

# HAZUS-MH: Earthquake Event Report

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**Region Name:** *Jefferson County*

**Earthquake Scenario:** *Jefferson County Random EQ*

**Print Date:** *February 08, 2006*

***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 1 county(ies) from the following state(s):

Colorado

Note:

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

The geographical size of the region is 777.10 square miles and contains 133 census tracts. There are over 206 thousand households in the region and has a total population of 527,056 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 171 thousand buildings in the region with a total building replacement value (excluding contents) of 32,456 (millions of dollars). Approximately 99.00 % of the buildings (and 87.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 2,023 and 1,115 (millions of dollars) , respectively.

## Building and Lifeline Inventory

### Building Inventory

HAZUS estimates that there are 171 thousand buildings in the region which have an aggregate total replacement value of 32,456 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 74% 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 2 hospitals in the region with a total bed capacity of 545 beds. There are 214 schools, 19 fire stations, 13 police stations and 1 emergency operation facilities. With respect to HPL facilities, there are 75 dams identified within the region. Of these, 20 of the dams are classified as 'high hazard'. The inventory also includes 25 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 are provided in Tables 2 and 3.

The total value of the lifeline inventory is over 3,138.00 (millions of dollars). This inventory includes over 374 kilometers of highways, 364 bridges, 11,157 kilometers of pipes.

**Table 2: Transportation System Lifeline Inventory**

<b>System</b>	<b>Component</b>	<b># locations/ # Segments</b>	<b>Replacement value (millions of dollars)</b>
<b>Highway</b>	Bridges	364	450.80
	Segments	56	1,315.50
	Tunnels	4	9.30
	Subtotal		<b>1,775.60</b>
<b>Railways</b>	Bridges	8	1.10
	Facilities	0	0.00
	Segments	17	50.20
	Tunnels	0	0.00
	Subtotal		<b>51.30</b>
<b>Light Rail</b>	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
	Subtotal		<b>0.00</b>
<b>Bus</b>	Facilities	0	0.00
	Subtotal		<b>0.00</b>
<b>Ferry</b>	Facilities	0	0.00
	Subtotal		<b>0.00</b>
<b>Port</b>	Facilities	0	0.00
	Subtotal		<b>0.00</b>
<b>Airport</b>	Facilities	3	15.90
	Runways	6	180.90
	Subtotal		<b>196.70</b>
		<b>Total</b>	<b>2,023.60</b>

**Table 3: Utility System Lifeline Inventory**

<b>System</b>	<b>Component</b>	<b># Locations / Segments</b>	<b>Replacement value (millions of dollars)</b>
<b>Potable Water</b>	Distribution Lines	NA	111.60
	Facilities	5	161.50
	Pipelines	0	0.00
	Subtotal		<b>273.10</b>
<b>Waste Water</b>	Distribution Lines	NA	66.90
	Facilities	13	839.80
	Pipelines	0	0.00
	Subtotal		<b>906.80</b>
<b>Natural Gas</b>	Distribution Lines	NA	44.60
	Facilities	5	5.30
	Pipelines	0	0.00
	Subtotal		<b>49.90</b>
<b>Oil Systems</b>	Facilities	1	0.10
	Pipelines	0	0.00
	Subtotal		<b>0.10</b>
<b>Electrical Power</b>	Facilities	1	106.70
	Subtotal		<b>106.70</b>
<b>Communication</b>	Facilities	25	2.40
	Subtotal		<b>2.40</b>
	Total		<b>1,339.00</b>

## Earthquake Scenario

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

<b>Scenario Name</b>	Jefferson County Random EQ
<b>Type of Earthquake</b>	Arbitrary
<b>Fault Name</b>	NA
<b>Historical Epicenter ID #</b>	NA
<b>Probabilistic Return Period</b>	NA
<b>Longitude of Epicenter</b>	-105.23
<b>Latitude of Epicenter</b>	39.63
<b>Earthquake Magnitude</b>	6.50
<b>Depth (Km)</b>	10.00
<b>Rupture Length (Km)</b>	18.20
<b>Rupture Orientation (degrees)</b>	150.00
<b>Attenuation Function</b>	CEUS Event

## Building Damage

### Building Damage

HAZUS estimates that about 50,103 buildings will be at least moderately damaged. This is over 29.00 % of the total number of buildings in the region. There are an estimated 2,603 buildings that will be damaged beyond repair. 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	(%)
<b>Agriculture</b>	1	0.00	2	0.00	2	0.01	2	0.02	1	0.04
<b>Commercial</b>	588	0.79	303	0.65	432	1.23	270	2.15	110	4.23
<b>Education</b>	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
<b>Government</b>	35	0.05	19	0.04	26	0.07	16	0.13	6	0.21
<b>Industrial</b>	34	0.05	21	0.04	36	0.10	25	0.20	10	0.38
<b>Other Residential</b>	2,074	2.78	1,489	3.17	1,513	4.33	733	5.84	211	8.10
<b>Religion</b>	19	0.03	12	0.03	15	0.04	9	0.07	3	0.12
<b>Single Family</b>	71,760	96.31	45,129	96.07	32,936	94.21	11,485	91.59	2,263	86.91
<b>Total</b>	<b>74,512</b>		<b>46,974</b>		<b>34,960</b>		<b>12,540</b>		<b>2,603</b>	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
<b>Wood</b>	57,403	77.04	40,332	85.86	24,013	68.69	5,154	41.10	644	24.73
<b>Steel</b>	233	0.31	102	0.22	177	0.51	117	0.93	57	2.21
<b>Concrete</b>	225	0.30	122	0.26	165	0.47	96	0.76	33	1.26
<b>Precast</b>	78	0.10	37	0.08	75	0.22	67	0.54	27	1.04
<b>RM</b>	14,867	19.95	4,911	10.46	8,455	24.19	5,757	45.91	1,123	43.14
<b>URM</b>	1,285	1.72	1,042	2.22	1,345	3.85	894	7.13	584	22.42
<b>MH</b>	421	0.57	427	0.91	730	2.09	454	3.62	136	5.21
<b>Total</b>	<b>74,512</b>		<b>46,974</b>		<b>34,960</b>		<b>12,540</b>		<b>2,603</b>	

\*Note:

RM Reinforced Masonry  
URM Unreinforced Masonry  
MH Manufactured Housing



## Essential Facility Damage

Before the earthquake, the region had 545 hospital beds available for use. On the day of the earthquake, the model estimates that only 335 hospital beds (62.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 89.00% of the beds will be back in service. By 30 days, 99.00% will be operational.

**Table 6: Expected Damage to Essential Facilities**

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	2	0	0	2
Schools	214	6	0	99
EOCs	1	0	0	0
PoliceStations	13	0	0	7
FireStations	19	0	0	9

## 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	Segments	56	0	0	56	56
	Bridges	364	14	1	350	355
	Tunnels	4	4	0	4	4
Railways	Segments	17	0	0	17	17
	Bridges	8	0	0	8	8
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	0	0	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	3	2	0	1	3
	Runways	6	0	0	6	6

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	5	4	0	0	3
Waste Water	13	12	0	1	6
Natural Gas	5	5	0	0	3
Oil Systems	1	1	0	0	0
Electrical Power	1	1	0	0	1
Communication	25	25	0	1	25

**Table 9 : Expected Utility System Pipeline Damage (Site Specific)**

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	5,579	281	70
Waste Water	3,347	223	56
Natural Gas	2,232	238	59
Oil	0	0	0

**Table 10: Expected Potable Water and Electric Power System Performance**

	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	206,067	345	0	0	0	0
Electric Power		113,457	76,550	36,561	8,477	147

## 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 45 ignitions that will burn about 0.47 sq. mi 0.06 % of the region's total area.) The model also estimates that the fires will displace about 1,113 people and burn about 65 (millions of 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 0.00 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 0.00% 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 0 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 6,403 households to be displaced due to the earthquake. Of these, 1,403 people (out of a total population of 527,056 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 if 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 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
<b>2 AM</b>	Commercial	18	5	1	2
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	11	3	0	1
	Industrial	22	6	1	2
	Other-Residential	264	57	7	13
	Single Family	1,124	239	30	59
	<b>Total</b>	<b>1,440</b>	<b>310</b>	<b>39</b>	<b>76</b>
<b>2 PM</b>	Commercial	1,054	283	45	88
	Commuting	1	1	1	0
	Educational	157	40	6	12
	Hotels	2	1	0	0
	Industrial	162	43	7	13
	Other-Residential	44	10	1	2
	Single Family	169	36	5	9
	<b>Total</b>	<b>1,589</b>	<b>414</b>	<b>65</b>	<b>124</b>
<b>5 PM</b>	Commercial	845	225	36	68
	Commuting	16	21	36	7
	Educational	22	6	1	2
	Hotels	3	1	0	0
	Industrial	102	27	4	8
	Other-Residential	101	22	3	5
	Single Family	440	94	12	23
	<b>Total</b>	<b>1,529</b>	<b>395</b>	<b>92</b>	<b>112</b>

## Economic Loss

The total economic loss estimated for the earthquake is 5,111.00 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. 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 4,608.72 (millions of dollars); 9 % 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 76 % 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	Single Family	Other Residential	Commercial	Industrial	Others	Total
<b>Income Losses</b>							
	Wage	0.00	6.22	109.12	3.12	4.08	122.53
	Capital-Related	0.00	2.65	99.92	1.89	0.82	105.29
	Rental	79.59	48.77	53.18	1.06	2.09	184.69
	Relocation	8.37	1.06	2.72	0.10	0.49	12.74
	<b>Subtotal</b>	<b>87.96</b>	<b>58.70</b>	<b>264.94</b>	<b>6.18</b>	<b>7.48</b>	<b>425.26</b>
<b>Capital Stock Losses</b>							
	Structural	420.08	57.78	111.46	15.46	14.16	618.95
	Non_Structural	1,702.15	382.40	330.10	58.22	39.70	2,512.57
	Content	667.67	115.09	187.89	40.29	24.42	1,035.37
	Inventory	0.00	0.00	6.89	9.09	0.61	16.58
	<b>Subtotal</b>	<b>2,789.90</b>	<b>555.27</b>	<b>636.34</b>	<b>123.05</b>	<b>78.89</b>	<b>4,183.46</b>
	<b>Total</b>	<b>2,877.86</b>	<b>613.97</b>	<b>901.28</b>	<b>129.23</b>	<b>86.37</b>	<b>4,608.72</b>

## 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	Segments	1,315.49	\$0.00	0.00
	Bridges	450.80	\$18.46	4.10
	Tunnels	9.31	\$1.71	18.35
	Subtotal	<b>1775.60</b>	<b>20.20</b>	
Railways	Segments	50.19	\$0.00	0.00
	Bridges	1.11	\$0.03	2.47
	Tunnels	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	<b>51.30</b>	<b>0.00</b>	
Light Rail	Segments	0.00	\$0.00	0.00
	Bridges	0.00	\$0.00	0.00
	Tunnels	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	<b>0.00</b>	<b>0.00</b>	
Bus	Facilities	0.00	\$0.00	0.00
	Subtotal	<b>0.00</b>	<b>0.00</b>	
Ferry	Facilities	0.00	\$0.00	0.00
	Subtotal	<b>0.00</b>	<b>0.00</b>	
Port	Facilities	0.00	\$0.00	0.00
	Subtotal	<b>0.00</b>	<b>0.00</b>	
Airport	Facilities	15.86	\$7.01	44.23
	Runways	180.89	\$0.00	0.00
	Subtotal	<b>196.70</b>	<b>7.00</b>	
	<b>Total</b>	<b>2023.60</b>	<b>27.20</b>	



**Table 14: Utility System Economic Losses**

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	\$0.00	0.00
	Facilities	161.50	\$61.03	37.79
	Distribution Line	111.60	\$1.27	1.13
	Subtotal	<b>273.08</b>	<b>\$62.29</b>	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	839.80	\$351.39	41.84
	Distribution Line	66.90	\$1.00	1.50
	Subtotal	<b>906.77</b>	<b>\$352.39</b>	
Natural Gas	Pipelines	0.00	\$0.00	0.00
	Facilities	5.30	\$1.82	34.46
	Distribution Line	44.60	\$1.07	2.40
	Subtotal	<b>49.92</b>	<b>\$2.89</b>	
Oil Systems	Pipelines	0.00	\$0.00	0.00
	Facilities	0.10	\$0.06	60.72
	Subtotal	<b>0.10</b>	<b>\$0.06</b>	
Electrical Power	Facilities	106.70	\$56.08	52.56
	Subtotal	<b>106.70</b>	<b>\$56.08</b>	
Communication	Facilities	2.40	\$1.36	55.91
	Subtotal	<b>2.43</b>	<b>\$1.36</b>	
	Total	<b>1,338.99</b>	<b>\$475.07</b>	

**Table 15. Indirect Economic Impact with outside aid**  
(Employment as # of people and Income in millions of \$)

	<b>LOSS</b>	<b>Total</b>	<b>%</b>
<b>First Year</b>			
	Employment Impact	5,803	3.72
	Income Impact	(14)	-0.16
<b>Second Year</b>			
	Employment Impact	2,421	1.55
	Income Impact	(100)	-1.09
<b>Third Year</b>			
	Employment Impact	56	0.04
	Income Impact	(143)	-1.56
<b>Fourth Year</b>			
	Employment Impact	0	0.00
	Income Impact	(147)	-1.60
<b>Fifth Year</b>			
	Employment Impact	0	0.00
	Income Impact	(147)	-1.60
<b>Years 6 to 15</b>			
	Employment Impact	0	0.00
	Income Impact	(147)	-1.60

**Appendix A: County Listing for the Region**

Jefferson,CO

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Jefferson	527,056	28,329	4,126	32,456
Total State		527,056	28,329	4,126	32,456
Total Region		527,056	28,329	4,126	32,456