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Pilot Project: Eugene-Springfield Earthquake Damage and Loss Estimate Final Report, January 1999

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EXECUTIVE SUMMARY

At the request of the State of Oregon Department of Geology and Mineral Industries, the Oregon State University Department of Civil, Construction and Environmental Engineering was tasked with performing a preliminary earthquake damage and loss estimate for the areas of Eugene and Springfield, Oregon. Estimates of building damage and immediate economic and casualty losses for 100 selected buildings in each city are made using current Federal Emergency Management Agency (FEMA) HAZUS program-based methodologies. **Buildings were selected for the study to focus, where possible, on those structures posing the Greatest potential for loss of life, injury, and building damage.**

Data collection was conducted using the rapid visual screening procedures outlined in FEMA 154: "Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook" (ATC-21, Applied Technology Council, 1988a). This handbook provides a standard procedure, involving a quick, walk-around examination of the building exterior, to identify buildings that may pose a significant risk of loss of life, injury, or structural damage in a large earthquake.

The project scope involves the estimation of the immediate facility damage and occupant casualties for 100 buildings in Eugene and 100 buildings in Springfield for an earthquake producing an effective peak ground acceleration of 0.3 *g* (based on Uniform Building Code (ICBO, 1994) seismic Zone 3 criteria).

Buildings were selected to provide a distribution of buildings in the Eugene downtown, Valley River, and industrial areas, and in the Springfield downtown, Shelly Street industrial, Gateway and Olympic/Mohawk areas. A focus on those buildings contributing most to losses was desired, by surveying unreinforced masonry (URM) buildings, larger/taller buildings, those with large occupancies and high property values and those buildings with obvious structural vulnerabilities (plan and vertical irregularities, soft stories, etc.), where possible. However, it was found that in a number of the areas, insufficient numbers of these higher risk facilities were available to survey, so other less vulnerable facilities were included as well.

The overall damage and losses estimated for the 200 buildings surveyed in Eugene and Springfield using the HAZUS program are very significant and were as follows:

56 buildings with no damage, 44 with slight damage, 62 with moderate damage, 28 with extensive damage, and 10 completely destroyed.

$14.5 million in structural damage, $34.2 million in nonstructural damage, $18.2 million in damage to building contents, $0.9 million in inventory losses, $42.2 million income losses, for a total of $110 million in direct economic losses.

For a 2 AM earthquake, casualties within these 200 buildings as follows:

19 persons injured and needing basic medical aid without requiring hospitalization,

2 persons requiring more medical care and hospitalization, but without life-threatening injuries.

For a 2 PM earthquake, casualties within the 200 buildings as follows:

238 persons injured and needing basic medical aid without requiring hospitalization,

39 persons requiring more medical care and hospitalization, but without life-threatening injuries,

4 persons with injuries posing an immediate life threatening condition if not treated adequately and expeditiously. Most of these casualties are the result of structural collapse and subsequent entrapment or impairment of the building occupants, 4 persons instantaneously killed or mortally injured.

1. BACKGROUND

At the request of the State of Oregon Department of Geology and Mineral Industries, the Oregon State University Department of Civil, Construction and Environmental Engineering was tasked with performing a preliminary earthquake damage and loss estimate for the areas of Eugene and Springfield, Oregon. Estimates of building damage and immediate economic and casualty losses for 100 selected buildings in each city are made using current Federal Emergency Management Agency (FEMA) HAZUS programbased methodologies. Buildings were selected for the study to focus, where possible, on those structures posing the greatest potential for loss of life, injury, and building damage.

Data collection was conducted using the rapid visual screening procedures outlined in FEMA 154: "Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook" (ATC-21, Applied Technology Council, 1988a). This handbook provides a standard procedure, involving a quick, walk-around examination of the building exterior, to identify buildings that may pose a significant risk of loss of life, injury, or structural damage in a large earthquake.

2. PROJECT OBJECTIVES

The overall goal of this project was to increase earthquake awareness and provide local and state officials with information to develop strategic planning guidelines for earthquake hazard mitigation / disaster response efforts in the Eugene-Springfield area.

The specific objectives of this study are as follows:

Conduct a damage and loss estimate of 200 buildings using a current, widely accepted methodology based on FEMA's HAZUS (FEMA 1997a,b) program,

Provide ATC-21 survey data sheets for the 200 buildings, and thus begin to establish an inventory of buildings and relative seismic vulnerabilities in the Eugene-Springfield region.

3. PROJECT SCOPE

The project scope involves the estimation of the immediate facility damage and occupant casualties for 100 buildings in Eugene and 100 buildings in Springfield for an earthquake producing an effective peak ground acceleration of 0.3 g's (based on Uniform Building Code (ICBO, 1994) seismic Zone 3 criteria). Damage and loss distributions are presented based on building structural type, occupancy class and study area. It is important to point out that the rapid visual screening method used is accurate only for assessing the average behavior of a large population of facilities, and should not be used at all to predict individual building performance.

Buildings were selected to provide a distribution of buildings in the Eugene downtown, Valley River, and industrial areas, and in the Springfield downtown, Shelly Street industrial, Gateway and Olympic/Mohawk areas. A focus on those buildings contributing most to losses was desired, by surveying unreinforced masonry (URM) buildings, larger/taller buildings, those with large occupancies and high property values and those buildings with obvious structural vulnerabilities (plan and vertical irregularities, soft stories, etc.), where possible. However, it was found that in a number of the areas, insufficient numbers of these higher risk facilities were available to survey, so other less vulnerable facilities were included as well.

Specifically not included in the scope of this study are the effects of local soil conditions (although easily incorporated in the HAZUS methodology), landslides, damage to lifelines, long term economic effects, industry impacts, and extrapolations of results to areas or buildings other than those specifically included in this report. Critical facilities (hospitals, fire stations, police stations, etc.), other public buildings, EWEB and University of Oregon facilities, and public schools are not included in the 200 building survey of this DOGAMI-funded project, as these have already been surveyed using a variety of techniques by local agencies. It is planned, however, to include these facilities in an expanded MS thesis study at a later date, if HAZUS input data is provided by the local agencies.

4. STUDY METHODOLOGY

A detailed description of the ATC-21 (ATC 1988a) study methodology is outside the scope of this report, but aspects and decisions particular to this study are briefly outlined here. The students involved in the survey were trained in the application of the standardized approach by the principal investigator, who has performed several similar investigations in the past (Miller et al. 1991, 1992a). In conducting the ATC-21 (1988a) survey of each of the 200 facilities, scores were recorded on the sheets for both the high (primary value provided) and low (second value in parentheses) seismic hazard categories to provide information for-a variety of applications. The SL3 soil designation was assigned based on the recommendation of Dr. Steven Dickenson of Oregon State University. As in all rapid visual screening techniques, considerable judgment and uncertainty is associated with the assignment of building type and performance modifiers to each individual facility. **The scores determined for any individual facility thus have a high degree of uncertainty and should not be used at all to estimate the seismic performance of individual buildings. The technique is intended only for the prediction of the aggregate performance of a large number of buildings.**

The ATC-21 survey technique was used to gather the basic data for input to the HAZUS (FEMA 1997 a,b) earthquake damage and loss estimation program. As this program is very complex, only a brief outline of the input approach used in this study is provided here. The reader is referred to the well-documented and referenced HAZUS (FEMA 1997 a,b) technical and users manuals for additional details. Building drainage is estimated using the default drainage functions (fragility curves and building capacity curves), and default relationships for estimating casualties and costs of earthquake-induced damage are also used.

Census tracts were used in identifying the individual study area regions. The building inventory mapping and count (occupancy category and building type, both general and specific, square footage, height and age for the buildings) reflect the ATC-21 survey sheet data collected. Building structure (model building) types and Building Occupancy Classes are defined in Tables 3.1 and 3.2 from the HAZUS technical manual (FEMA 1997a). The building stock mapping schemes used were developed specially for the 200 study area buildings, and the default mappings were not used.

The "moderate" seismic design level appropriate to Uniform Building Code seismic zone 3 (ICBO, 1994) was used for all buildings (see Table 5.20 from FENM (1997a) and Table 5.19 for performance level descriptions). Building quality bias was assigned as suggested by Table 5.20 as well, as follows: Post '70's - Code, Post '50's - Code, and Pre '50's - Inferior (note that an exception is for building type W1 which is assigned moderate/code).

The default demographic data for entire census tracts were not applicable to the relatively specific subset of buildings investigated in this pilot study. Thus, the data from Table 7.1 of Goettel and Homer, Inc. (1995) were used to estimate the occupancies for the buildings surveyed as follows:

For each commercial (COM) building, the square footage (SF) for the facility was divided by the average SF/occupant from Table 7.1, and then this average occupancy was multiplied by the number of days occupied per week divided by 7 days per week, and this occupancy summed over all of the commercial buildings and input to HAZUS as the number of people employed in the commercial sector (COMW).

For each industrial (IND) building, the square footage (SF) for the facility was divided by the average SF/occupant from Table 7. 1, and then this average occupancy was multiplied by the number of days occupied per week divided by 7 days per week, and this occupancy summed over all of the industrial buildings and input to HAZUS as the number of people employed in the industrial sector (INDW).

For each religious/non-profit (REL) or government (GOV) building, the square footage (SF) for the facility was divided by the average SF/occupant from Table 7.1, and then this average occupancy was multiplied by the number of days occupied per week divided by 7 days per week, and this occupancy summed over all buildings in this occupancy class and input to HAZUS as an addition to the number of people employed in the commercial sector (COMW).

For each residential (RES) building, the square footage (SF) for the facility was divided by the average SF/occupant from Table 7.1, then this average occupancy was multiplied by the number of days occupied per week divided by 7 days per week, and this occupancy summed over all of the residential buildings and input to HAZUS as the nighttime residential population (NRES). The daytime residential population was estimated by proportioning this calculated NRES value for the inventoried buildings in each census tract using the ratio of DRES/NRES from the default data for the entire census tract.

The HAZUS program then determined population distributions at different times of the day as explained in Table 13.2 (FEMA 1997a).

A user-supplied seismic hazard map was defined by the authors for the 0.3 g effective peak ground acceleration (EPA) earthquake appropriate to the Uniform Building Code (ICBO, 1994) zone 3 design criteria for Eugene-Springfield. A uniform ground motion map was established over each census tract and in fact the whole study area. No soil amplification effects were considered. The seismic input was characterized as follows (FEMA 1997a):

Peak ground acceleration (PGA) = 0.3g/0.75 = 0.4 g (ATC, 1998b)

Peak ground velocity (PGV) = (386.4/2 7t)(PGA=0.4g)/1.65 = 14.9 in/sec

Spectral acceleration at 0.3 second period = 2.5* PGA = 2.5(0.4 g) = 1.0 g

Spectral acceleration at 1 second period = PGA 0.4 g

Moment magnitude = 7.0

Finally, it is most important to note that the HAZUS program (FEMA 1997 a,b) was developed to estimate earthquake damage and losses over broad geographic regions, including data from entire population census tracts. In this pilot study, we collected building inventory data for just 200 buildings spread over six different census tracts. Thus, modifications needed to be made to properly input the data, most particularly in the population demographics and mapping schemes defining the proportions of different building types in each census tract. We provided data for the 200 buildings surveyed in this study, and did not use the default values. The damage and loss estimates that follow are thus for the 200 buildings inventoried in this project only.

Table 3.1. Building Structure (Model Building) Types

No.	Label	Description	Height: Range Name	Range Stories	Typical Stories	Typical Feet
1	W1	Wood, Light Frame (< 5,000 sq.ft.)	—	1–2	1	14
2	W2	Wood, Commercial and Industrial(>5,000 sq.ft.)	—	All	2	24
3	S1L		Low-Rise	1–3	2	24
4	S1M	Steel Moment Frame	Mid-Rise	4–7	5	60
5	S1H		High-Rise	8+	13	156
6	S2L		Low-Rise	1–3	2	24
7	S2M	Steel Braced Frame	Mid-Rise	4–7	5	60
8	S2H		High-Rise	8+	13	156
9	S3	Steel Light Frame	—	All	1	15
10	S4L	Steel Frame with Cast-in-Place	Low-Rise	1–3	2	24
11	S4M	Concrete Shear Walls	Mid-Rise	4–7	5	60
12	S4H		High-Rise	8+	13	156
13	S5L	Steel Frame with Unreinforced	Low-Rise	1–3	2	24
14	S5M	Masonry Infill Walls	Mid-Rise	4–7	5	60
15	S5H		High-Rise	8+	13	156
16	C1L		Low-Rise	1–3	2	20
17	C1M	Concrete Moment Frame	Mid-Rise	4–7	5	50
18	C1H		High-Rise	8+	12	120
19	C2L		Low-Rise	1–3	2	20
20	C2M	Concrete Shear Walls	Mid-Rise	4–7	5	50
21	C2H		High-Rise	8+	12	120
22	C3L	Concrete Frame with Unreinforced	Low-Rise	1–3	2	20
23	C3M	Masonry Infill Walls	Mid-Rise	4–7	5	50
24	C3H		High-Rise	8+	12	120
25	PC1	Precast Concrete Tilt-up Walls	—	All	1	15
26	PC2L	Precast Concrete Frames with	Low-Rise	1–3	2	20
27	PC2M	Concrete Shear Walls	Mid-Rise	4–7	5	50
28	PC2H		High-Rise	8+	12	120
29	RM1L	Reinforced Masonry Bearing Walls	Low-Rise	1–3	2	20
30	RM1M	With Wood or Metal DeckDiaphragms	Mid-Rise	4+	5	50
31	RM2L	Reinforced Masonry Bearing Walls	Low-Rise	1–3	2	20
32	RM2M	with Precast Concrete Diaphragms	Mid-Rise	4–7	5	50
33	RM2H		High-Rise	8+	12	120
34	URML	Unreinforced Masonry BearingWalls	Low-Rise	1–2	1	15
35	URMM		Mid-Rise	3+	3	35
36	MH	Mobile Homes	—	All	1	10

Table 3.2. Building Occupancy Classes

No.	Label	Occupancy Class	Example Descriptions
		Residential	
1	RES1	Single Family Dwelling	House
2	RES2	Mobile Home	Mobile Home
3	RES3	Multi Family Dwelling	Apartment/Condominium
4	RES4	Temporary Lodging	Hotel/Motel
5	RES5	Institutional Dormitory	Group Housing (military, college), Jails
6	RES6	Nursing Home	—
		Commercial	
7	COM1	Retail Trade	Store
8	COM2	Wholesale Trade	Warehouse
9	COM3	Personal and Repair Services	Service Station/Shop
10	COM4	Professional/Technical Services	Offices
11	COM5	Banks	—
12	COM6	Hospital	—
13	COM7	Medical Office/Clinic	—
14	COM8	Entertainment & Recreation	Restaurants/Bars
15	COM9	Theaters	Theaters
16	COM10	Parking	Garages
		Industrial	
17	IND1	Heavy	Factory
18	IND2	Light	Factory
19	IND3	Food/Drugs/Chemicals	Factory
20	IND4	Metals/Minerals Processing	Factory
21	IND5	High Technology	Factory
22	IND6	Construction	Office
		Agriculture	
23	AGR1	Agriculture	—
		Religion/Non-Profit	
24	REL1	Church/Non-Profit	—
		Government	
25	GOV1	General Services	Office
26	GOV2	Emergency Response	Police/Fire Station/EOC
		Education	
27	EDU1	Grade Schools	—
28	EDU2	Colleges/Universities	Does not include group housing

Table 5.19. Seismic Design and Performance Levels of Default Building Damage Functions (and Approximate Structural Strength and Ductility)

Seismic DesignLevel	Seismic Performance Level: Superior[1]	Ordinary	Inferior
High (UBC Zone 4)	*Special High-Code* Maximum Strength Maximum Ductility	*High-Code* High Strength High Ductility	— Moderate Strength Moderate/Low Ductility
Moderate (UBC Zone 2B)	*Special Moderate-Code* High/Moderate Strength High Ductility	*Moderate-Code* Moderate Strength Moderate Ductility	Low Strength Low Ductility
Low (UBC Zone 1)	*Special Low-Code* Moderate/Low Strength Moderate Ductility	*Low-Code* Low Strength Low Ductility	*Pre-Code* Minimal Strength Minimal Ductility

[1].See Chapter 6 for Special High-Code, Moderate-Code and Low-Code building damage functions.

Table 5.20. Guidelines for Selection of Damage Function for Typical Buildings Based on UBC Seismic Zone and Building Age

UBC Seismic Zone (NEHRP Map Area)	Post-1975	1941–1975	Pre-1941
Zone 4 (Map Area 7)	High-Code	Moderate-Code	Pre-Code (W1 = Moderate-Code)
Zone 3 (Map Area 6)	Moderate-Code	Moderate-Code	Pre-Code (W1 = Moderate-Code)
Zone 2B (Map Area 5)	Moderate-Code	Low-Code	Pre-Code (W1 = Low-Code)
Zone 2A (Map Area 4)	Low-Code	Low-Code	Pre-Code (W1 = Low-Code)
Zone 1 (Map Area 2/3)	Low-Code	Pre-Code (W1 = Low-Code)	Pre-Code (W1 = Low-Code)
Zone 0 (Map Area 1)	Pre-Code (W1 = Low-Code)	Pre-Code (W1 = Low-Code)	Pre-Code (W1 = Low-Code)

Table 7.1
Typical Occupancies Based On Building Uses

Use Description	Average Square Feet per occupant[1]	Occupied Hours/Day	Occupied Days/Week	Weighted Average Occupants per 1,000 square feet
Offices	200	9	5	1.33
Multi-family residential	350	14	7	1.67
high-tech industry	300	16	6	1.90
heavy industry	500	24	7	2.00
churches	25	6	2	2.86
schools	50	7	3.75	3.13
hospitals	225	24	7	4.44
retail	100	12	7	5.00
restaurants	50	7	7	5.83
movie theaters	25	12	7	20.00

[1] These square footages are based on the expected occupant density during business hours and may be higher or lower in specific buildings

[2] The number of days per week for schools is adjusted to less than five, based on a school year of nine months duration.

A typical calculation of the weighted average number of occupants per 1,000 square feet is performed as follows:

The values of square feet per occupant are converted to a number of occupants per 1,000 square feet by dividing that number into 1,000. For office uses, the occupants per 1,000 square feet is therefore 1000/200 = 5.0. This value is then weighted according to the fraction of hours per week that the building is occupied. For offices, 9 hours per day times 5 days gives 45 hours per week of occupancy. Dividing this number by the number of hours per week (168) gives the fraction of a week for which the building is occupied (e.g., 45/168 = 0.268). Finally, multiplying this value times the occupants per 1,000 square feet during occupied hours (5 x 0.268) yields the value of 1.33 for the weighted average occupants per 1,000 square feet. If desired, differing occupancy levels at different times of the day and/or on different days of the week could be averaged in a similar manner.

Table 13.2. Default Relationships for Estimating Population Distribution

	Distribution of People in Census Tract		
Basic Group	2:00 a.m.	2:00 p.m.	5:00 p.m.
Residential	0.99(NRES)	0.80(DRES)	0.95(DRES)
Commercial	0.02(COMW)	0.98(COMW) +0.15(DRES) +0.80(AGE_16)	0.50(COMW)
Industrial	0.10(INDW)	0.80(INDW)	0.50(INDW)
Commuting	0.01(POP)	0.05(POP)	0.05(DRES) +1.0(COMM)

Where:

POP is the census tract population taken from census data

DRES is the daytime residential population inferred from census data

NRES is the nighttime residential population inferred from census data

COMM is the number of people commuting inferred from census data

COMW is the number of people employed in the commercial sector

INDW is the number of people employed in the industrial sector

AGE_16 is the number of people 16 years of age and under inferred from census data (used as a proxy for the portion of population located in schools)

SUMMARY OF RESULTS

The 200 building inventory is described in terms of general occupancy class in Table 1, and in terms of general building type in Table 2. Graphical representations of the distributions of the facilities among the different study areas, occupancy classes and building types are shown in the figures that follow these tables.

The 200 building inventory is quantified on a square footage of floor area basis in Table 3, and graphically described in the pie charts that follow.

Estimates for the population distribution associated with the 200 study region buildings determined as explained in section 4 above are outlined in Table 4.

Building damage estimates from HAZAUS, (FEMA 1997a,b) are shown in terms of feneral occupancy class and general building type in Tables 5 and 6, respectively. Pie charts showing the same results follow.

HAZUS-based (FEMA 1997 a,b) estimates of direct economic losses associated with the 200 buildings inEugene and Springfield are shown in Table 7 and in the pie charts following the table.

Estimated casualties (injuries and deaths) from HAZUS (FEMA 1997 a, b) for the 100 buildings in Eugene and 100 buildings in Springfield, Oregon are shown in Table 8 both for an earthquake occurring during working hours (2PM) and one when most residents would be at home sleeping (2 AM). Graphical presentation of the same information follows the tables.

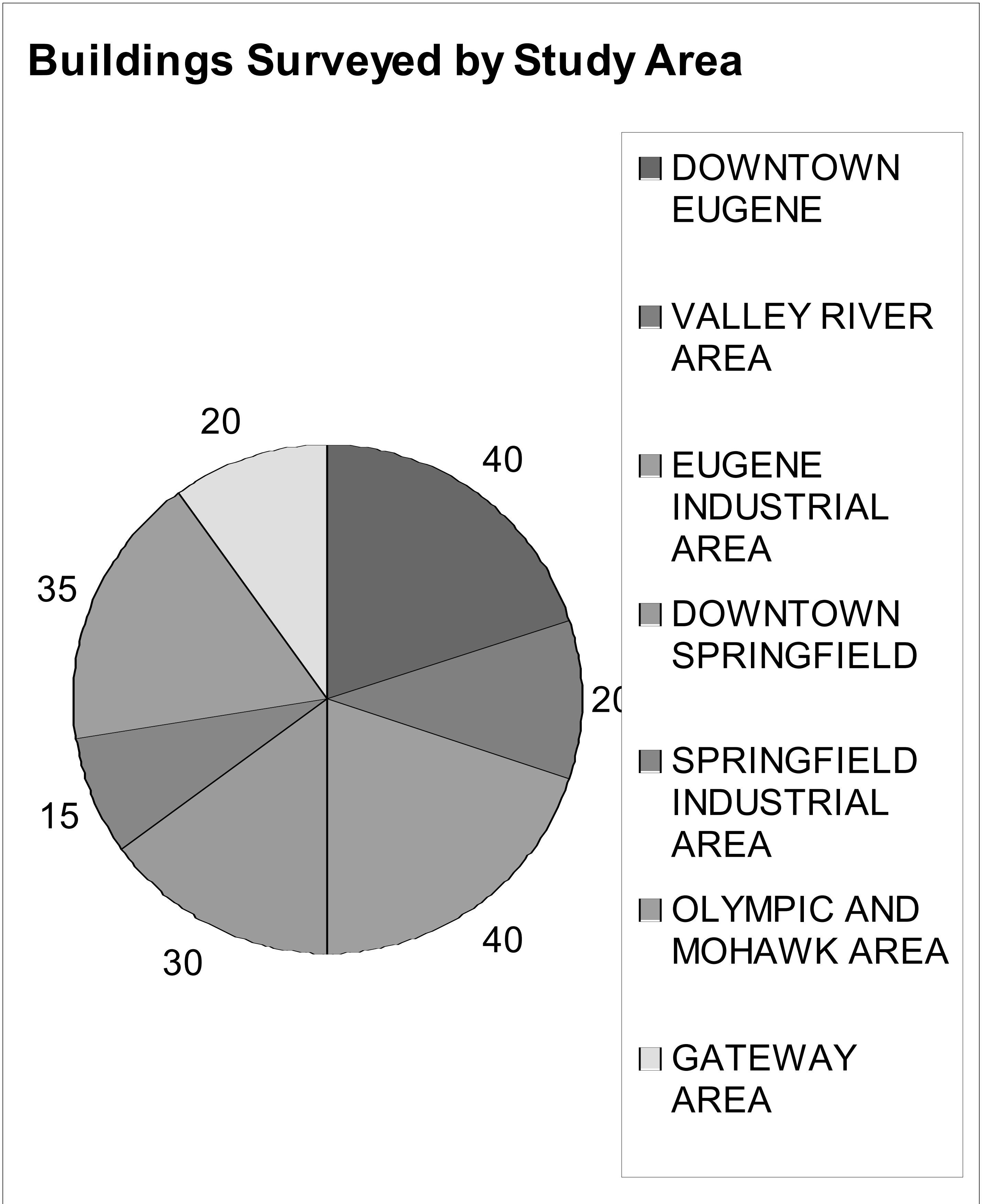
Note: Individual entries in Table 8 are rounded to the nearest integer in this table, ut totals for each region are a summation of decimal quantities. Total for entire study region are summations of the integer quantities for each area.

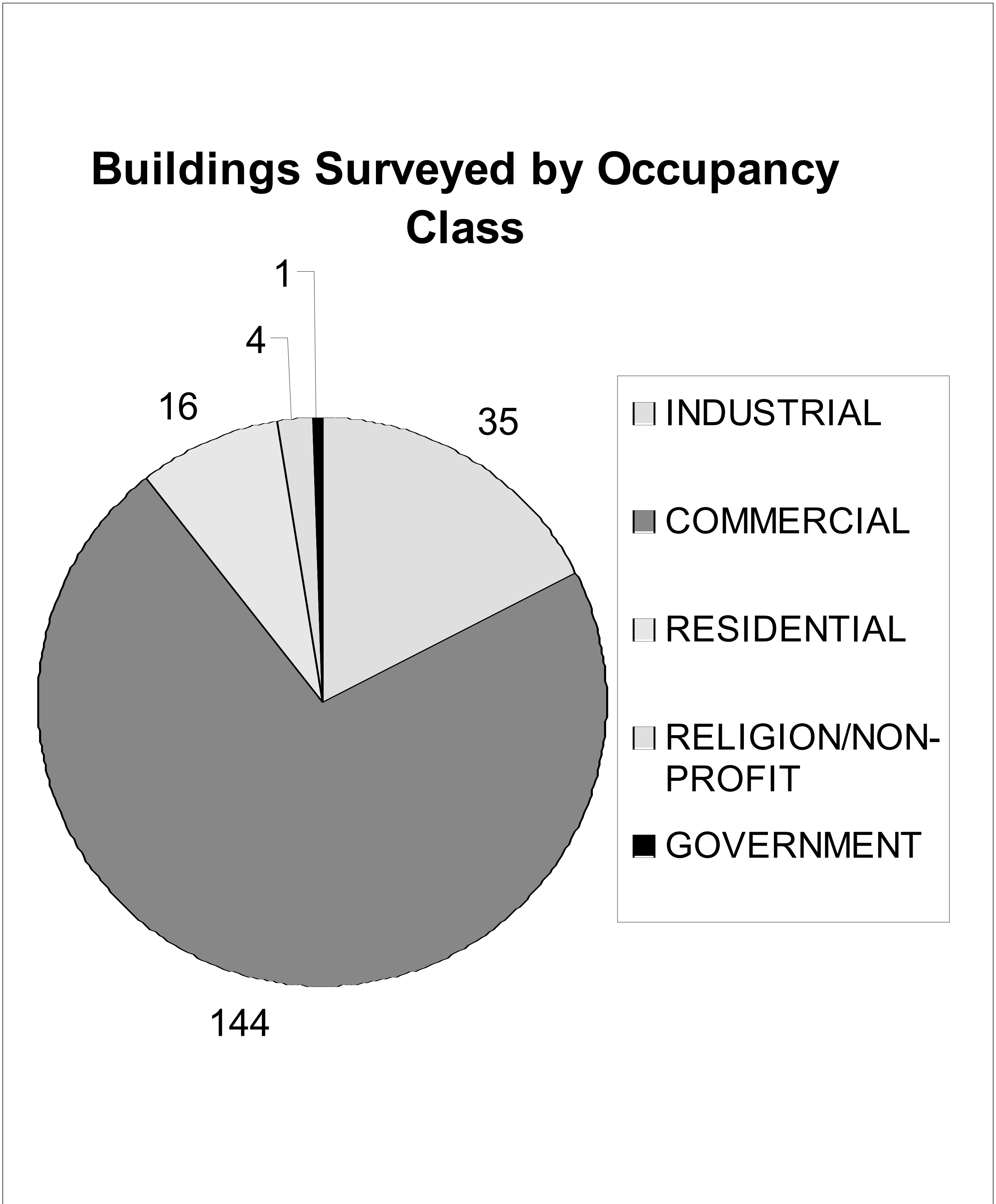
Table 1 - BUILDING COUNT BY GENERAL OCCUPANCY

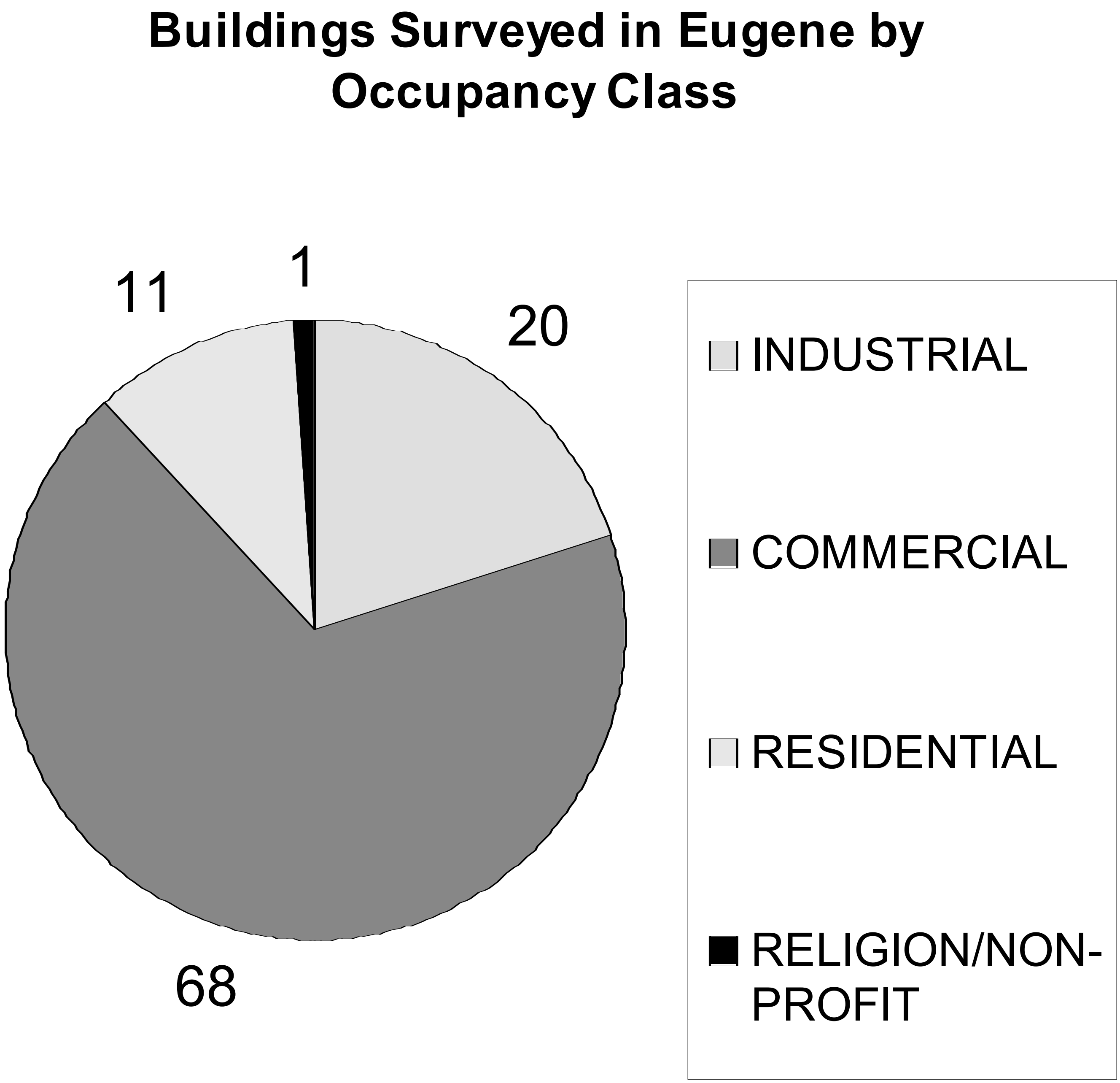
Study Area	Resid.	Comm.	Indust.	Religion	Govt.	Total
Downtown Eugene	11	28	0	1	0	40
Valley River	0	20	0	0	0	20
W. Eugene Industrial	0	20	20	0	0	40
Downtown Springfield	1	28	0	0	1	30
Springfield Industrial & Gateway	4	16	15	0	0	35
Olympic & Mohawk	0	32	0	3	0	35
Total Eugene	11	68	20	1	0	100
Total Springfield	5	76	15	3	1	100
Total Study Area	16	144	35	4	1	200

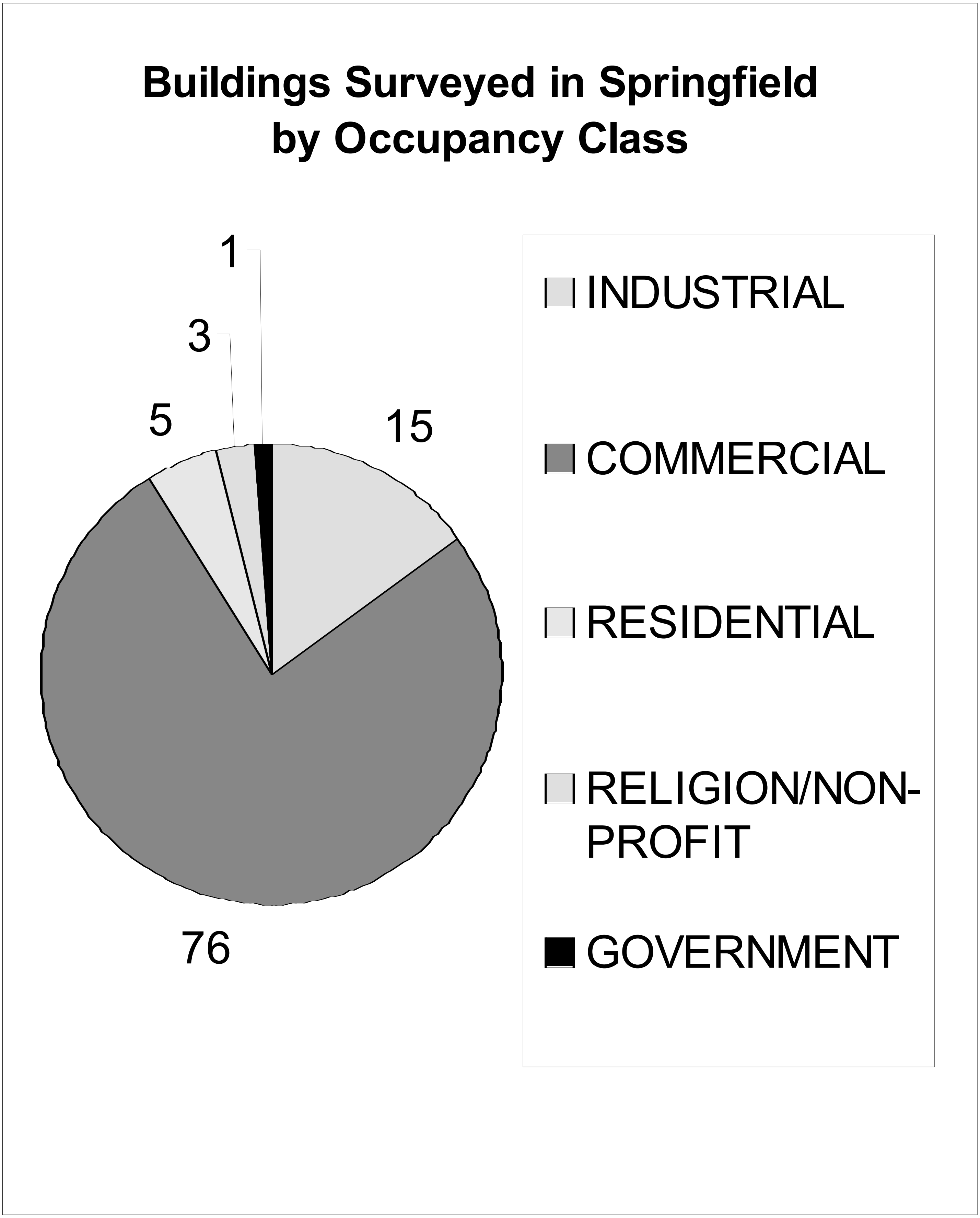
Table 2 - BUILDING COUNT BY GENERAL BUILDING TYPE

Study Area	Wood	Steel	Reinf. Conc.	Precast Conc.	Reinf. Masonry	URM	Total
Downtown Eugene	0	14	12	2	3	9	40
Valley River	2	7	2	2	7	0	20
W. Eugene Industrial	6	5	3	14	10	2	40
Downtown Springfield	1	0	8	0	2	19	30
Springfield Industrial & Gateway	6	6	0	12	9	2	35
Olympic & Mohawk	9	2	0	3	18	3	35
Total Eugene	8	26	17	18	20	11	100
Total Springfield	16	8	8	15	29	24	100
Total Study Area	24	34	25	33	49	35	200

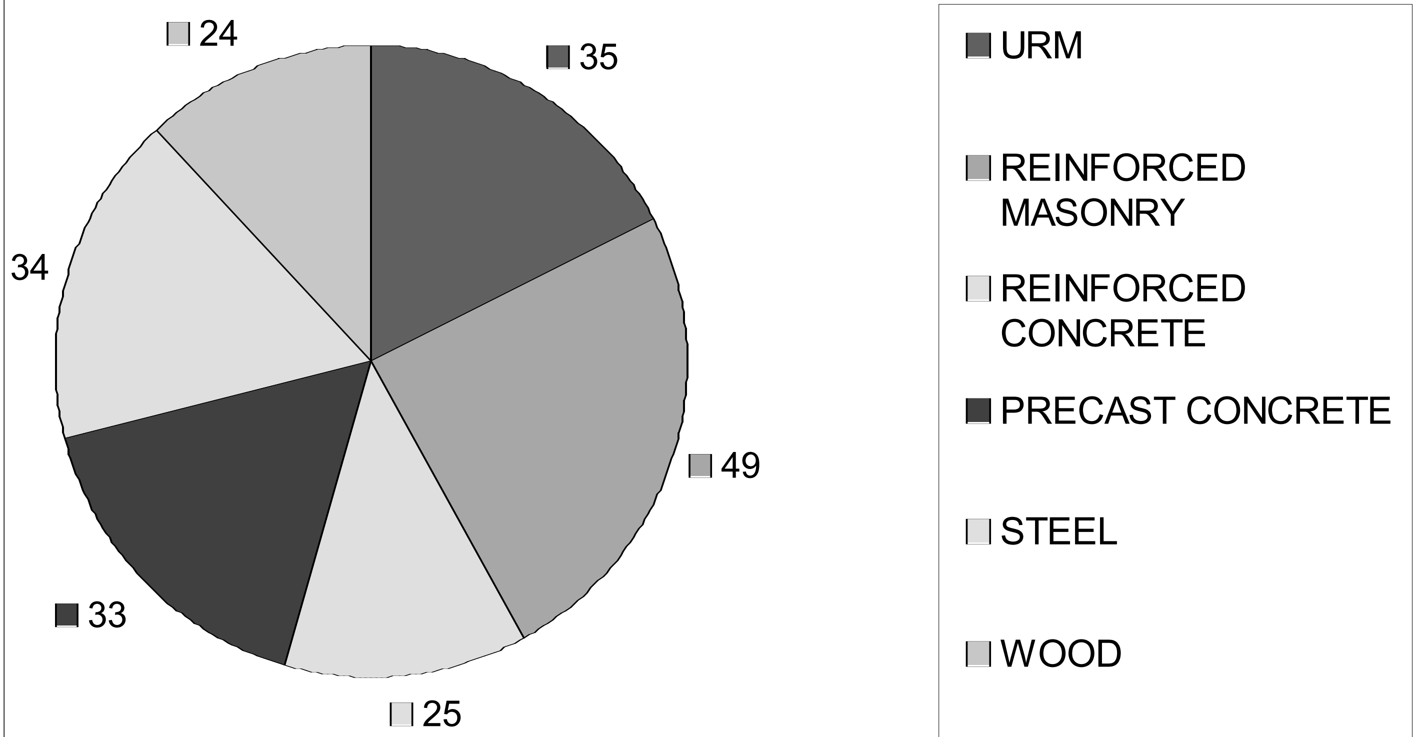

Buildings Surveyed by Study Area
20
40
35
20
15
30
40
DOWNTOWN EUGENE
VALLEY RIVER AREA
EUGENE INDUSTRIAL AREA
DOWNTOWN SPRINGFIELD
SPRINGFIELD INDUSTRIAL AREA
OLYMPIC AND MOHAWK AREA
GATEWAY AREA

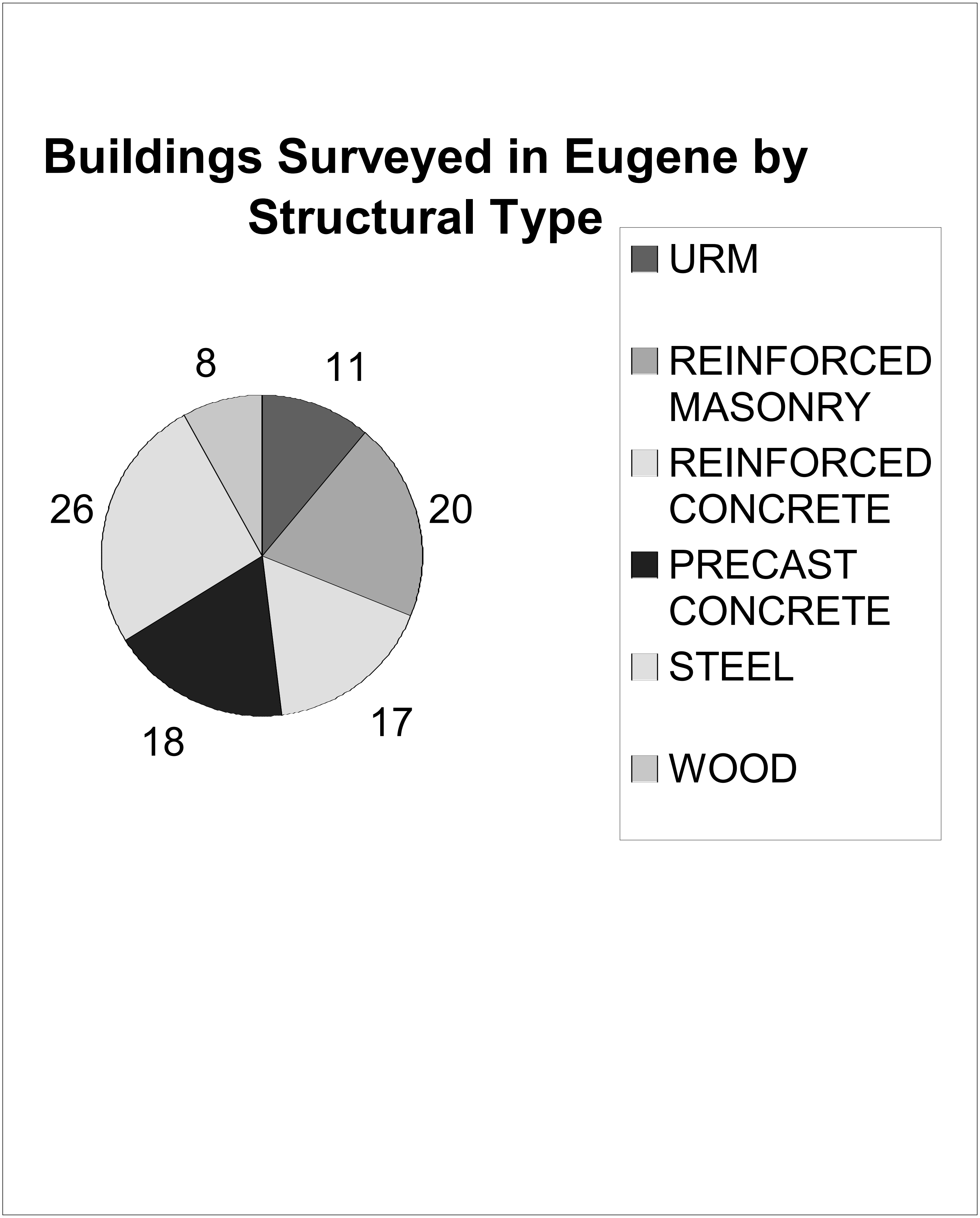

Buildings Surveyed by Occupancy Class
1
4
16
35
144
INDUSTRIAL
COMMERCIAL
RESIDENTIAL
RELIGION/NON-PROFIT
GOVERNMENT


Buildings Surveyed in Eugene by Occupancy Class
11
1
20
68
INDUSTRIAL
COMMERCIAL
RESIDENTIAL
RELIGION/NON-PROFIT


Buildings Surveyed in Springfield
by Occupancy Class
1
3
5
15
76
INDUSTRIAL
COMMERCIAL
RESIDENTIAL
RELIGION/NON-PROFIT
GOVERNMENT

Buildings Surveyed by Structural Type




Buildings Surveyed in Eugene by Structural Type
8
11
20
17
18
26
URM
REINFORCED MASONRY
REINFORCED CONCRETE
PRECAST CONCRETE
STEEL
WOOD

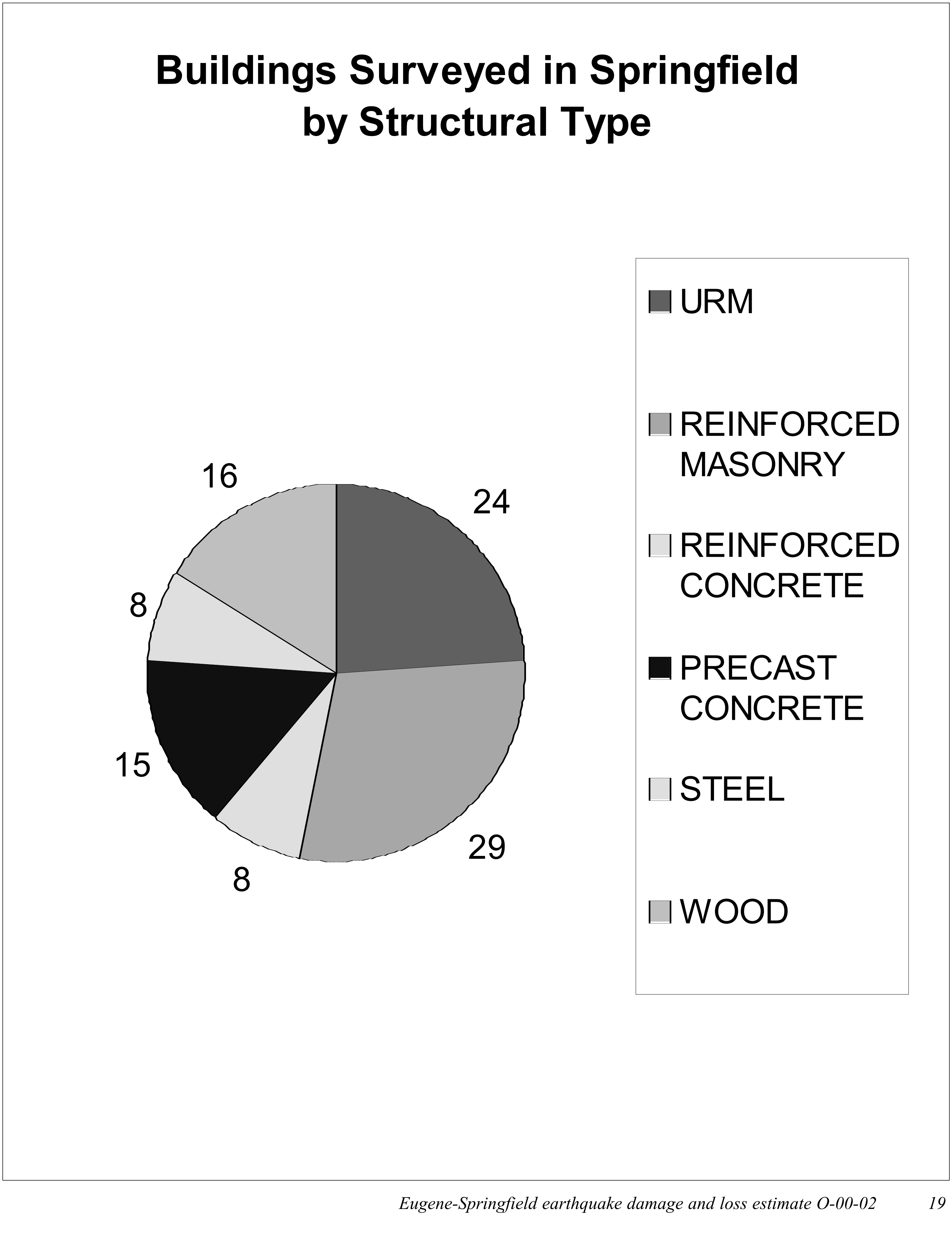
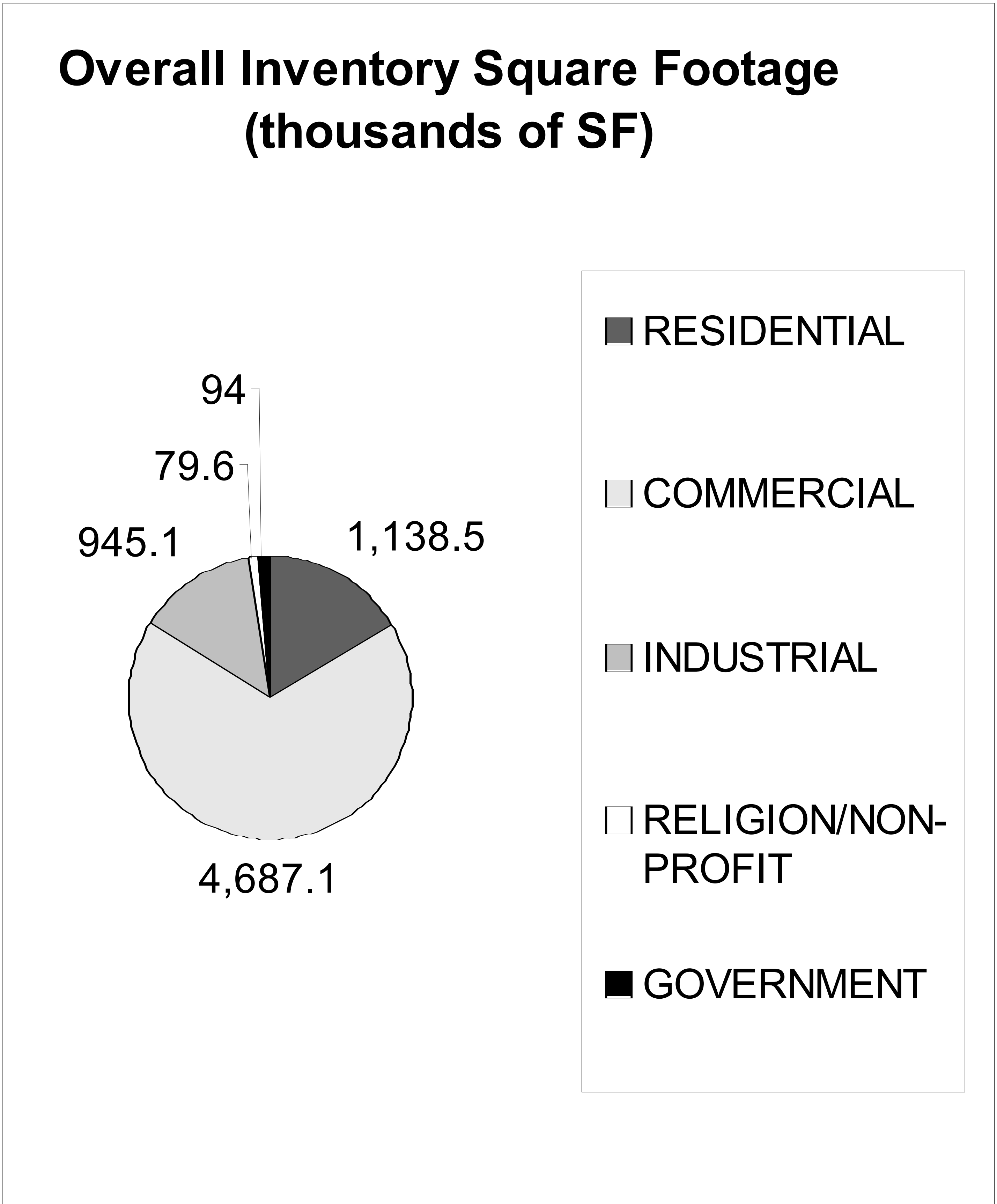
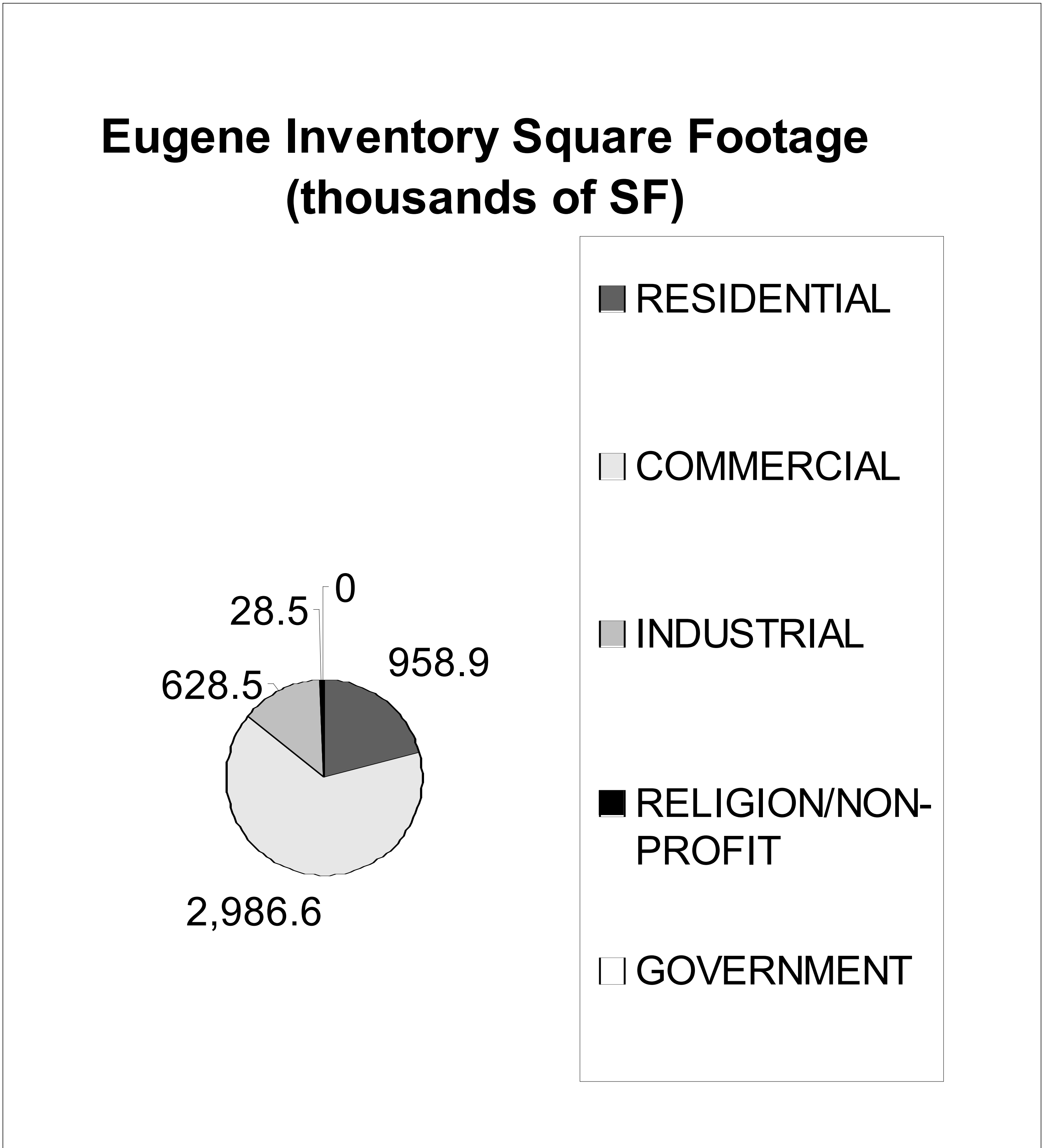

Buildings Surveyed in Springfield
by Structural Type
16
24
8
15
8
29
URM
REINFORCED MASONRY
REINFORCED CONCRETE
PRECAST CONCRETE
STEEL
WOOD

Table 3 - INVENTORY SQUARE FOOTAGE BY GENERAL OCCUPANCY

Values in thousands of square feet

Study Area	**Resid.**	**Comm.**	**Indust.**	**Religion**	**Govt.**	**Total**
Downtown Eugene	**958.9**	**1283.3**	**0**	**28.5**	**0**	**2270.7**
Valley River	**0**	**1370.1**	**0**	**0**	**0**	**1370.1**
W. Eugene Industrial	**0**	**333.2**	**628.5**	**0**	**0**	**961.7**
Downtown Springfield	**18.6**	**208.7**	**0**	**0**	**94.0**	**321.3**
Springfield Industrial & Gateway	**161.0**	**815.8**	**316.6**	**0**	**0**	**1293.4**
Olympic & Mohawk	**0**	**676.0**	**0**	**51.1**	**0**	**727.1**
Total Eugene	**958.9**	**2986.6**	**628.5**	**28.5**	**0**	**4602.5**
Total Springfield	**179.6**	**1700.5**	**316.6**	**51.1**	**94.0**	**2341.8**
Total Study Area	**1138.5**	**4687.1**	**945.1**	**79.6**	**94.0**	**6944.3**


Overall Inventory Square Footage
(thousands of SF)
94
79.6
945.1
1,138.5
4,687.1
RESIDENTIAL
COMMERCIAL
INDUSTRIAL
RELIGION/NON-PROFIT
GOVERNMENT


Eugene Inventory Square Footage
(thousands of SF)
28.5
0
958.9
628.5
2,986.6
RESIDENTIAL
COMMERCIAL
INDUSTRIAL
RELIGION/NON-PROFIT
GOVERNMENT

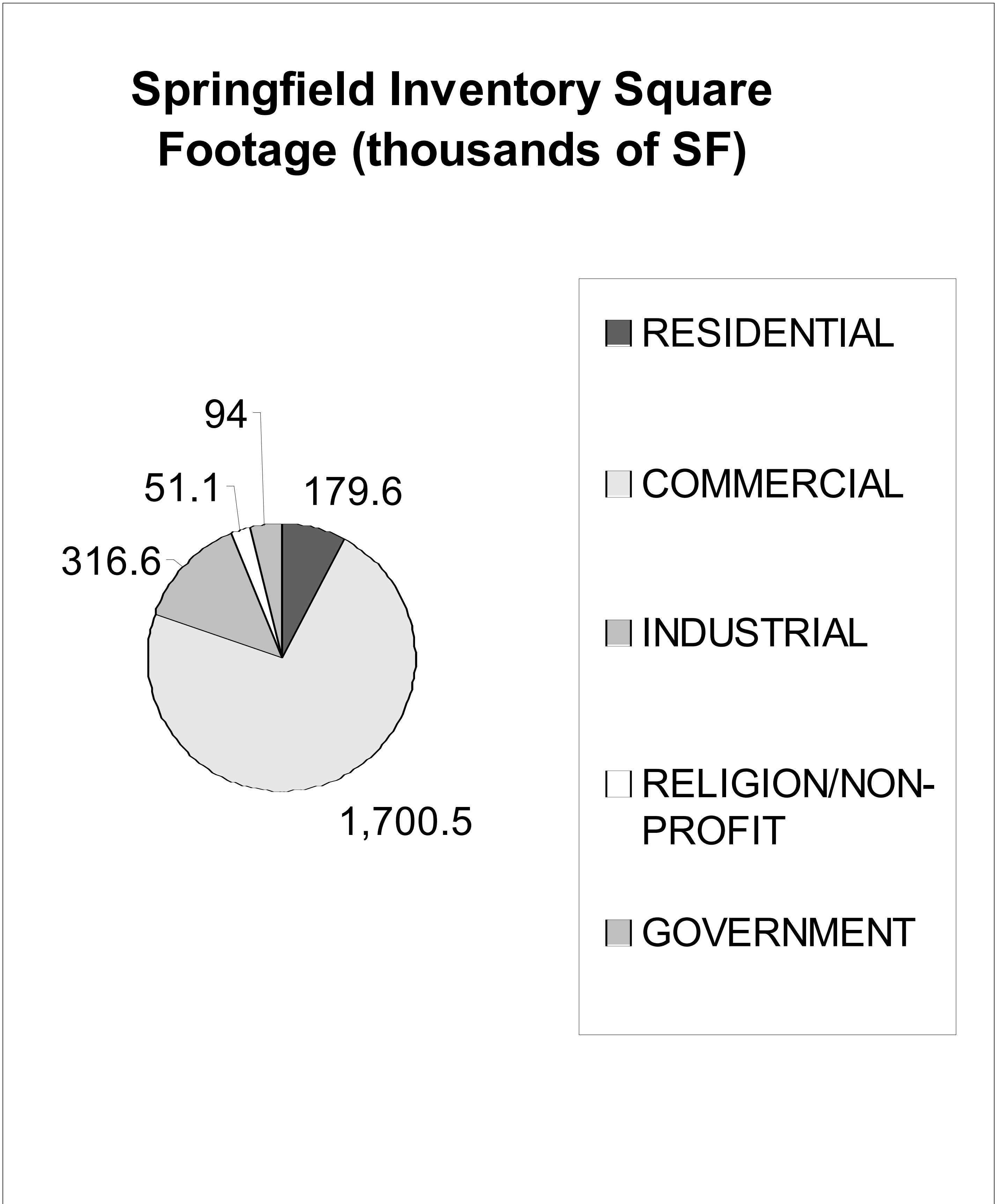

Springfield Inventory Square Footage (thousands of SF)
94
51.1
179.6
316.6
1,700.5
RESIDENTIAL
COMMERCIAL
INDUSTRIAL
RELIGION/NON-PROFIT
GOVERNMENT

Table 4 - DEMOGRAPHIC INVENTORY DATA

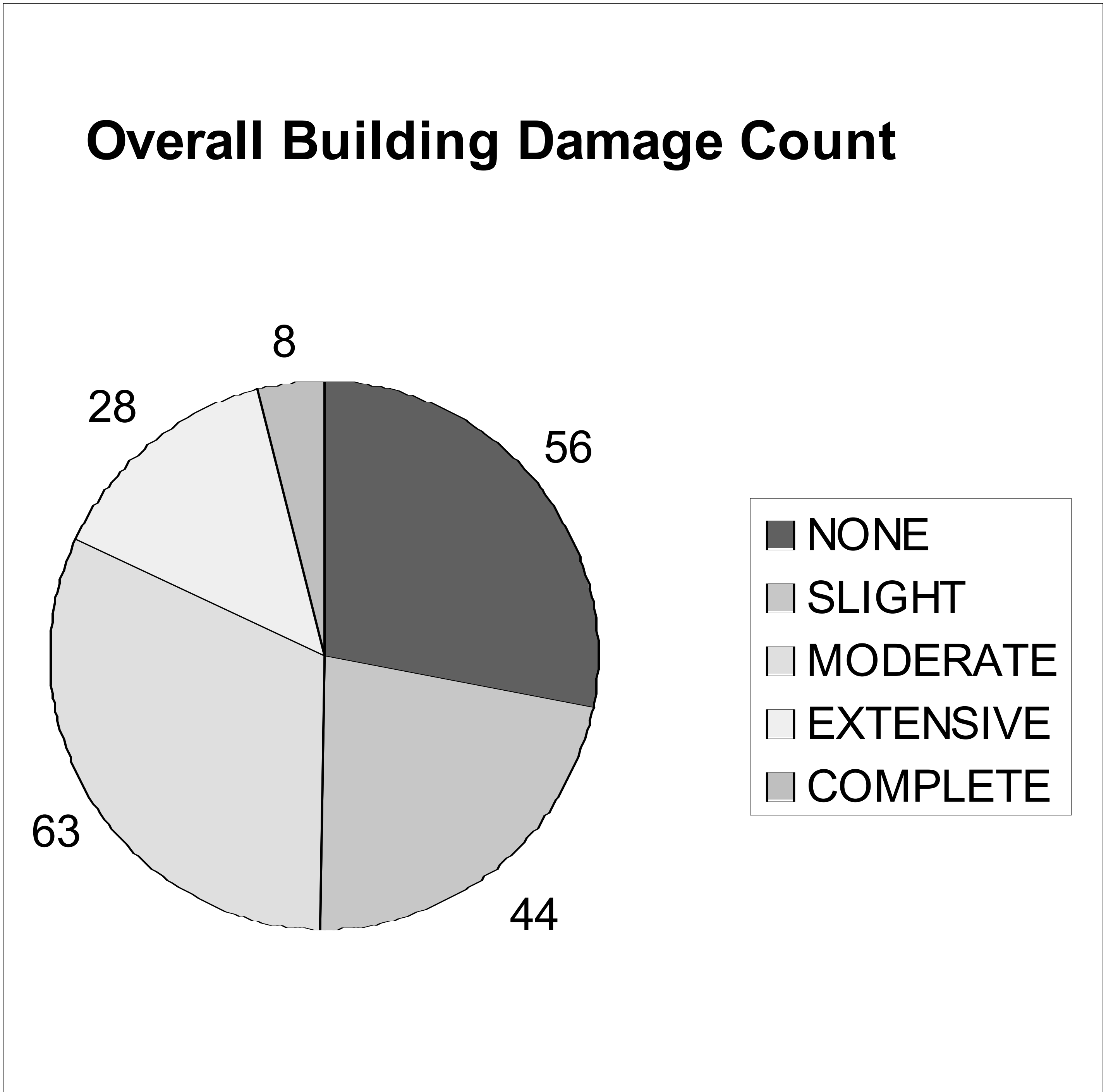
Study Area	Pop. Residential At Day	Pop. Residential At Night	Pop. Working Commercial	Pop. Working Industrial
Downtown Eugene	1,201	2,739	7,069	0
Valley River	0	0	13,417	0
W. Eugene Industrial	0	0	746	1,257
Downtown Springfield	23	53	2,104	0
Springfield Industrial & Gateway	159	460	7,972	638
Olympic & Mohawk	0	0	6,800	0
Total Eugene	1,201	2,739	21,232	1,257
Total Springfield	182	513	16,876	638
Total Study Area	1,383	3,252	38,108	1,895

Table 5 - BUILDING DAMAGE COUNT BY GENERAL OCCUPANCY

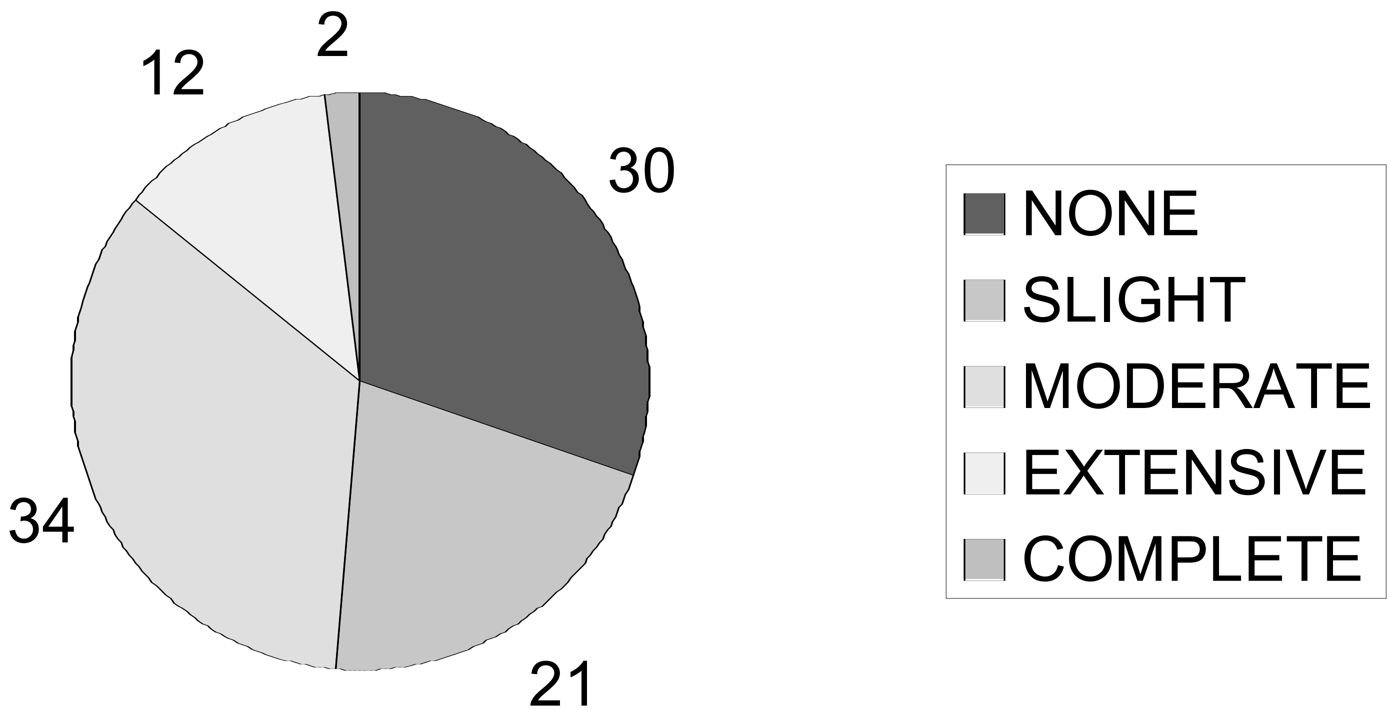
Study Area	Damage	Comm.	Govt.	Indust.	Religion	Resid.	Total
Downtown Eugene	None	10	0	0	0	3	13
	Slight	6	0	0	0	0	6
	Moderate	7	0	0	0	7	14
	Extensive	5	0	0	0	0	5
	Complete	2	0	0	0	0	2
Valley River	None	7	0	0	0	0	7
	Slight	6	0	0	0	0	6
	Moderate	6	0	0	0	0	6
	Extensive	1	0	0	0	0	1
	Complete	0	0	0	0	0	0
W. Eugene Industrial	None	6	0	4	0	0	10
	Slight	4	0	5	0	0	9
	Moderate	7	0	7	0	0	14
	Extensive	4	0	2	0	0	6
	Complete	0	0	0	0	0	0
Downtown Springfield	None	5	1	0	0	0	6
	Slight	6	0	0	0	0	6
	Moderate	7	0	0	0	0	7
	Extensive	6	0	0	0	0	6
	Complete	5	0	0	0	0	5
Springfield Industrial & Gateway	None	6	0	2	0	1	9
	Slight	4	0	3	0	1	8
	Moderate	6	0	5	0	1	12
	Extensive	2	0	3	0	0	5
	Complete	0	0	1	0	0	1
Olympic & Mohawk	None	10	0	0	1	0	11
	Slight	8	0	0	1	0	9
	Moderate	9	0	0	1	0	10
	Extensive	4	0	0	1	0	5
	Complete	0	0	0	0	0	0
Total Eugene	None	23	0	4	0	3	30
	Slight	16	0	5	0	0	21
	Moderate	20	0	7	0	7	34
	Extensive	10	0	2	0	0	12
	Complete	2	0	0	0	0	2
Total Springfield	None	21	1	2	1	1	26
	Slight	18	0	3	1	1	23
	Moderate	22	0	5	1	1	29
	Extensive	12	0	3	1	0	16
	Complete	5	0	1	0	0	6
Total Study Area	None	44	1	6	1	4	56
	Slight	34	0	8	1	1	44
	Moderate	42	0	12	1	8	63
	Extensive	22	0	5	1	0	28
	Complete	7	0	1	0	0	8

Table 6 - BUILDING DAMAGE COUNT BY BUILDING TYPE

Study Area	Damage	Reinf.Conc.	Precast Conc.	Reinf. Masonry	Steel	URM	Wood	Total
Downtown Eugene	None	4	2	1	4	2	0	13
	Slight	3	0	0	2	1	0	6
	Moderate	4	0	2	6	2	0	14
	Extensive	1	0	0	2	2	0	5
	Complete	0	0	0	0	2	0	2
Valley River	None	0	2	2	3	0	0	7
	Slight	1	0	2	2	0	1	6
	Moderate	1	0	2	2	0	1	6
	Extensive	0	0	1	0	0	0	1
	Complete	0	0	0	0	0	0	0
W. Eugene Industrial	None	1	3	3	1	0	2	10
	Slight	1	3	2	1	0	2	9
	Moderate	1	5	3	2	1	2	14
	Extensive	0	2	2	1	1	0	6
	Complete	0	1	0	0	0	0	1
Downtown Springfield	None	2	0	1	0	2	1	6
	Slight	3	0	0	0	3	0	6
	Moderate	2	0	1	0	4	0	7
	Extensive	1	0	0	0	5	0	6
	Complete	0	0	0	0	5	0	5
Springfield Industrial & Gateway	None	0	2	3	2	0	2	9
	Slight	0	3	2	1	0	2	8
	Moderate	0	4	3	2	1	2	12
	Extensive	0	2	1	1	1	0	5
	Complete	0	1	0	0	0	0	1
Olympic & Mohawk	None	0	0	6	2	0	3	11
	Slight	0	1	4	0	0	4	9
	Moderate	0	1	5	0	1	2	9
	Extensive	0	1	3	0	1	0	5
	Complete	0	0	0	0	1	0	1
Total Eugene	None	5	7	6	8	2	2	30
	Slight	5	3	4	5	1	3	21
	Moderate	6	5	7	10	3	3	34
	Extensive	1	2	3	3	3	0	12
	Complete	0	1	0	0	2	0	3
Total Springfield	None	2	2	10	4	2	6	26
	Slight	3	4	6	1	3	6	23
	Moderate	2	5	9	2	6	4	28
	Extensive	1	3	4	1	7	0	16
	Complete	0	1	0	0	6	0	7
Total Study Area	None	7	9	16	12	4	8	56
	Slight	8	7	10	6	4	9	44
	Moderate	8	10	16	12	9	7	62
	Extensive	2	5	7	4	10	0	28
	Complete	0	2	0	0	8	0	10


Overall Building Damage Count
8
28
56
63
44
NONE
SLIGHT
MODERATE
EXTENSIVE
COMPLETE

Eugene Building Damage Count



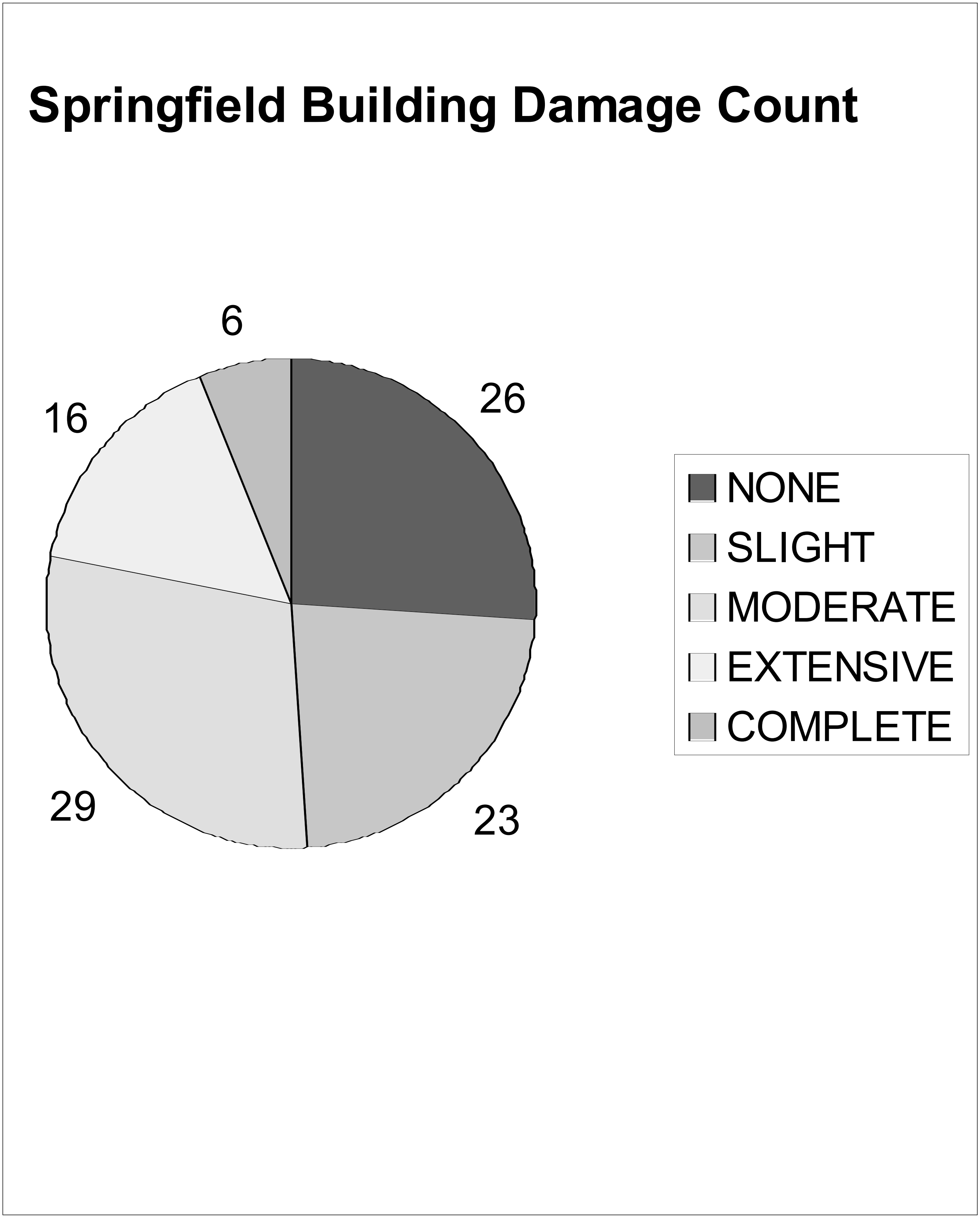
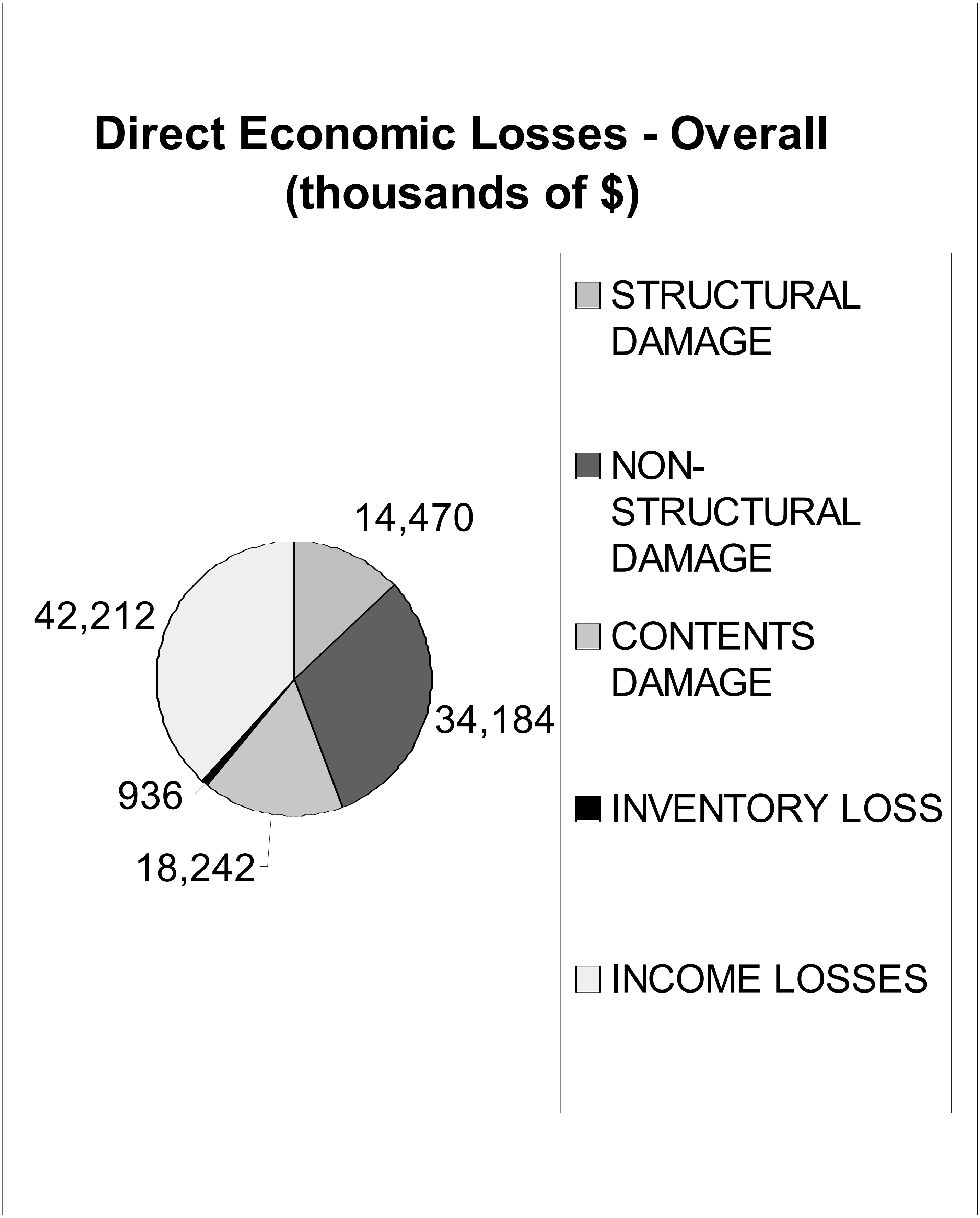

Springfield Building Damage Count
6
26
16
29
23
NONE
SLIGHT
MODERATE
EXTENSIVE
COMPLETE

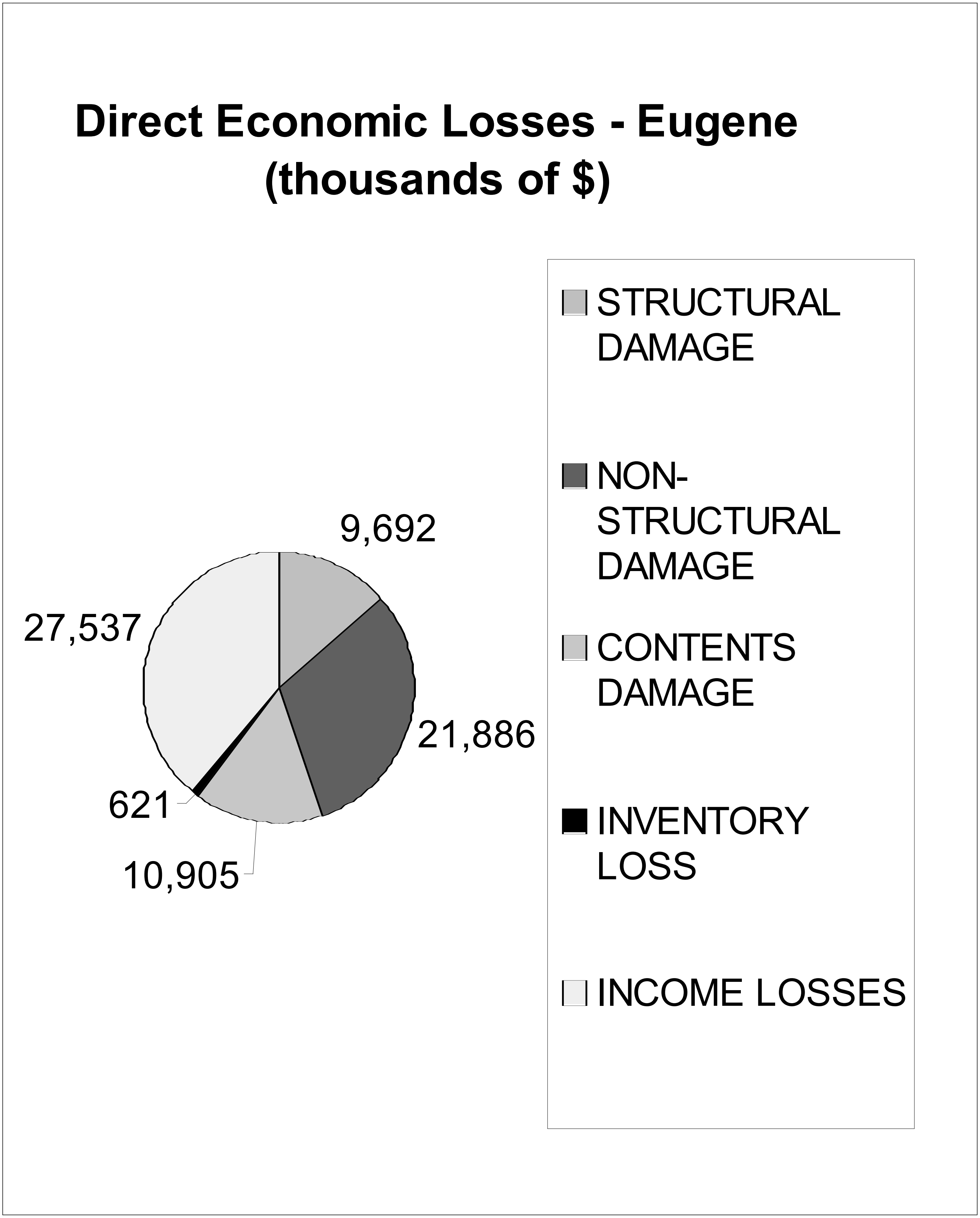
Table 7 - DIRECT ECONOMIC LOSSES FOR BUILDINGS

Values are in thousands of dollars

Study Area	Capital Stock Losses				Income Losses (Relocation, capital related, wages and rental income)	Total Losses
	Cost Struct. Damage	Cost Non-Struct. Damage	Cost Contents Damage	Inventory Loss		
Downtown Eugene	5,607	12,406	4,498	39	19,430	41,980
Valley River	2,627	5,537	3,378	191	5,944	17,677
W. Eugene Industrial	1,458	3,943	3,029	391	2,163	10,984
Downtown Springfield	1,161	2,762	1,381	20	5,332	10,656
Springfield Industrial & Gateway	2,225	5,910	3,667	202	5,121	17,125
Olympic & Mohawk	1,392	3,626	2,289	93	4,222	11,622
Total Eugene	9,692	21,886	10,905	621	27,537	70,641
Total Springfield	4,778	12,298	7,337	315	14,675	39,403
Total Study Area	14,470	34,184	18,242	936	42,212	110,044



Direct Economic Losses - Overall
(thousands of $)
14,470
42,212
34,184
936
18,242
STRUCTURAL DAMAGE
NON-STRUCTURAL DAMAGE
CONTENTS DAMAGE
INVENTORY LOSS
INCOME LOSSES


Direct Economic Losses - Eugene
(thousands of $)
9,692
27,537
21,886
621
10,905
STRUCTURAL DAMAGE
NON-STRUCTURAL DAMAGE
CONTENTS DAMAGE
INVENTORY LOSS
INCOME LOSSES

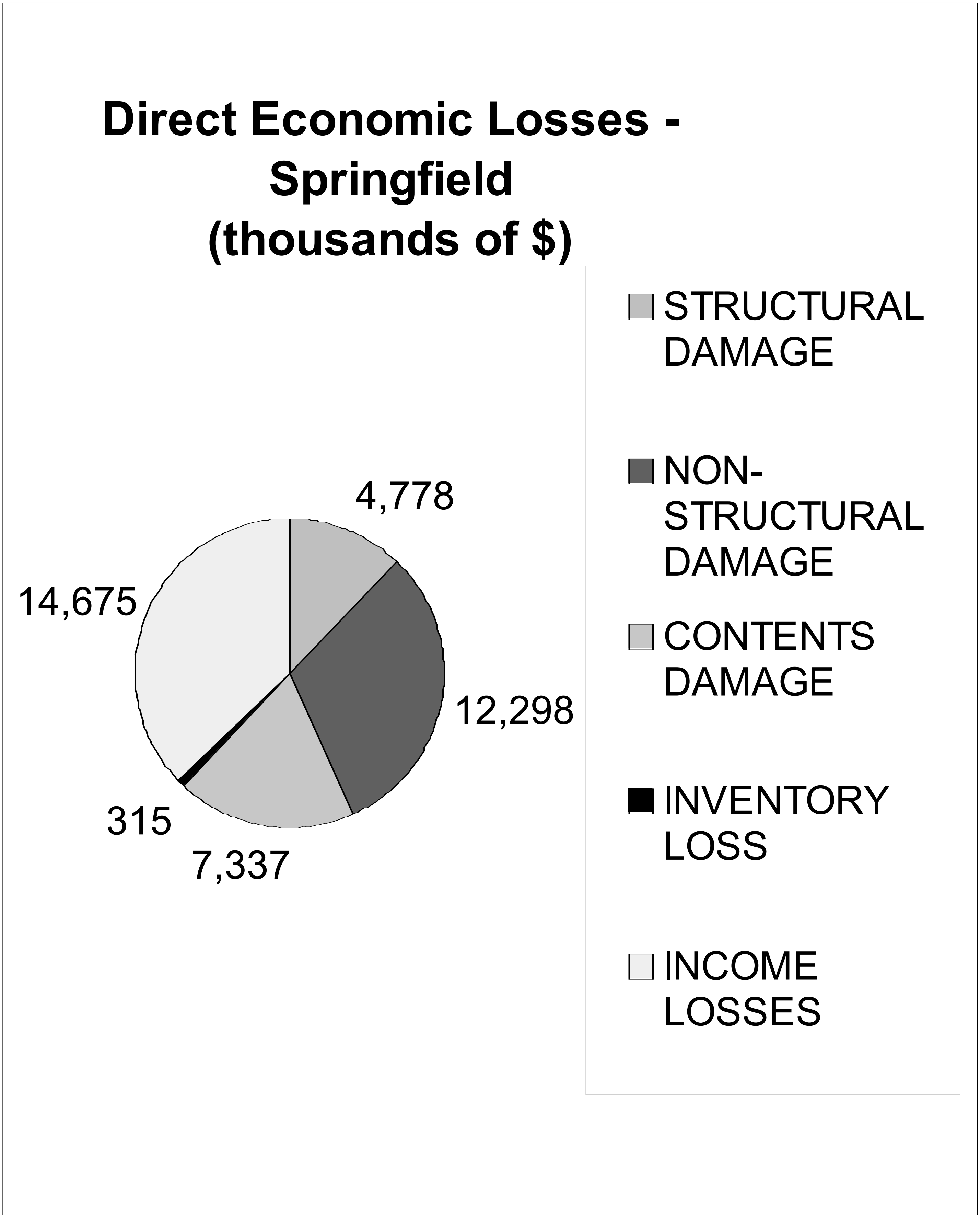

Direct Economic Losses - Springfield (thousands of $)
4,778
12,298
7,337
315
14,675
STRUCTURAL DAMAGE
NON-STRUCTURAL DAMAGE
CONTENTS DAMAGE
INVENTORY LOSS
INCOME LOSSES

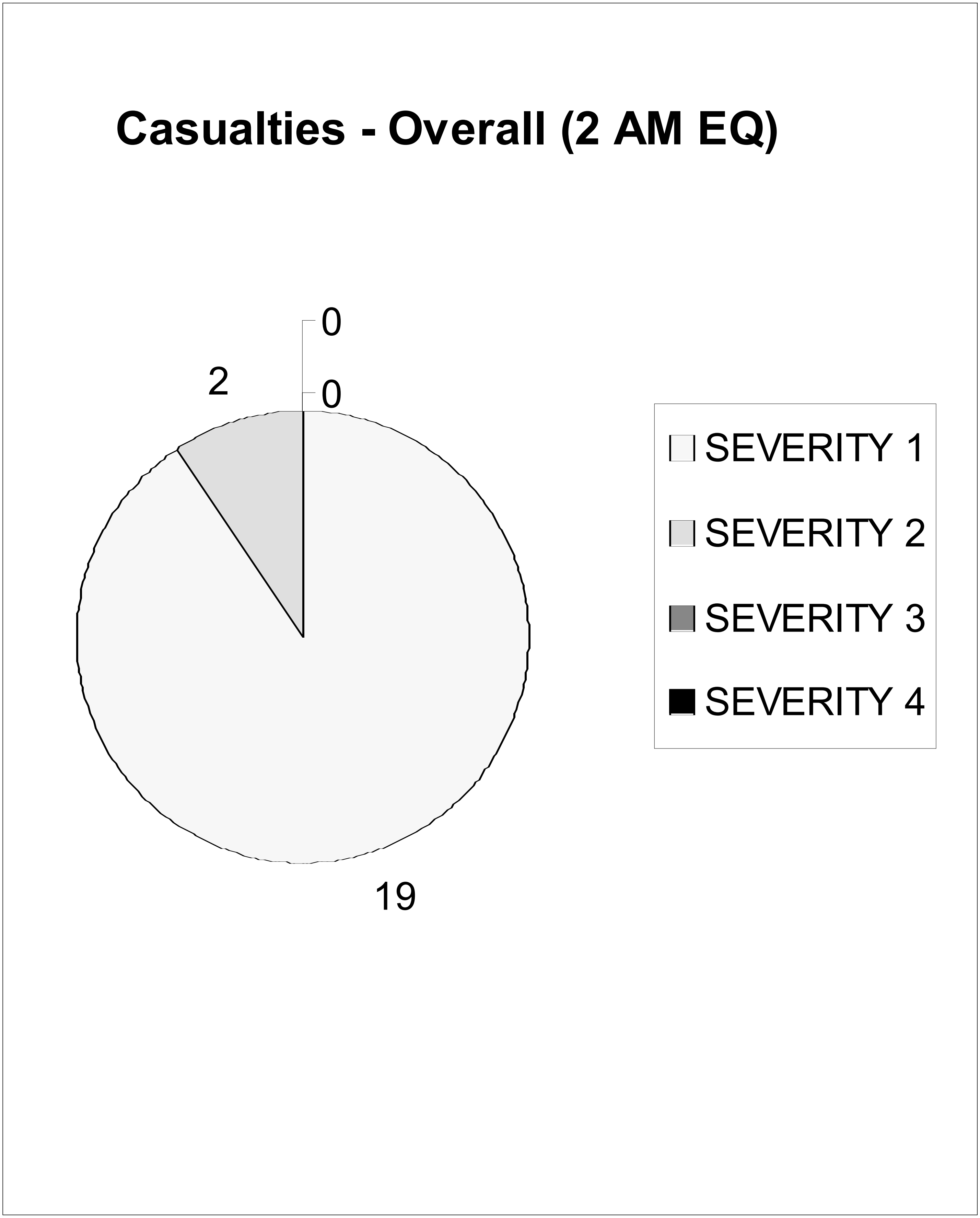
Table 8 – CASUALTIES

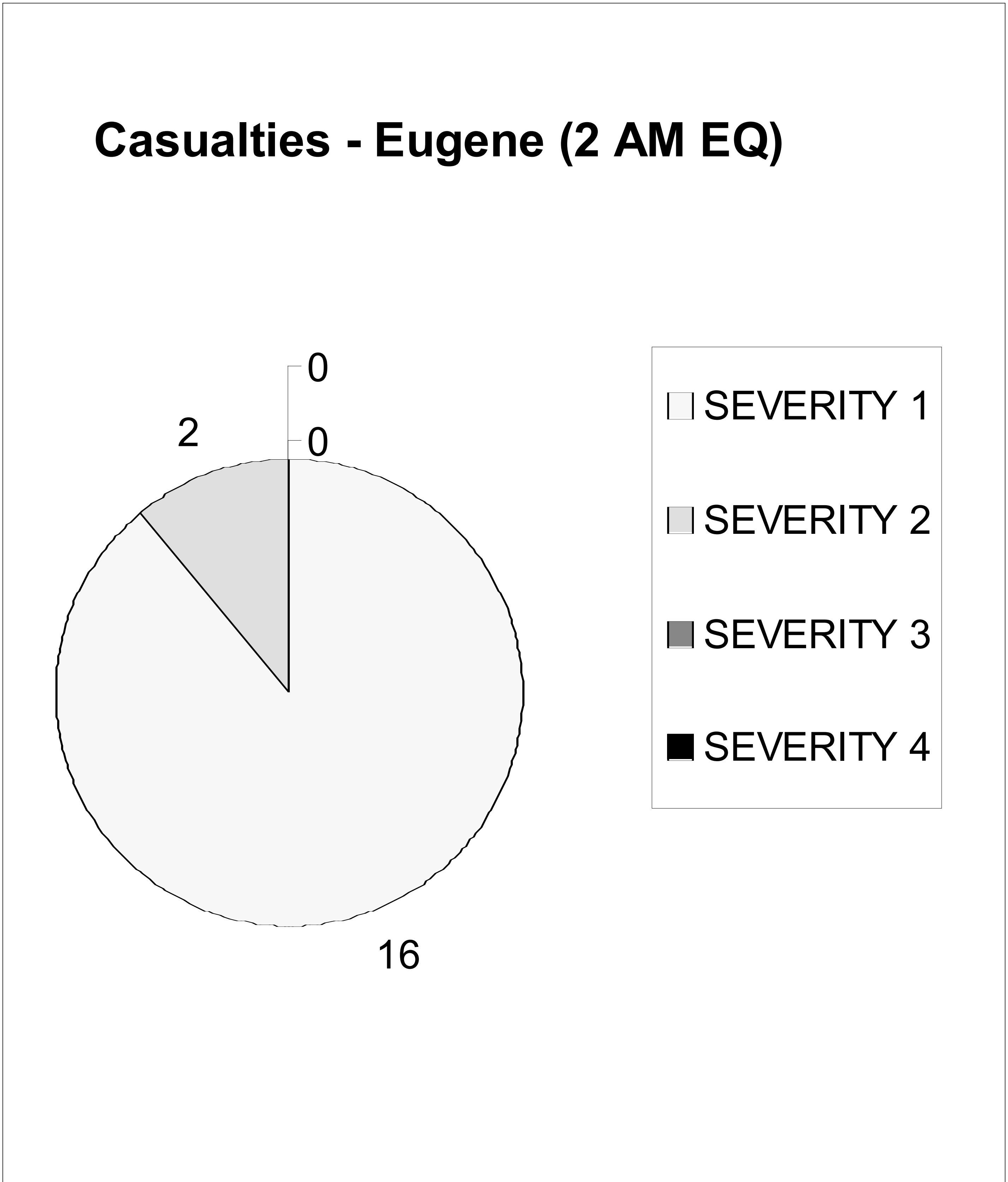
Severity levels are defined in Table 13.1 (FEMA 1997a)

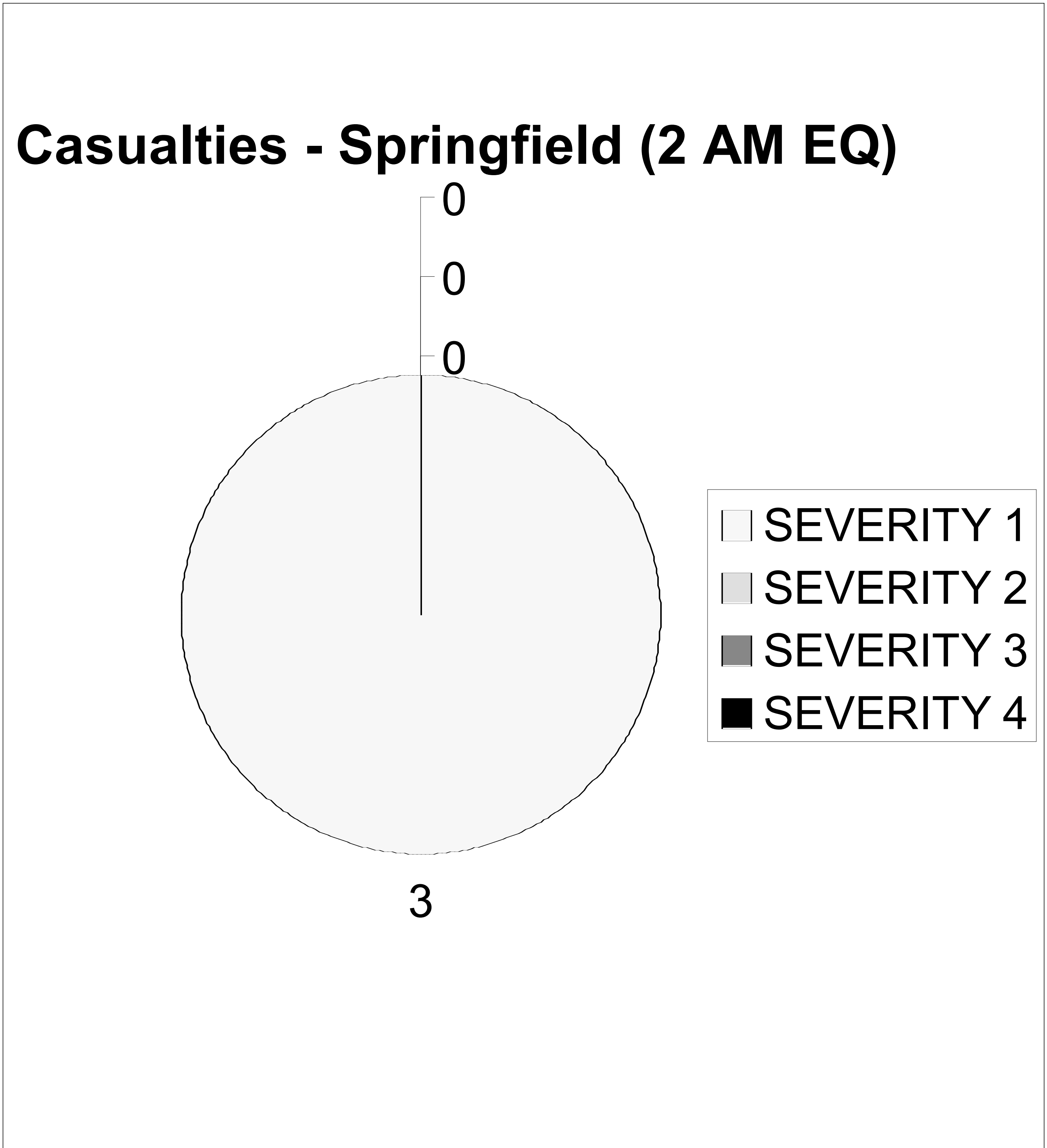
Study Area	Severity 1		Severity 2		Severity 3		Severity 4		Total	
	2 AM	2 PM	2 AM	2 PM	2 AM	2 PM	2 AM	2 PM	2 AM	2 PM
Downtown Eugene	14	53	2	9	0	1	0	1	17	65
Valley River	1	53	0	8	0	1	0	1	1	62
W. Eugene Industrial	1	7	0	1	0	0	0	0	1	8
Downtown Springfield	1	53	0	10	0	1	0	1	2	66
Springfield Industrial & Gateway	1	28	0	4	0	0	0	0	1	33
Olympic & Mohawk	1	44	0	7	0	1	0	1	1	53
Total Eugene	16	113	2	18	0	2	0	2	19	135
Total Springfield	3	125	0	21	0	2	0	2	4	152
Total Study Area	19	238	2	39	0	4	0	4	23	287

Table 13.1: Injury Classification Scale

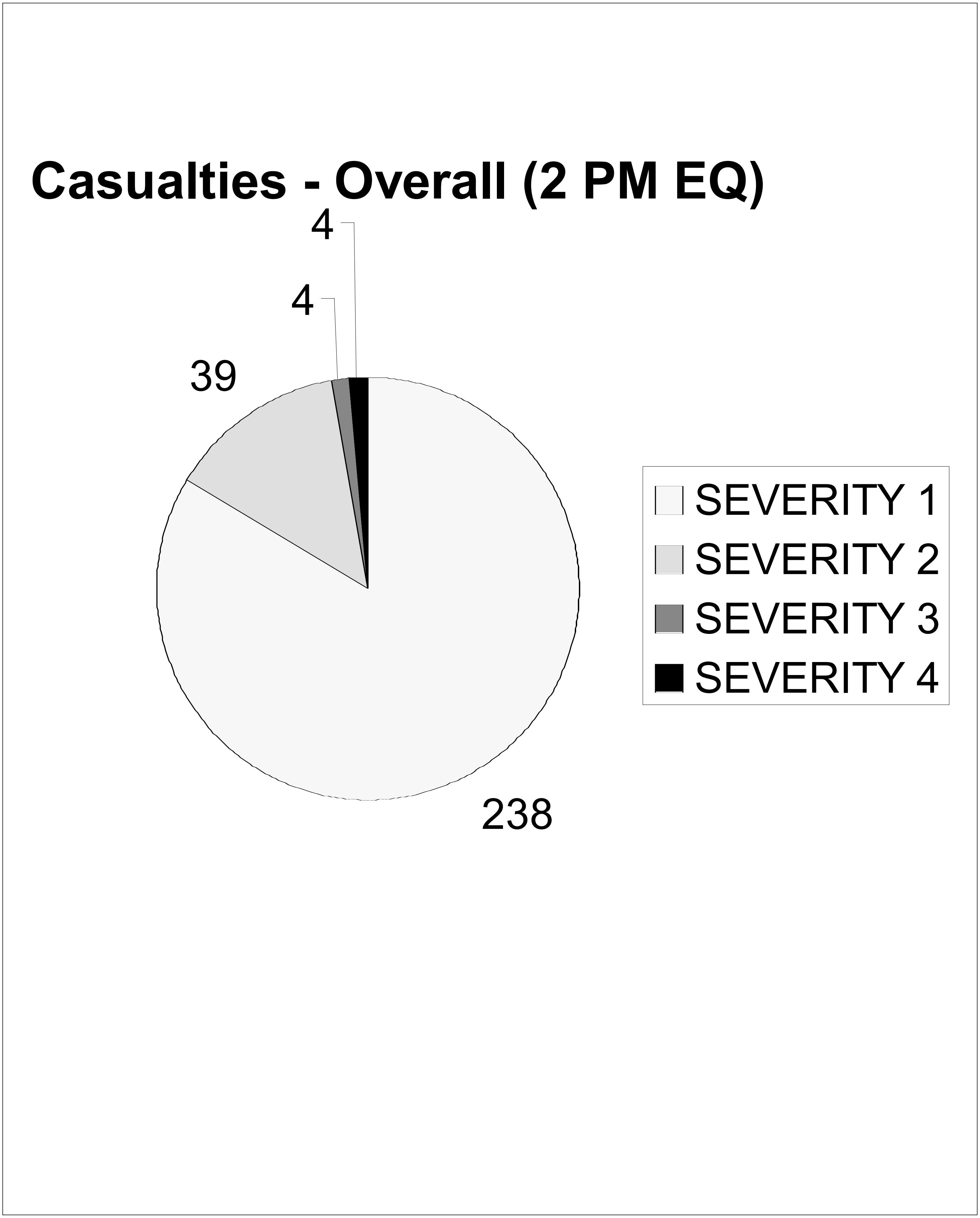
Injury Severity Level	Injury Description
Severity 1	Injuries requiring basic medical aid without requiring hospitalization
Severity 2	Injuries requiring a greater degree of medical care and hospitalization, but not expected to progress to a life threatening status
Severity 3	Injuries which pose an immediate life threatening condition if not treated adequately and expeditiously. The majority of these injuries are the result of structural collapse and subsequent entrapment or impairment of the occupants.
Severity 4	Instantaneously killed or mortally injured

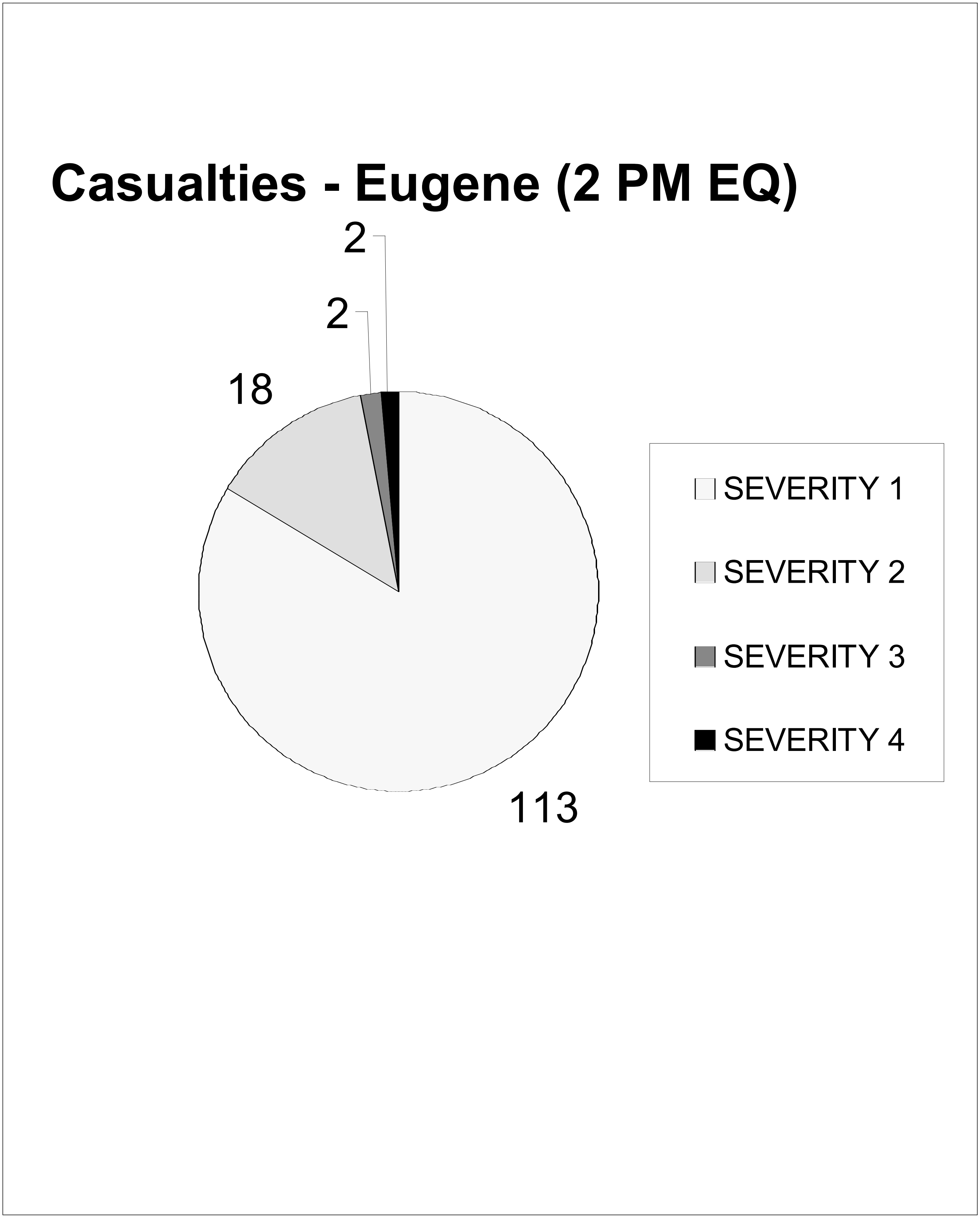

Casualties - Overall (2 AM EQ)
0
2
0
19
SEVERITY 1
SEVERITY 2
SEVERITY 3
SEVERITY 4

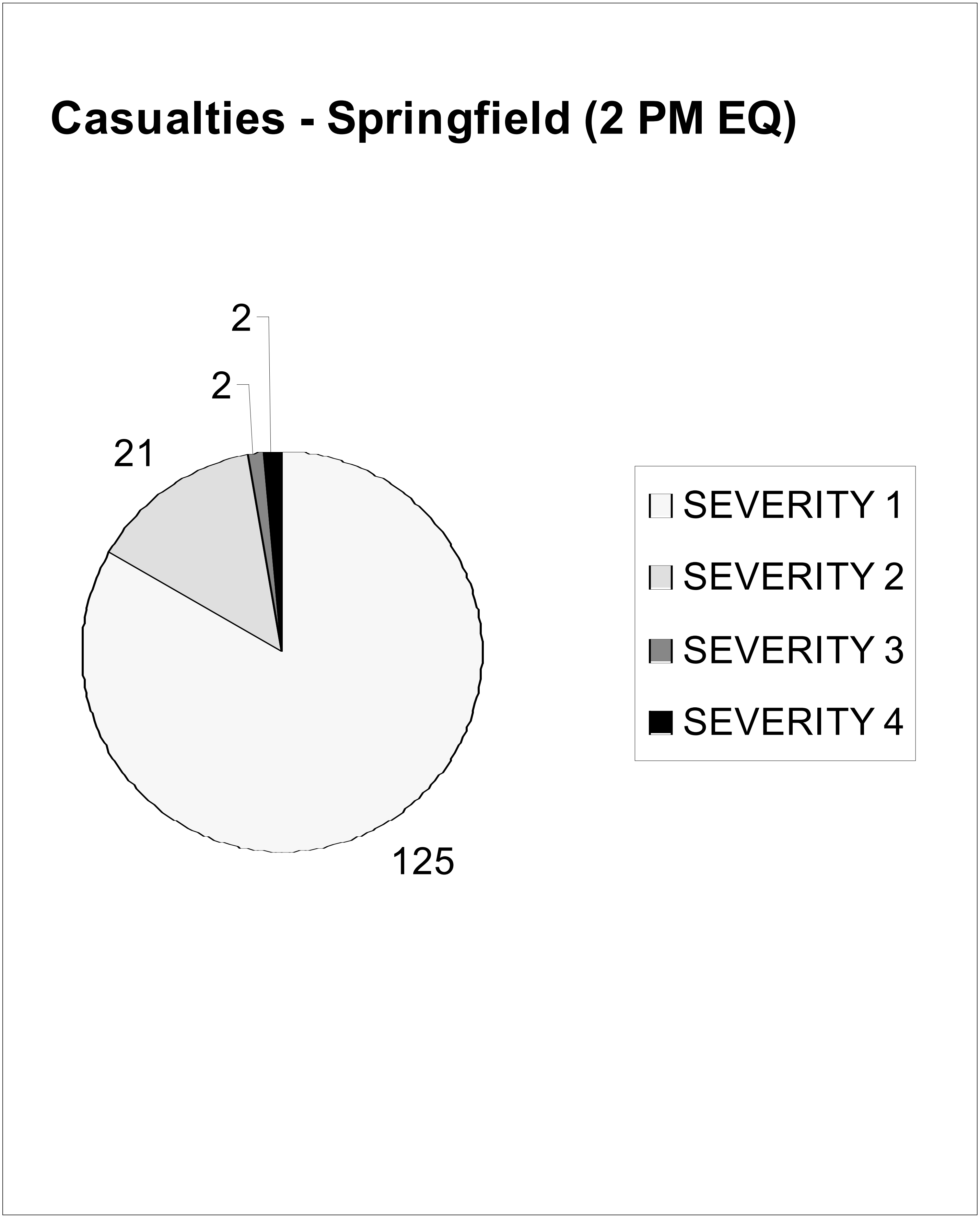

Casualties - Eugene (2 AM EQ)
0
2
0
16
SEVERITY 1
SEVERITY 2
SEVERITY 3
SEVERITY 4



Casualties - Springfield (2 AM EQ)
0
0
0
3
SEVERITY 1
SEVERITY 2
SEVERITY 3
SEVERITY 4


Casualties - Overall (2 PM EQ)
4
4
39
238
SEVERITY 1
SEVERITY 2
SEVERITY 3
SEVERITY 4


Casualties - Eugene (2 PM EQ)
2
2
18
113
SEVERITY 1
SEVERITY 2
SEVERITY 3
SEVERITY 4


Casualties - Springfield (2 PM EQ)
2
2
21
125
SEVERITY 1
SEVERITY 2
SEVERITY 3
SEVERITY 4

6. CONCLUSIONS AND RECOMMENDATIONS

This pilot project to develop earthquake damage and loss estimates for 200 selected buildings in the Eugene and Springfield, Oregon area has *clearly demonstrated the applicability of the FEMA HAZUS methodology in incorporating ATC-21 survey data collected for specific structures in the study area. The damage and loss estimates will aid regional planning and emergency response agencies to increase earthquake awareness in the region and to begin to develop hazard mitigation and response strategies*.

However, the reader is cautioned in several areas:

1) *The pilot study only involved 100 buildings in each city* and

2) *The buildings were generally selected to include those most likely to contribute to losses and casualties*.

Thus, the authors strongly discourage simplistic attempts to extrapolate the results of this study to the aggregate performance of all of the buildings in larger portions of the entire study region. The 200 buildings were never intended to be a representative sampling from the entire study area. We do recommend a broader survey of the area facilities by local personnel to establish a more extensive facility inventory database and a basis for determining the actual distribution of different occupancy classes and building types.

7. ACKNOWLEDGMENTS

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