

HAZUS 99-SR1: Earthquake Event Report

Region Name: grnvl68_35

Earthquake Scenario: grnville68b

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Disclaimer:

The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

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General Description of the Region

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 4 county(ies) from the following state(s):

- California

Note:

Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 610 square miles and contains 393 census tracts. There are over 573 thousand households in the region and has a total population of 1,633,000 people (1990 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 434 thousand buildings in the region with a total building replacement value (excluding contents) of 89,184 million dollars (1994 dollars). Approximately 96% of the buildings (and 72% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 8,504 and 3,425 million dollars (1994 dollars), respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 434,000 buildings in the region which have an aggregate total replacement value of 89,184 million dollars (1994 dollars). Figure 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provides a general distribution of the building value by State and County.

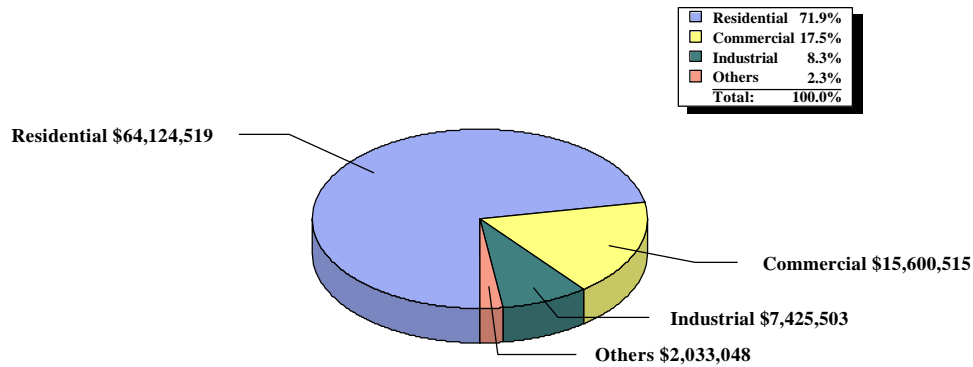


Figure 1: Building Exposure by Occupancy Type
(Thousands of dollars)

In terms of building construction types found in the region, wood frame construction makes up 76% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

HAZUS breaks critical facilities into two (2) groups: essential facilities and high potential loss (HPL) facilities. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 16 hospitals in the region with a total bed capacity of 4,908 beds. There are 689 schools, 26 fire stations, 48 police stations and 8 emergency operation facilities. With respect to HPL facilities, there are 26 dams identified within the region. Of these, 17 of the dams are classified as 'high hazard'. The inventory also includes 5,273 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data is provided in Tables 2 and 3.

The total value of the lifeline inventory is over 9,358 million dollars. This inventory includes over 369 kilometers of highways, 1,295 bridges, 0 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

| System | Component | # locations/ # Segments | Replacement value (millions of dollars) |
|-------------------|------------------|------------------------------------|--|
| Highway | Major Roads | 73 | 3,688 |
| | Bridges | 1,291 | 4,119 |
| | Tunnels | 0 | 0 |
| | | Subtotal | 7,807 |
| Railways | Rail Tracks | 214 | 372 |
| | Bridges | 4 | 20 |
| | Tunnels | 0 | 0 |
| | Facilities | 1 | 3 |
| | | Subtotal | 395 |
| Light Rail | Rail Tracks | 0 | 0 |
| | Bridges | 0 | 0 |
| | Tunnels | 0 | 0 |
| | Facilities | 0 | 0 |
| | | Subtotal | 0 |
| Bus | Facilities | 0 | 0 |
| Ferry | Facilities | 0 | 0 |
| Port | Facilities | 0 | 0 |
| Airport | Facilities | 10 | 50 |
| | Runways | 9 | 252 |
| | | Subtotal | 302 |
| | | Total | 8,504 |

Table 3: Utility System Lifeline inventory

| System | Component | # Locations / Segments | Replacement value (millions of dollars) |
|------------------|--------------------|------------------------|---|
| Potable Water | Pipelines | 0 | 0.0 |
| | Facilities | 0 | 0.0 |
| | Distribution Lines | NA | 1,264.2 |
| | | Subtotal | 1,264.2 |
| Waste Water | Pipelines | 0 | 0.0 |
| | Facilities | 2 | 120.0 |
| | Distribution Lines | NA | 758.5 |
| | | Subtotal | 878.5 |
| Natural Gas | Pipelines | 4 | 10.5 |
| | Facilities | 0 | 0.0 |
| | Distribution Lines | NA | 505.7 |
| | | Subtotal | 516.2 |
| Oil Systems | Pipelines | 0 | 0.0 |
| | Facilities | 2 | 4.0 |
| | | Subtotal | 4.0 |
| Electrical Power | Facilities | 0 | 0.0 |
| | Distribution Lines | NA | 379.3 |
| | | Subtotal | 379.3 |
| Communication | Facilities | 107 | 214.0 |
| | Distribution Lines | NA | 168.6 |
| | | Subtotal | 382.6 |
| | | Total | 3,424.8 |

Earthquake Scenario

HAZUS uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

| | |
|--------------------------------------|-----------------------|
| Scenario Name | grnville68b |
| Type of Earthquake | Arbitrary event |
| Fault Name | NA |
| Historical Epicenter ID # | NA |
| Probabilistic Return Period | NA |
| Longitude of Epicenter | -121.619 |
| Latitude of Epicenter | 37.625 |
| Earthquake Magnitude | 6.8 |
| Depth (Km) | 5 |
| Rupture Length (Km) | 44.2588 |
| Rupture Orientation (degrees) | 151 |
| Attenuation Function | Project 97 West Coast |

Building Damage

Building Damage

HAZUS estimates that about 22 thousand buildings will be at least moderately damaged. This is over 5% of the total number of buildings in the region. There are an estimated 223 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 4 below summarizes the expected damage by general occupancy for the buildings in the region. Table 5 summarizes the expected damage by general building type.

Table 4: Expected Building Damage by Occupancy

| | None | | Slight | | Moderate | | Extensive | | Complete | |
|--------------------|----------------|-------|---------------|-------|---------------|-------|--------------|-------|------------|-------|
| | Count | (%) | Count | (%) | Count | (%) | Count | (%) | Count | (%) |
| Residential | 338,942 | 96.28 | 58,250 | 97.39 | 17,562 | 95.42 | 3,569 | 94.09 | 214 | 95.96 |
| Commercial | 7,995 | 2.27 | 839 | 1.40 | 391 | 2.12 | 88 | 2.32 | 2 | 0.90 |
| Industrial | 3,916 | 1.11 | 661 | 1.11 | 438 | 2.38 | 136 | 3.59 | 7 | 3.14 |
| Agriculture | 211 | 1.11 | 15 | 0.00 | 4 | 0.02 | 0 | 0.00 | 0 | 0.00 |
| Religion | 447 | 0.13 | 27 | 0.00 | 7 | 0.04 | 0 | 0.00 | 0 | 0.00 |
| Government | 106 | 0.03 | 1 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Education | 420 | 0.12 | 15 | 0.03 | 3 | 0.02 | 0 | 0.00 | 0 | 0.00 |
| Total | 352,037 | | 59,808 | | 18,405 | | 3,793 | | 223 | |

Table 5: Expected Building Damage by Building Type (All Design Levels)

| | None | | Slight | | Moderate | | Extensive | | Complete | |
|-------------------------|---------|------|--------|------|----------|------|-----------|------|----------|------|
| | Count | (%) | Count | (%) | Count | (%) | Count | (%) | Count | (%) |
| Concrete | 2,828 | 0.8 | 312 | 0.5 | 123 | 0.7 | 27 | 0.7 | 0 | 0.0 |
| Mobile Homes | 10,391 | 3.0 | 5,068 | 8.5 | 4,823 | 26.2 | 1,209 | 31.9 | 86 | 38.1 |
| Precast Concrete | 2,957 | 0.8 | 396 | 0.7 | 294 | 1.6 | 112 | 3.0 | 7 | 3.1 |
| RM* | 28,489 | 8.1 | 3,216 | 5.4 | 2,252 | 12.2 | 670 | 17.7 | 12 | 5.3 |
| Steel | 24,400 | 6.9 | 5,247 | 8.8 | 4,151 | 22.6 | 1,051 | 27.7 | 23 | 10.2 |
| URM* | 2,810 | 0.8 | 1,010 | 1.7 | 804 | 4.4 | 300 | 7.9 | 41 | 18.1 |
| Wood | 280,162 | 79.6 | 44,559 | 74.5 | 5,958 | 32.4 | 425 | 11.2 | 57 | 25.2 |

*Note:

RM Reinforced Masonry

URM Unreinforced Masonry

Essential Facility Damage

Before the earthquake, the region had 4,908 hospital beds available for use. On the day of the earthquake, the model estimates that only 4,094 hospital beds (83%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 91% of the beds will be back in service. By 30 days, 97% will be operational.

Table 6: Expected Damage to Essential Facilities

| Classification | Total | # Facilities | | |
|-----------------|-------|--------------------------------|--------------------------|---------------------------------|
| | | Least Moderate Damage > 50% | Complete Damage > 50% | Functionality > 50% at day 1 |
| Hospitals | 16 | 0 | 0 | 16 |
| Schools | 689 | 0 | 0 | 689 |
| EOCs | 8 | 0 | 0 | 8 |
| Police Stations | 48 | 0 | 0 | 48 |
| Fire Stations | 26 | 26 | 0 | 26 |

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

| System | Component | Number of Locations | | | | |
|------------|------------|------------------------|------------------------------|-------------------------|---------------------------|-------------|
| | | Locations/ Segments | With at Least Mod. Damage | With Complete Damage | With Functionality > 50 % | |
| | | | | | After Day 1 | After Day 7 |
| Highway | Roads | 73 | | | 73 | 73 |
| | Bridges | 1,291 | 33 | 6 | 1,291 | 1,291 |
| | Tunnels | 0 | 0 | 0 | 0 | 0 |
| Railways | Tracks | 0 | | | 214 | 214 |
| | Bridges | 4 | 0 | 0 | 4 | 4 |
| | Tunnels | 0 | 0 | 0 | 0 | 0 |
| | Facilities | 1 | 0 | 0 | 1 | 1 |
| Light Rail | Tracks | 0 | | | 0 | 0 |
| | Bridges | 0 | 0 | 0 | 0 | 0 |
| | Tunnels | 0 | 0 | 0 | 0 | 0 |
| | Facilities | 0 | 0 | 0 | 0 | 0 |
| Bus | Facilities | 0 | 0 | 0 | 0 | 0 |
| Ferry | Facilities | 0 | 0 | 0 | 0 | 0 |
| Port | Facilities | 0 | 0 | 0 | 0 | 0 |
| Airport | Facilities | 10 | 1 | 0 | 10 | 10 |
| | Runways | 9 | 0 | 0 | 9 | 9 |

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 8-10 provide information on the damage to the utility lifeline systems. Table 8 provides damage to the utility system facilities. Table 9 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 10 provides a summary of the system performance information.

Table 8 : Expected Utility System Facility Damage

| System | # of Locations | | | | |
|------------------|----------------|-------------------------------|----------------------|---------------------------|-------------|
| | Total # | With at Least Moderate Damage | With Complete Damage | with Functionality > 50 % | |
| | | | | After Day 1 | After Day 7 |
| Potable Water | 0 | 0 | 0 | 0 | 0 |
| Waste Water | 2 | 0 | 0 | 2 | 2 |
| Natural Gas | 0 | 0 | 0 | 0 | 0 |
| Oil Systems | 2 | 0 | 0 | 2 | 2 |
| Electrical Power | 0 | 0 | 0 | 0 | 0 |
| Communication | 107 | 9 | 0 | 107 | 107 |
| Total | 111 | 9 | 0 | 111 | 111 |

Table 9 : Expected Utility System Pipeline Damage

| System | Total Pipelines Length (kms) | Number of Leaks | Number of Breaks |
|---------------|------------------------------|-----------------|------------------|
| Potable Water | 0 | 0 | 0 |
| Waste Water | 0 | 0 | 0 |
| Natural Gas | 63 | 2 | 2 |
| Oil | 0 | 0 | 0 |
| Total | 63 | 2 | 2 |

Table 10: Expected Potable Water and Electric Power System Performance (Level 1)

| | Total # of Households | Number of Households without Service | | | | |
|----------------|-----------------------|--------------------------------------|----------|----------|-----------|-----------|
| | | At Day 1 | At Day 3 | At Day 7 | At Day 30 | At Day 90 |
| Potable Water | 573,147 | 1,299 | 0 | 0 | 0 | 0 |
| Electric Power | 573,147 | 134,256 | 32,075 | 3,709 | 0 | 0 |

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 15 ignitions that will burn about 10 sq. mi (0.7% of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 million dollars of building value.

Debris Generation

HAZUS estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 1.38 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 32% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 55,000 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 1,141 households to be displaced due to the earthquake. Of these, 762 people (out of a total population of 1,633,000) will seek temporary shelter in public shelters.

Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening is not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 11: Casualty Estimates

| | | Level 1 | Level 2 | Level 3 | Level 4 |
|-------------|------------------------|---------|---------|---------|---------|
| 2 AM | Residential | 540 | 70 | 3 | 3 |
| | Non-Residential | 64 | 10 | 1 | 1 |
| | Commute | 0 | 0 | 1 | 0 |
| | Total | 604 | 80 | 5 | 5 |
| 2 PM | Residential | 125 | 16 | 1 | 1 |
| | Non-Residential | 1,302 | 193 | 18 | 18 |
| | Commute | 1 | 2 | 3 | 1 |
| | Total | 1,429 | 212 | 22 | 19 |
| 5 PM | Residential | 149 | 19 | 1 | 1 |
| | Non-Residential | 554 | 83 | 8 | 8 |
| | Commute | 4 | 6 | 10 | 2 |
| | Total | 707 | 108 | 18 | 11 |

Economic Loss

The total economic loss estimated for the earthquake is 1,949 million dollars, which represents 2 % of the total replacement value of the region's buildings. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 1,949 million dollars. 20% of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 46% of the total loss. Table 12 below provides a summary of the losses associated with the building damage.

Table 12: Building-Related Economic Loss Estimates
(Millions of dollars)

| Category | Area | Residential | Commercial | Industrial | Others | Total |
|-----------------------------------|-----------------|--------------|--------------|--------------|-------------|----------------|
| Building Loss | Structural | 135.1 | 75.9 | 43.8 | 7.3 | 262.1 |
| | Non-Structural | 482.5 | 200.1 | 145.6 | 22.9 | 851.1 |
| | Content | 158.0 | 124.5 | 125.6 | 14.3 | 422.4 |
| | Inventory | N/A | 2.9 | 17.9 | 0.1 | 20.9 |
| | Subtotal | 775.6 | 403.4 | 332.8 | 44.7 | 1,556.5 |
| Business Interruption Loss | Wage | 3.2 | 60.1 | 10.2 | 2.4 | 75.9 |
| | Income | 1.4 | 56.7 | 6.1 | 0.6 | 64.7 |
| | Rental | 40.2 | 33.7 | 8.0 | 1.1 | 83.0 |
| | Relocation | 84.5 | 55.1 | 19.4 | 10.2 | 169.2 |
| | Subtotal | 129.3 | 205.6 | 43.7 | 14.2 | 392.8 |
| Total | | 905.0 | 609.0 | 376.5 | 58.9 | 1,949.3 |

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 13 & 14 provide a detailed breakdown in the expected lifeline losses.

HAZUS estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 15 presents the results of the region for the given earthquake.

Table 13: Transportation System Economic Losses
(Millions of dollars)

| System | Component | Inventory Value | Economic Loss | Loss Ratio (%) |
|------------|-----------------|-----------------|---------------|----------------|
| Highway | Roads | 3,687.6 | 0.2 | 0.0 |
| | Bridges | 4,119.0 | 34.0 | 0.8 |
| | Tunnels | 0.0 | 0.0 | 0.0 |
| | Subtotal | 7,806.6 | 34.1 | 0.4 |
| Railways | Tracks | 372.0 | 0.0 | 0.0 |
| | Bridges | 20.0 | 0.3 | 1.5 |
| | Tunnels | 0.0 | 0.0 | 0.0 |
| | Facilities | 3.0 | 0.1 | 2.9 |
| | Subtotal | 395.0 | 0.4 | 0.1 |
| Light Rail | Tracks | 0.0 | 0.0 | 0.0 |
| | Bridges | 0.0 | 0.0 | 0.0 |
| | Tunnels | 0.0 | 0.0 | 0.0 |
| | Facilities | 0.0 | 0.0 | 0.0 |
| | Subtotal | 0.0 | 0.0 | 0.0 |
| Bus | Facilities | 0.0 | 0.0 | 0.0 |
| Ferry | Facilities | 0.0 | 0.0 | 0.0 |
| Port | Facilities | 0.0 | 0.0 | 0.0 |
| Airport | Facilities | 50.0 | 3.2 | 6.4 |
| | Runways | 252.0 | 0.6 | 0.3 |
| | Subtotal | 302.0 | 3.8 | 1.3 |
| | | 8,503.6 | 38.4 | 0.5 |

Table 14: Utility System Economic Losses
(Millions of dollars)

| System | Component | Inventory Value | Economic Loss | Loss Ratio (%) |
|-------------------------|--------------------|-----------------|---------------|----------------|
| Potable Water | Pipelines | 0.0 | 0.0 | 0.0 |
| | Facilities | 0.0 | 0.0 | 0.0 |
| | Distribution Lines | 1,264.2 | NA | NA |
| | Subtotal | 1,264.2 | 0.0 | 0.0 |
| Waste Water | Pipelines | 0.0 | 0.0 | 0.0 |
| | Facilities | 120.0 | 4.0 | 3.3 |
| | Distribution Lines | 758.5 | NA | NA |
| | Subtotal | 878.5 | 4.0 | 0.5 |
| Natural Gas | Pipelines | 10.5 | 0.0 | 0.0 |
| | Facilities | 0.0 | 0.0 | 0.0 |
| | Distribution Lines | 505.7 | NA | NA |
| | Subtotal | 516.2 | 0.0 | 0.0 |
| Oil Systems | Pipelines | 0.0 | 0.0 | 0.0 |
| | Facilities | 4.0 | 0.1 | 2.8 |
| | Subtotal | 4.0 | 0.1 | 2.75 |
| Electrical Power | Facilities | 0.0 | 0.0 | 0.0 |
| | Distribution Lines | 379.3 | NA | NA |
| | Subtotal | 379.3 | 0.0 | 0.0 |
| Communication | Facilities | 214.0 | 11.9 | 5.5 |
| | Distribution Lines | 168.6 | NA | NA |
| | Subtotal | 382.6 | 11.9 | 5.5 |
| Total | | 3,424.8 | 16.0 | 1.9 |

Table 15. Indirect Economic Impact
(with outside aid)

| Year(s) | 1 | 2 | 3 | 4 | 5 | 6-15 |
|-----------------------------|-------|-------|--------|--------|--------|--------|
| Income Impact (millions \$) | 87 | 27 | 1,688 | 1,689 | 1,689 | 1,689 |
| % Income Impact | 0.26 | 0.08 | 4.96 | 4.97 | 4.97 | 4.97 |
| Employment Impact (#) | 2,232 | 1,615 | 43,036 | 43,065 | 43,068 | 43,068 |
| % Employment Impact | 0.23 | 0.16 | 4.36 | 4.36 | 4.36 | 4.36 |

Appendix A: County Listing for the Region

California

- Alameda
- San Mateo
- Santa Clara
- Santa Cruz

Appendix B: Regional Population and Building Value Data

| State | County Name | Population | Building Value (millions of dollars) | | |
|---------------------|-------------|------------------|--------------------------------------|-----------------|---------------|
| | | | Residential | Non-Residential | Total |
| California | Alameda | 63,200 | 2,330 | 1,880 | 4,220 |
| | San Mateo | 153,600 | 6,330 | 2,220 | 8,550 |
| | Santa Clara | 1,413,800 | 55,350 | 20,940 | 76,300 |
| | Santa Cruz | 2,500 | 110 | 10 | 120 |
| <i>State Total</i> | | <i>1,633,000</i> | <i>64,120</i> | <i>25,060</i> | <i>89,180</i> |
| Region Total | | 1,633,000 | 64,120 | 25,060 | 89,180 |