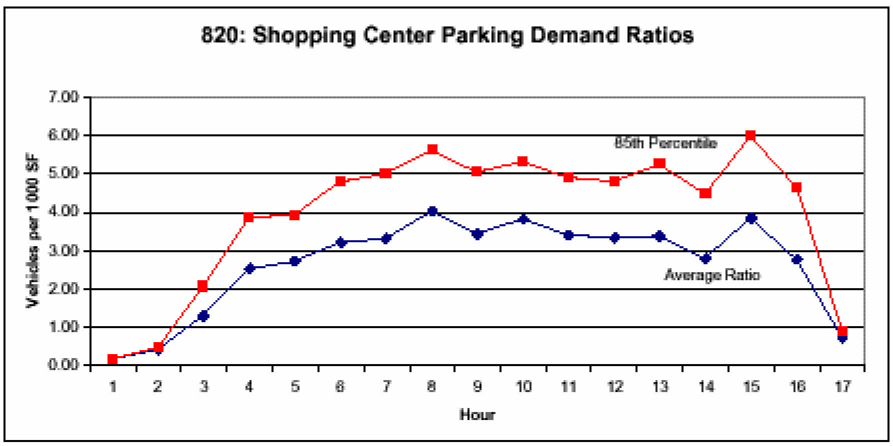

Figure 3.4 Commercial Shopping Center Parking Demand Ratios

Results from various parking studies show 2.5 (mid-day) at Austin, 1.74 at Indianapolis (for all land uses regardless of time), 1.2-3.8 (1.76-6.23 supplied, with 40%-67% utilization rate) at Puget Sound, 1.7 at Seattle, and 3 (mid-day, 3.33 in zoning) at Westfield.

The 1995 Dollars and Cents Guide to Shopping Centers found median amount of parking supplied by developers to be 5.1 spaces per 1,000 square feet gross land area in American neighborhood and community-sized shopping centers; the Urban Land Institute recommends 4, 4.5, and 5 spaces per 1,000 square foot of retail for shopping centers under 400, 400-600, and over 600 thousand square feet.

The off-street parking requirements manual from APA also indicates 5 spaces per thousand square feet floor area, while the minimum requirements for metro areas of Seattle, Portland, Tacoma, and San Francisco are 1-2.86, 2.5, 3, and 1-2 respectively.

Considering this information, 2.4 vehicles per 1,000 square feet is selected to be used as the mid-day rate, while 0.68 is selected as the night rate. Suppose that 4 is the peak parking demand, then parking utilization rates would be 60% and 17% of the peak rate respectively. The expected utilization rates corresponding to time of day are developed from the updated parking generation informational report and the Westfield comprehensive parking plan. The latter is shown in Table 3.31.

Table 3.32 Expected Daily Utilization Commercial Parking

Hour of Day	% of Peak
6:00	0%
7:00	8%
8:00	18%
9:00	42%
10:00	68%
11:00	87%
12:00	97%
13:00	100%
14:00	97%
15:00	95%

Hour of Day	% of Peak
16:00	87%
17:00	79%
18:00	82%
19:00	89%
20:00	87%
21:00	61%
22:00	32%
23:00	13%
24:00	0%

The second example deals with the multi-family dwelling, HAZUS$^{®MH}$ category RES3. Since parking generation studies generally relate parked vehicles to residential units, average square footage of floor area shared by a unit needs to be estimated for the conversion. For this purpose, multifamily properties owned by Associated Estate Realty Corporation are referred. The company owns garden, townhome, ranch, mid-rise, and high-rise style properties across 12 Midwest states including Indiana, Michigan, and Ohio. Average unit size of these properties is slightly over 900 square foot, excluding those with government assistance, which is generally smaller. This estimated parking requirement is compared with various residential construction projects and zoning requirements. After taking into account the shared public space of multifamily dwellings, 1,000 square feet per unit is assumed.

Peak parking generation per unit shown in ITE's study is around 1, while the Westfield study uses 0.88 with mid-day estimate of 0.75. The range of minimum parking requirements for Seattle, Portland, Tacoma, and San Francisco is 0.25-2. If we consider the fact that the number of average vehicles per household stabilizes around 1.8, these numbers seem low. This phenomenon may be due to the bias found in urban areas, where crowded lands, convenient public transportation, and high-rise structures are prevalent. For our estimation purpose, 1.5 (for 5-49 units) is chosen as this rate is closer to what is used in planning parking demand for new development.

The distribution of vehicle occupancy for residential dwellings with regard to the time of day assumed in Westfield study is around 90% during daytime and 100% during nighttime, while the same study assumes 50% daytime occupancy for hotels. The seemingly high occupancy during daytime may be due to the bias of urban areas, where people utilize other means of travel than personal vehicles and parking of vehicles attracted by businesses. Summing up the factors for multifamily parking generation, 0.3 is used for the daytime, while 1.35 is used for the nighttime.

Similar processes were applied for each of the remaining occupancy groups in HAZUS®MH. More information is available for some of the groups than for others. Generally, ITE, parking studies of metropolitan areas, the National Personal Travel Survey (NPTS), and related projects of private organizations, are combined to develop a best estimate for this purpose. The table for parking generation, column by column, contains labels and classes of occupancy groups in HAZUS®MH, units other than thousand square foot, conversion factors that turn other units into square footage, peak parking rate used, and percentage of peak parking rates as average daytime/nighttime rate

3.6.2 Parking Supply and Parking Occupancy

Once the numbers of vehicles potentially at risk are determined, these vehicles are further distributed to various parking facilities, such as on-street, surface lot, garage, or underground, in order to determine the impacts of flood water levels on vehicles. This distribution is irrelevant to non-urban areas, where all vehicles can be assumed to be on the surface. In urban areas, population density and land values result in underground and multi-story parking facilities. The elevation of the parked vehicle will determine the level of damage, with below ground vehicles having no salvage value and above ground vehicles being afforded a level of added protection.

Parking supplied by each source and its respective occupancy in an area are taken together to distribute vehicles among four parking facility types. After consulting various parking studies, Table 3.32 shows the estimated distribution:

Table 3.33 Estimated Parking Distribution by Parking Area Type

Urban	On-Street	Surface Log	Garage	Underground
Parking Spaces	12.5%	31.5%	33.6%	22.4%
Occupancy	78%	65%	45%	45%
Distribution	18%	37%	27%	18%

While the actual number of levels varies, a parking garage can be represented by a five-floor structure, with the roof also available for parking.

To estimate the impact of flood damage to vehicles in urban areas, it is assumed that 18% of vehicles are below ground level and under water during all flood events and, therefore, total losses. Another 60% of the vehicles (18% (on-street) + 37% (surface lot) + 5% (first floor from garage)) are subject to damage based on the appropriate flood damage equation. The remainder is located at least one level above ground and are assumed to receive no damage.

3.6.3 Vehicle Population by Age Group and Type

To estimate the probability of damage and vehicle value, vehicles are further assigned to three vehicle types: automobiles, light trucks and heavy trucks. Vehicle class estimates are developed by compiling data from the National Automobile Dealers Association (NADA), the US Department of Transportation's comprehensive Truck Size and Weight Study (TSWS), and the 1995 National Personal Transportation Survey (NPTS). The distribution of vehicle age and percentage of trucks versus cars were taken from NADA, with further distribution among trucks by size from TSWS. The 1995 NPTS data is shown in Table 3.33 to fill in the details of vehicle age and type.

Table 3.34 Vehicle Age Distribution by Vehicle Classification

Percentage Distribution

Age	Car	LiteTrk	HvyTrk	Total
0-2	8.438%	4.631%	0.459%	13.53%
3-6	17.500%	6.703%	1.969%	26.17%
7-10	15.625%	5.241%	0.919%	21.78%
10+	20.938%	7.800%	9.778%	38.52%
Sum	62.500%	24.375%	13.125%	100%

3.6.4 Vehicle Value Estimation

In order to calculate the dollar loss from vehicle damages from flood events, research was done to calculate the average price of new and used vehicles under the three categories. According to the 2001 NADA data, the average selling price of a new light vehicle is $24,923, while that of a used light vehicle is $13,648. Thus the value of an average used vehicle is approximately 55% of the value of a new vehicle. Consider the fact that vehicles sold at the dealership tend to be younger than the whole vehicle population. As such, average used vehicle values are assumed to be 50% of the value of average new vehicle.

The vehicle values given by NADA data do not differentiate between cars and trucks. The NADA estimates are actual dealer selling prices for NADA members and include all accessories and options sold with the vehicle.

New vehicles are estimated to be seven percent for cars and nine percent for light- and heavy-duty trucks of all vehicles sold. These estimates are obtained by dividing new vehicles by total vehicles in use between 1990-2000 in Car/Truck Scrappage and Growth in the US table of 2001 Ward's Automotive Yearbook. From the same yearbook, the tables of US Light Vehicle Sales by Segment (2000) and Ward's '01 Light Vehicle US Market Segmentation and Prices are put together to come up with the average prices of new cars and light trucks, which are $22,618.47 and $20,969.21 respectively. These new car prices are applied in the vehicle value estimate.

Using the table of US Truck Shipments by GVW by Make from the Ward's Automotive Yearbook and researching websites such as Truck Paper, Truck Trader Online, Working Wheels, Trucks.com, and numerous individual dealers' inventory lists, each Make and Class (4-8) category was assigned a value to calculate average price of a new heavy duty truck. The estimate is $76,087.67.

To compute the total value of vehicles in an area, the number of total vehicles will be multiplied by the percentage of car/light truck/heavy truck, percentage of new/used vehicles, and the average value of vehicles that match both categories.

3.7 Hazardous Materials Facilities

Hazardous material facilities contain substances that can pose significant hazards because of their toxicity, radioactivity, flammability, explosiveness or reactivity. Significant casualties or property damage could occur form a small number or even a single hazardous materials release induced by an flood, and the consequence of an flood-caused release can vary greatly according to the type and quantity of substance released, meteorological conditions and timeliness and effectiveness of emergency response. Similarly to the case of critical faculties with a potential for high loss, such as large dams, the methodology does not attempt to estimate losses caused by flood, which caused hazardous materials releases. Thus, the hazardous materials module of HAZUS®*MH* is limited to inventory data concerning the location and nature of hazardous materials located at various sites. Section 10.1.2 describes the scheme used to define the degree of danger of hazardous materials.

3.8 Direct Economic and Social Loss

In this section, information related to inventory data required to determine direct economic and social loss is presented. The two main databases used to determine direct economic and social loss are demographic and building square footage databases.

3.8.1 Demographics Data

The census data are used to estimate direct social loss due to displaced households, casualties due to floods, and, as discussed in previous sections, estimation quality of building space (square footage) for certain occupancy classes. The Census Bureau collects and publishes statistics about the people of the United States based on the constitutionally required census every 10 years, which is taken in the years ending in "0" (e.g., 2000). The Bureau's population census data describes the characteristics of the population including age, income, housing and ethnic origin.

The census data were processed for all of the census blocks in the United States, and 37 fields of direct importance to the methodology were extracted and stored. These fields are shown in Table 3-38 and are supplied as default information with the methodology. The population information is aggregated to a census block level. As stated previously, census blocks are divisions of land that are based on hard geographic features that allow for the designation of territory. Examples of these hard features include roads, rivers, and railway tracks. Census blocks are the smallest unit of aggregation for the census data. This small unit of aggregation was better suited for the flood model damage analysis because of its, generally, small area of coverage (typically one square mile or smaller). In those cases where the census data is aggregated to the census block group (20-40 census blocks) rather than the census block, the data is smoothed over every census block within the block group. Generally it is conceived that census blocks contain populations or land uses that have relatively homogeneous population characteristics, economic status and living conditions.

Census block divisions and boundaries change once every ten years. Census block boundaries never cross county boundaries, and all the area within a county is contained within one or more census blocks. This characteristic allows for a unique division of land from country to state to county to census tract to census block group to census block. Each Census block is identified by a unique 15 digit number. The first two digits represent the block's state (called the State FIPS), the next three digits represent the block's county (when combined with the State FIPS is called the County FIPS), the next 6 digits identify the census tract within the county, another 2 digits are used to identify the block group and the final two - three digits identify the census block. For example, a census block numbered 06037575900702 would be located in California (06) in Los Angeles County (037), in census tract (575900), in census block group (7).

Table 3.35 Demographics Data and Utilization Within HAZUS®*MH*

Description of Field	Module Usage			
	Shelter	Casualty	Occupancy Class	Lifelines
Total Population in Census Block	*	*		*
Total Household in Census Block	*			*
Total # of People in General Quarter	*			
Total # of People < 16 years old	*	*		
Total # of People 16-65 years old	*			
Total # of People > 65 years old	*			
Total # of People – White	*			
Total # of People – Black	*			
Total # of People - Native American	*			
Total # of People – Asian	*			
Total # of People – Hispanic	*			
Total # of Households with Income < $10,000	*			
Total # of Households with Income $10 - $15K	*			
Total # of Households with Income $15 - $25K	*			
Total # of Households with Income $25 - $35K	*			
Total # of Households with Income > $35,000	*			
Total in Residential Property during Day		*		
Total in Residential Property at Night		*		
Total Working Population in Commercial Industry		*		
Total Working Population in Industrial Industry		*		
Total Commuting at 5 PM		*		
Total Owner Occupied - Single Household Units	*		*	
Total Owner Occupied - Multi-Household Units	*		*	
Total Owner Occupied - Multi-Household Structure	*		*	
Total Owner Occupied - Mobile Homes	*		*	
Total Renter Occupied - Single Household Units	*		*	

Table 3.35 Demographics Data and Utilization Within HAZUS®MH (Continued)

Description of Field	Module Usage			
	Shelter	Casualty	Occupancy Class	Lifelines
Total Renter Occupied - Multi-Household Units	*		*	
Total Renter Occupied - Multi-Household Structure	*		*	
Total Renter Occupied - Mobile Homes	*		*	
Total Vacant - Single Household Units			*	
Total Vacant - Multi-Household Units			*	
Total Vacant - Multi-Household Structure			*	
Total Vacant - Mobile Homes			*	
Structure Age <40 years			*	
Structure Age >40 years			*	
Median Income			*	
Median Age of Housing Units			*	

3.9 Indirect Economic Data

The indirect economic data refers to the post-flood change in the demand and supply of products, change in employment and change in tax revenues. The user can specify the levels of potential increase in imports and exports, supply and product inventories and unemployment rates.

3.10 References

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