

# HAZUS-MH: Earthquake Event Report

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**Region Name:** *Arapahoe County*

**Earthquake Scenario:** *Chase Gulch M6.75 CEUS Event*

**Print Date:** *January 24, 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 804.43 square miles and contains 121 census tracts. There are over 190 thousand households in the region and has a total population of 487,967 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 148 thousand buildings in the region with a total building replacement value (excluding contents) of 29,919 (millions of dollars). Approximately 98.00 % of the buildings (and 83.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,736 and 402 (millions of dollars) , respectively.

## Building and Lifeline Inventory

### Building Inventory

HAZUS estimates that there are 148 thousand buildings in the region which have an aggregate total replacement value of 29,919 (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 5 hospitals in the region with a total bed capacity of 1,034 beds. There are 181 schools, 12 fire stations, 9 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 18 dams identified within the region. Of these, 6 of the dams are classified as 'high hazard'. The inventory also includes 22 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 2,138.00 (millions of dollars). This inventory includes over 228 kilometers of highways, 290 bridges, 8,741 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	290	392.20
	Segments	41	840.10
	Tunnels	1	0.30
	Subtotal		<b>1,232.60</b>
<b>Railways</b>	Bridges	10	1.90
	Facilities	0	0.00
	Segments	31	50.40
	Tunnels	0	0.00
	Subtotal		<b>52.30</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	1	1.10
	Subtotal		<b>1.10</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	11	58.20
	Runways	13	391.90
	Subtotal		<b>450.10</b>
		Total	<b>1,736.00</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	87.40
	Facilities	1	32.30
	Pipelines	0	0.00
	Subtotal		<b>119.70</b>
<b>Waste Water</b>	Distribution Lines	NA	52.40
	Facilities	4	258.40
	Pipelines	0	0.00
	Subtotal		<b>310.90</b>
<b>Natural Gas</b>	Distribution Lines	NA	35.00
	Facilities	4	4.20
	Pipelines	0	0.00
	Subtotal		<b>39.20</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	8	0.80
	Subtotal		<b>0.80</b>
	Total		<b>577.30</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>	Chase Gulch M6.75 CEUS Event
<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>	-105.62
<b>Latitude of Epicenter</b>	39.00
<b>Earthquake Magnitude</b>	6.75
<b>Depth (Km)</b>	10.00
<b>Rupture Length (Km)</b>	27.86
<b>Rupture Orientation (degrees)</b>	157.00
<b>Attenuation Function</b>	CEUS Event

## Building Damage

### Building Damage

HAZUS estimates that about 8,727 buildings will be at least moderately damaged. This is over 6.00 % of the total number of buildings in the region. There are an estimated 102 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 summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries 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>	4	0.00	1	0.00	0	0.01	0	0.01	0	0.01
<b>Commercial</b>	1,486	1.20	303	1.88	249	3.57	72	4.37	7	7.05
<b>Education</b>	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00
<b>Government</b>	28	0.02	7	0.04	6	0.09	2	0.11	0	0.17
<b>Industrial</b>	127	0.10	16	0.10	12	0.17	3	0.20	0	0.27
<b>Other Residential</b>	5,056	4.08	1,121	6.97	764	10.95	155	9.44	11	10.84
<b>Religion</b>	78	0.06	14	0.09	11	0.16	3	0.20	0	0.29
<b>Single Family</b>	117,220	94.53	14,631	90.92	5,936	85.04	1,410	85.67	83	81.38
<b>Total</b>	<b>124,000</b>		<b>16,093</b>		<b>6,979</b>		<b>1,646</b>		<b>102</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>	94,939	76.56	11665	72.49	2,569	36.81	207	12.56	8	7.81
<b>Steel</b>	531	0.43	103	0.64	114	1.63	34	2.08	4	4.21
<b>Concrete</b>	466	0.38	117	0.73	99	1.42	27	1.65	2	1.84
<b>Precast</b>	233	0.19	41	0.26	51	0.73	23	1.38	2	1.56
<b>RM</b>	23,104	18.63	2846	17.69	3,066	43.94	1,070	65.03	33	32.25
<b>URM</b>	2,872	2.32	770	4.79	569	8.15	192	11.69	47	46.12
<b>MH</b>	1,854	1.50	549	3.41	511	7.32	92	5.60	6	6.22
<b>Total</b>	<b>124,000</b>		<b>16,093</b>		<b>6,979</b>		<b>1,646</b>		<b>102</b>	

\*Note:

RM Reinforced Masonry  
URM Unreinforced Masonry  
MH Manufactured Housing



## Essential Facility Damage

Before the earthquake, the region had 1,034 hospital beds available for use. On the day of the earthquake, the model estimates that only 539 hospital beds (52.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 83.00% 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	5	0	0	4
Schools	181	0	0	181
EOCs	0	0	0	0
PoliceStations	9	0	0	9
FireStations	12	0	0	12

## 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	41	0	0	41	41
	Bridges	290	0	0	290	290
	Tunnels	1	0	0	1	1
Railways	Segments	31	0	0	31	31
	Bridges	10	0	0	10	10
	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	1	0	0	1	1
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	11	0	0	11	11
	Runways	13	0	0	13	13

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	1	0	0	1	1
Waste Water	4	0	0	3	4
Natural Gas	4	0	0	4	4
Oil Systems	1	0	0	1	1
Electrical Power	1	0	0	1	1
Communication	8	0	0	8	8

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	4,371	30	8
Waste Water	2,622	24	6
Natural Gas	1,748	26	6
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	190,909	0	0	0	0	0
Electric Power		0	0	0	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 12 ignitions that will burn about 0.07 sq. mi 0.01 % of the region's total area.) The model also estimates that the fires will displace about 354 people and burn about 22 (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 1,066 households to be displaced due to the earthquake. Of these, 260 people (out of a total population of 487,967) 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	4	1	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	1	0	0	0
	Industrial	2	0	0	0
	Other-Residential	53	7	1	1
	Single Family	121	17	1	3
	<b>Total</b>	<b>181</b>	<b>25</b>	<b>2</b>	<b>4</b>
<b>2 PM</b>	Commercial	199	34	4	7
	Commuting	0	0	0	0
	Educational	22	4	0	1
	Hotels	0	0	0	0
	Industrial	16	3	0	0
	Other-Residential	10	1	0	0
	Single Family	20	3	0	0
	<b>Total</b>	<b>267</b>	<b>45</b>	<b>5</b>	<b>9</b>
<b>5 PM</b>	Commercial	139	24	3	5
	Commuting	1	1	2	0
	Educational	3	0	0	0
	Hotels	0	0	0	0
	Industrial	10	2	0	0
	Other-Residential	20	3	0	0
	Single Family	47	7	1	1
	<b>Total</b>	<b>220</b>	<b>37</b>	<b>6</b>	<b>7</b>

## Economic Loss

The total economic loss estimated for the earthquake is 678.30 (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 653.55 (millions of dollars); 17 % 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 65 % 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	1.02	33.23	0.51	0.91	35.67
	Capital-Related	0.00	0.43	29.48	0.31	0.23	30.46
	Rental	10.80	12.56	17.23	0.16	0.37	41.12
	Relocation	1.12	0.30	0.93	0.02	0.13	2.50
	<b>Subtotal</b>	<b>11.92</b>	<b>14.32</b>	<b>80.88</b>	<b>0.99</b>	<b>1.64</b>	<b>109.75</b>
<b>Capital Stock Losses</b>							
	Structural	54.85	15.27	29.27	2.36	2.94	104.69
	Non_Structural	170.47	76.58	61.33	5.79	6.46	320.63
	Content	58.77	20.14	30.69	3.64	3.28	116.51
	Inventory	0.00	0.00	1.08	0.83	0.05	1.96
	<b>Subtotal</b>	<b>284.09</b>	<b>111.99</b>	<b>122.38</b>	<b>12.62</b>	<b>12.73</b>	<b>543.80</b>
	<b>Total</b>	<b>296.01</b>	<b>126.31</b>	<b>203.26</b>	<b>13.61</b>	<b>14.36</b>	<b>653.55</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	840.14	\$0.00	0.00
	Bridges	392.21	\$1.17	0.30
	Tunnels	0.26	\$0.00	0.72
	Subtotal	<b>1232.60</b>	<b>1.20</b>	
Railways	Segments	50.38	\$0.00	0.00
	Bridges	1.92	\$0.00	0.02
	Tunnels	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	<b>52.30</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	1.06	\$0.15	14.28
	Subtotal	<b>1.10</b>	<b>0.20</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	58.15	\$2.55	4.38
	Runways	391.92	\$0.00	0.00
	Subtotal	<b>450.10</b>	<b>2.50</b>	
	<b>Total</b>	<b>1736.00</b>	<b>3.90</b>	



**Table 14: Utility System Economic Losses**

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
<b>Potable Water</b>	Pipelines	0.00	\$0.00	0.00
	Facilities	32.30	\$1.81	5.60
	Distribution Line	87.40	\$0.14	0.16
	<b>Subtotal</b>	<b>119.71</b>	<b>\$1.94</b>	
<b>Waste Water</b>	Pipelines	0.00	\$0.00	0.00
	Facilities	258.40	\$10.39	4.02
	Distribution Line	52.40	\$0.11	0.21
	<b>Subtotal</b>	<b>310.85</b>	<b>\$10.50</b>	
<b>Natural Gas</b>	Pipelines	0.00	\$0.00	0.00
	Facilities	4.20	\$0.11	2.64
	Distribution Line	35.00	\$0.12	0.33
	<b>Subtotal</b>	<b>39.19</b>	<b>\$0.23</b>	
<b>Oil Systems</b>	Pipelines	0.00	\$0.00	0.00
	Facilities	0.10	\$0.01	7.84
	<b>Subtotal</b>	<b>0.10</b>	<b>\$0.01</b>	
<b>Electrical Power</b>	Facilities	106.70	\$8.17	7.65
	<b>Subtotal</b>	<b>106.70</b>	<b>\$8.17</b>	
<b>Communication</b>	Facilities	0.80	\$0.03	4.29
	<b>Subtotal</b>	<b>0.78</b>	<b>\$0.03</b>	
	<b>Total</b>	<b>577.33</b>	<b>\$20.87</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	1,626	0.68
	Income Impact	2	0.01
<b>Second Year</b>			
	Employment Impact	705	0.30
	Income Impact	(11)	-0.07
<b>Third Year</b>			
	Employment Impact	16	0.01
	Income Impact	(19)	-0.11
<b>Fourth Year</b>			
	Employment Impact	0	0.00
	Income Impact	(20)	-0.12
<b>Fifth Year</b>			
	Employment Impact	0	0.00
	Income Impact	(20)	-0.12
<b>Years 6 to 15</b>			
	Employment Impact	0	0.00
	Income Impact	(20)	-0.12

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

Arapahoe, CO

**Appendix B: Regional Population and Building Value Data**

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Arapahoe	487,967	24,792	5,126	29,919
Total State		487,967	24,792	5,126	29,919
Total Region		487,967	24,792	5,126	29,919

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**Region Name:** *Arapahoe County*

**Earthquake Scenario:** *Cheraw M7.0 CEUS Event*

**Print Date:** *January 24, 2006*

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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 804.43 square miles and contains 121 census tracts. There are over 190 thousand households in the region and has a total population of 487,967 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 148 thousand buildings in the region with a total building replacement value (excluding contents) of 29,919 (millions of dollars). Approximately 98.00 % of the buildings (and 83.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,736 and 402 (millions of dollars) , respectively.

## Building and Lifeline Inventory

### Building Inventory

HAZUS estimates that there are 148 thousand buildings in the region which have an aggregate total replacement value of 29,919 (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 5 hospitals in the region with a total bed capacity of 1,034 beds. There are 181 schools, 12 fire stations, 9 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 18 dams identified within the region. Of these, 6 of the dams are classified as 'high hazard'. The inventory also includes 22 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 2,138.00 (millions of dollars). This inventory includes over 228 kilometers of highways, 290 bridges, 8,741 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	290	392.20
	Segments	41	840.10
	Tunnels	1	0.30
	Subtotal		<b>1,232.60</b>
<b>Railways</b>	Bridges	10	1.90
	Facilities	0	0.00
	Segments	31	50.40
	Tunnels	0	0.00
	Subtotal		<b>52.30</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	1	1.10
	Subtotal		<b>1.10</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	11	58.20
	Runways	13	391.90
	Subtotal		<b>450.10</b>
		Total	<b>1,736.00</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	87.40
	Facilities	1	32.30
	Pipelines	0	0.00
	Subtotal		<b>119.70</b>
<b>Waste Water</b>	Distribution Lines	NA	52.40
	Facilities	4	258.40
	Pipelines	0	0.00
	Subtotal		<b>310.90</b>
<b>Natural Gas</b>	Distribution Lines	NA	35.00
	Facilities	4	4.20
	Pipelines	0	0.00
	Subtotal		<b>39.20</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	8	0.80
	Subtotal		<b>0.80</b>
	Total		<b>577.30</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>	Cheraw M7.0 CEUS Event
<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>	-103.42
<b>Latitude of Epicenter</b>	38.28
<b>Earthquake Magnitude</b>	7.00
<b>Depth (Km)</b>	10.00
<b>Rupture Length (Km)</b>	42.66
<b>Rupture Orientation (degrees)</b>	44.00
<b>Attenuation Function</b>	CEUS Event

## Building Damage

### Building Damage

HAZUS estimates that about 1,024 buildings will be at least moderately damaged. This is over 1.00 % of the total number of buildings in the region. There are an estimated 4 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 summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries 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>	5	0.00	0	0.00	0	0.00	0	0.00	0	0.00
<b>Commercial</b>	2,018	1.40	66	2.06	29	3.23	4	3.66	0	5.19
<b>Education</b>	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00
<b>Government</b>	43	0.03	1	0.03	0	0.04	0	0.04	0	0.05
<b>Industrial</b>	154	0.11	3	0.09	1	0.14	0	0.16	0	0.09
<b>Other Residential</b>	6,859	4.74	179	5.59	64	7.04	5	4.07	0	2.87
<b>Religion</b>	104	0.07	2	0.07	1	0.10	0	0.10	0	0.13
<b>Single Family</b>	135,409	93.65	2,952	92.16	809	89.44	106	91.98	4	91.68
<b>Total</b>	<b>144,593</b>		<b>3,203</b>		<b>905</b>		<b>115</b>		<b>5</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>	107,064	74.05	2049	63.98	262	28.95	14	11.75	0	0.00
<b>Steel</b>	748	0.52	24	0.76	13	1.45	2	1.50	0	2.24
<b>Concrete</b>	681	0.47	22	0.68	8	0.87	1	0.64	0	0.32
<b>Precast</b>	331	0.23	10	0.32	7	0.77	1	1.23	0	0.34
<b>RM</b>	28,902	19.99	721	22.51	431	47.60	66	57.28	0	4.67
<b>URM</b>	3,987	2.76	285	8.88	144	15.97	30	26.27	4	91.96
<b>MH</b>	2,880	1.99	92	2.86	40	4.40	2	1.32	0	0.47
<b>Total</b>	<b>144,593</b>		<b>3,203</b>		<b>905</b>		<b>115</b>		<b>5</b>	

\*Note:

RM Reinforced Masonry  
URM Unreinforced Masonry  
MH Manufactured Housing

## Essential Facility Damage

Before the earthquake, the region had 1,034 hospital beds available for use. On the day of the earthquake, the model estimates that only 931 hospital beds (90.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 99.00% of the beds will be back in service. By 30 days, 100.00% 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	5	0	0	5
Schools	181	0	0	181
EOCs	0	0	0	0
PoliceStations	9	0	0	9
FireStations	12	0	0	12

## 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	41	0	0	41	41
	Bridges	290	0	0	290	290
	Tunnels	1	0	0	1	1
Railways	Segments	31	0	0	31	31
	Bridges	10	0	0	10	10
	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	1	0	0	1	1
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	11	0	0	11	11
	Runways	13	0	0	13	13

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	1	0	0	1	1
Waste Water	4	0	0	4	4
Natural Gas	4	0	0	4	4
Oil Systems	1	0	0	1	1
Electrical Power	1	0	0	1	1
Communication	8	0	0	8	8

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	4,371	5	1
Waste Water	2,622	4	1
Natural Gas	1,748	4	1
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	190,909	0	0	0	0	0
Electric Power		0	0	0	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 1 ignitions that will burn about 0.01 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 17 people and burn about 1 (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 45 households to be displaced due to the earthquake. Of these, 10 people (out of a total population of 487,967 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	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	4	0	0	0
	Single Family	14	1	0	0
	<b>Total</b>	<b>18</b>	<b>2</b>	<b>0</b>	<b>0</b>
<b>2 PM</b>	Commercial	17	2	0	0
	Commuting	0	0	0	0
	Educational	2	0	0	0
	Hotels	0	0	0	0
	Industrial	1	0	0	0
	Other-Residential	1	0	0	0
	Single Family	2	0	0	0
	<b>Total</b>	<b>23</b>	<b>3</b>	<b>0</b>	<b>0</b>
<b>5 PM</b>	Commercial	12	2	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	1	0	0	0
	Other-Residential	1	0	0	0
	Single Family	5	1	0	0
	<b>Total</b>	<b>20</b>	<b>2</b>	<b>0</b>	<b>0</b>

## Economic Loss

The total economic loss estimated for the earthquake is 57.94 (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 55.97 (millions of dollars); 18 % 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 66 % 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	0.09	2.95	0.04	0.07	3.15
	Capital-Related	0.00	0.04	2.87	0.02	0.02	2.96
	Rental	1.21	0.79	1.62	0.01	0.01	3.63
	Relocation	0.12	0.02	0.08	0.00	0.01	0.24
	<b>Subtotal</b>	<b>1.33</b>	<b>0.95</b>	<b>7.52</b>	<b>0.08</b>	<b>0.11</b>	<b>9.98</b>
<b>Capital Stock Losses</b>							
	Structural	6.66	1.14	2.70	0.21	0.21	10.91
	Non_Structural	17.50	4.67	4.73	0.34	0.42	27.67
	Content	4.04	0.90	2.00	0.19	0.18	7.30
	Inventory	0.00	0.00	0.06	0.04	0.00	0.11
	<b>Subtotal</b>	<b>28.19</b>	<b>6.71</b>	<b>9.50</b>	<b>0.77</b>	<b>0.82</b>	<b>45.99</b>
	<b>Total</b>	<b>29.52</b>	<b>7.66</b>	<b>17.02</b>	<b>0.85</b>	<b>0.92</b>	<b>55.97</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	840.14	\$0.00	0.00
	Bridges	392.21	\$0.17	0.04
	Tunnels	0.26	\$0.00	0.00
	Subtotal	<b>1232.60</b>	<b>0.20</b>	
Railways	Segments	50.38	\$0.00	0.00
	Bridges	1.92	\$0.00	0.00
	Tunnels	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	<b>52.30</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	1.06	\$0.00	0.00
	Subtotal	<b>1.10</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	58.15	\$1.31	2.26
	Runways	391.92	\$0.00	0.00
	Subtotal	<b>450.10</b>	<b>1.30</b>	
	<b>Total</b>	<b>1736.00</b>	<b>1.50</b>	

**Table 14: Utility System Economic Losses**

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
<b>Potable Water</b>	Pipelines	0.00	\$0.00	0.00
	Facilities	32.30	\$0.18	0.56
	Distribution Line	87.40	\$0.02	0.03
	<b>Subtotal</b>	<b>119.71</b>	<b>\$0.21</b>	
<b>Waste Water</b>	Pipelines	0.00	\$0.00	0.00
	Facilities	258.40	\$0.17	0.06
	Distribution Line	52.40	\$0.02	0.03
	<b>Subtotal</b>	<b>310.85</b>	<b>\$0.19</b>	
<b>Natural Gas</b>	Pipelines	0.00	\$0.00	0.00
	Facilities	4.20	\$0.06	1.50
	Distribution Line	35.00	\$0.02	0.06
	<b>Subtotal</b>	<b>39.19</b>	<b>\$0.08</b>	
<b>Oil Systems</b>	Pipelines	0.00	\$0.00	0.00
	Facilities	0.10	\$0.00	0.00
	<b>Subtotal</b>	<b>0.10</b>	<b>\$0.00</b>	
<b>Electrical Power</b>	Facilities	106.70	\$0.00	0.00
	<b>Subtotal</b>	<b>106.70</b>	<b>\$0.00</b>	
<b>Communication</b>	Facilities	0.80	\$0.00	0.48
	<b>Subtotal</b>	<b>0.78</b>	<b>\$0.00</b>	
	<b>Total</b>	<b>577.33</b>	<b>\$0.48</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	140	0.06
	Income Impact	0	0.00
<b>Second Year</b>			
	Employment Impact	51	0.02
	Income Impact	(1)	-0.01
<b>Third Year</b>			
	Employment Impact	0	0.00
	Income Impact	(2)	-0.01
<b>Fourth Year</b>			
	Employment Impact	0	0.00
	Income Impact	(2)	-0.01
<b>Fifth Year</b>			
	Employment Impact	0	0.00
	Income Impact	(2)	-0.01
<b>Years 6 to 15</b>			
	Employment Impact	0	0.00
	Income Impact	(2)	-0.01

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

Arapahoe, CO

**Appendix B: Regional Population and Building Value Data**

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Arapahoe	487,967	24,792	5,126	29,919
Total State		487,967	24,792	5,126	29,919
Total Region		487,967	24,792	5,126	29,919



# HAZUS-MH: Earthquake Event Report

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**Region Name:** *Arapahoe County*

**Earthquake Scenario:** *Golden M6.5 Arapahoe CEUS Event Normal*

**Print Date:** *June 28, 2005*

***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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### Building Inventory

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For essential facilities, there are 5 hospitals in the region with a total bed capacity of 1,034 beds. There are 181 schools, 12 fire stations, 9 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 18 dams identified within the region. Of these, 6 of the dams are classified as 'high hazard'. The inventory also includes 22 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 2,138.00 (millions of dollars). This inventory includes over 228 kilometers of highways, 290 bridges, 8,741 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	290	392.20
	Segments	41	840.10
	Tunnels	1	0.30
	Subtotal		<b>1,232.60</b>
<b>Railways</b>	Bridges	10	1.90
	Facilities	0	0.00
	Segments	31	50.40
	Tunnels	0	0.00
	Subtotal		<b>52.30</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	1	1.10
	Subtotal		<b>1.10</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	11	58.20
	Runways	13	391.90
	Subtotal		<b>450.10</b>
		<b>Total</b>	<b>1,736.00</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	87.40
	Facilities	1	32.30
	Pipelines	0	0.00
	Subtotal		<b>119.70</b>
<b>Waste Water</b>	Distribution Lines	NA	52.40
	Facilities	4	258.40
	Pipelines	0	0.00
	Subtotal		<b>310.90</b>
<b>Natural Gas</b>	Distribution Lines	NA	35.00
	Facilities	4	4.20
	Pipelines	0	0.00
	Subtotal		<b>39.20</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	8	0.80
	Subtotal		<b>0.80</b>
	Total		<b>577.30</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>	Golden M6.5 Arapahoe CEUS Event Normal
<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>	-105.22
<b>Latitude of Epicenter</b>	39.74
<b>Earthquake Magnitude</b>	6.50
<b>Depth (Km)</b>	10.00
<b>Rupture Length (Km)</b>	18.20
<b>Rupture Orientation (degrees)</b>	157.00
<b>Attenuation Function</b>	CEUS Event

## Building Damage

### Building Damage

HAZUS estimates that about 42,239 buildings will be at least moderately damaged. This is over 28.00 % of the total number of buildings in the region. There are an estimated 2,845 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 summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries 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>	3	0.00	1	0.00	1	0.00	1	0.00	0	0.01
<b>Commercial</b>	794	1.10	329	0.95	507	1.81	345	3.04	144	5.04
<b>Education</b>	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00
<b>Government</b>	12	0.02	6	0.02	12	0.04	10	0.09	4	0.16
<b>Industrial</b>	78	0.11	23	0.07	31	0.11	19	0.17	8	0.27
<b>Other Residential</b>	2,440	3.39	1,615	4.67	1,781	6.34	951	8.41	320	11.24
<b>Religion</b>	41	0.06	18	0.05	24	0.09	16	0.15	6	0.23
<b>Single Family</b>	68,647	95.32	32,572	94.23	25,721	91.61	9,977	88.15	2,363	83.06
<b>Total</b>	<b>72,015</b>		<b>34,565</b>		<b>28,076</b>		<b>11,318</b>		<b>2,846</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>	55,111	76.53	29,546	85.48	19,488	69.41	4,622	40.84	621	21.82
<b>Steel</b>	276	0.38	92	0.27	185	0.66	154	1.36	79	2.77
<b>Concrete</b>	240	0.33	117	0.34	183	0.65	127	1.12	45	1.59
<b>Precast</b>	120	0.17	41	0.12	81	0.29	76	0.67	32	1.12
<b>RM</b>	13,916	19.32	3,503	10.14	6,348	22.61	5,059	44.70	1,294	45.48
<b>URM</b>	1,382	1.92	778	2.25	996	3.55	726	6.42	569	19.98
<b>MH</b>	970	1.35	488	1.41	795	2.83	554	4.89	206	7.25
<b>Total</b>	<b>72,015</b>		<b>34,565</b>		<b>28,076</b>		<b>11,318</b>		<b>2,846</b>	

\*Note:

RM Reinforced Masonry  
URM Unreinforced Masonry  
MH Manufactured Housing



## Essential Facility Damage

Before the earthquake, the region had 1,034 hospital beds available for use. On the day of the earthquake, the model estimates that only 137 hospital beds (13.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 38.00% of the beds will be back in service. By 30 days, 81.00% 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	5	3	0	0
Schools	181	1	0	61
EOCs	0	0	0	0
PoliceStations	9	0	0	2
FireStations	12	0	0	6

## 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	41	0	0	41	41
	Bridges	290	15	1	275	277
	Tunnels	1	0	0	1	1
Railways	Segments	31	0	0	31	31
	Bridges	10	0	0	10	10
	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	1	0	0	1	1
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	11	0	0	11	11
	Runways	13	0	0	13	13

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	1	1	0	0	1
Waste Water	4	2	0	1	4
Natural Gas	4	0	0	4	4
Oil Systems	1	1	0	0	1
Electrical Power	1	1	0	0	1
Communication	8	4	0	8	8

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	4,371	223	56
Waste Water	2,622	176	44
Natural Gas	1,748	188	47
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	190,909	190	0	0	0	0
Electric Power		4,752	2,724	996	171	7

## 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 33 ignitions that will burn about 0.25 sq. mi 0.03 % of the region's total area.) The model also estimates that the fires will displace about 1,192 people and burn about 77 (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 9,835 households to be displaced due to the earthquake. Of these, 2,373 people (out of a total population of 487,967 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	30	8	1	3
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	7	2	0	0
	Industrial	20	5	1	2
	Other-Residential	437	99	12	23
	Single Family	1,071	243	33	64
	<b>Total</b>	<b>1,565</b>	<b>358</b>	<b>47</b>	<b>92</b>
<b>2 PM</b>	Commercial	1,654	456	73	144
	Commuting	1	1	1	0
	Educational	174	46	7	14
	Hotels	1	0	0	0
	Industrial	148	40	6	12
	Other-Residential	80	18	2	4
	Single Family	183	42	6	11
	<b>Total</b>	<b>2,241</b>	<b>604</b>	<b>96</b>	<b>185</b>
<b>5 PM</b>	Commercial	1,141	314	50	98
	Commuting	20	26	44	9
	Educational	22	6	1	2
	Hotels	2	0	0	0
	Industrial	93	25	4	8
	Other-Residential	168	38	5	9
	Single Family	420	95	13	24
	<b>Total</b>	<b>1,865</b>	<b>504</b>	<b>117</b>	<b>149</b>

## Economic Loss

The total economic loss estimated for the earthquake is 3,900.99 (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 3,807.26 (millions of dollars); 14 % 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 68 % 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	6.07	148.56	2.72	4.10	161.45
	Capital-Related	0.00	2.58	131.71	1.66	1.06	137.01
	Rental	68.35	74.39	70.36	0.92	2.11	216.13
	Relocation	7.18	1.67	3.88	0.09	0.64	13.45
	<b>Subtotal</b>	<b>75.53</b>	<b>84.72</b>	<b>354.50</b>	<b>5.38</b>	<b>7.92</b>	<b>528.05</b>
<b>Capital Stock Losses</b>							
	Structural	343.03	86.40	143.17	12.59	15.32	600.52
	Non_Structural	1,132.54	458.96	368.80	41.73	39.91	2,041.95
	Content	300.83	101.55	175.69	26.98	18.73	623.78
	Inventory	0.00	0.00	6.35	6.30	0.31	12.97
	<b>Subtotal</b>	<b>1,776.40</b>	<b>646.92</b>	<b>694.02</b>	<b>87.61</b>	<b>74.27</b>	<b>3,279.22</b>
	<b>Total</b>	<b>1,851.92</b>	<b>731.64</b>	<b>1,048.52</b>	<b>92.99</b>	<b>82.19</b>	<b>3,807.26</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	840.14	\$0.00	0.00
	Bridges	392.21	\$13.65	3.48
	Tunnels	0.26	\$0.01	4.39
	Subtotal	<b>1232.60</b>	<b>13.70</b>	
Railways	Segments	50.38	\$0.00	0.00
	Bridges	1.92	\$0.04	2.02
	Tunnels	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	<b>52.30</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	1.06	\$0.33	30.79
	Subtotal	<b>1.10</b>	<b>0.30</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	58.15	\$6.99	12.03
	Runways	391.92	\$0.00	0.00
	Subtotal	<b>450.10</b>	<b>7.00</b>	
	<b>Total</b>	<b>1736.00</b>	<b>21.00</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	32.30	\$6.45	19.97
	Distribution Line	87.40	\$1.00	1.15
	Subtotal	119.71	\$7.45	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	258.40	\$40.23	15.57
	Distribution Line	52.40	\$0.79	1.51
	Subtotal	310.85	\$41.02	
Natural Gas	Pipelines	0.00	\$0.00	0.00
	Facilities	4.20	\$0.32	7.53
	Distribution Line	35.00	\$0.85	2.43
	Subtotal	39.19	\$1.17	
Oil Systems	Pipelines	0.00	\$0.00	0.00
	Facilities	0.10	\$0.02	22.37
	Subtotal	0.10	\$0.02	
Electrical Power	Facilities	106.70	\$22.94	21.50
	Subtotal	106.70	\$22.94	
Communication	Facilities	0.80	\$0.11	13.89
	Subtotal	0.78	\$0.11	
	Total	577.33	\$72.71	

**Table 15. Indirect Economic Impact with outside aid**

(Employment as # of people and Income in millions of \$)

LOSS	Total	%

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

Arapahoe, CO

**Appendix B: Regional Population and Building Value Data**

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Arapahoe	487,967	24,792	5,126	29,919
Total State		487,967	24,792	5,126	29,919
Total Region		487,967	24,792	5,126	29,919

# HAZUS-MH: Earthquake Event Report

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**Region Name:** *Arapahoe County*

**Earthquake Scenario:** *Rampart M7 Arapahoe CEUS Event*

**Print Date:** *June 28, 2005*

***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 804.43 square miles and contains 121 census tracts. There are over 190 thousand households in the region and has a total population of 487,967 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 148 thousand buildings in the region with a total building replacement value (excluding contents) of 29,919 (millions of dollars). Approximately 98.00 % of the buildings (and 83.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,736 and 402 (millions of dollars) , respectively.

## Building and Lifeline Inventory

### Building Inventory

HAZUS estimates that there are 148 thousand buildings in the region which have an aggregate total replacement value of 29,919 (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 5 hospitals in the region with a total bed capacity of 1,034 beds. There are 181 schools, 12 fire stations, 9 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 18 dams identified within the region. Of these, 6 of the dams are classified as 'high hazard'. The inventory also includes 22 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 2,138.00 (millions of dollars). This inventory includes over 228 kilometers of highways, 290 bridges, 8,741 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	290	392.20
	Segments	41	840.10
	Tunnels	1	0.30
	Subtotal		<b>1,232.60</b>
<b>Railways</b>	Bridges	10	1.90
	Facilities	0	0.00
	Segments	31	50.40
	Tunnels	0	0.00
	Subtotal		<b>52.30</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	1	1.10
	Subtotal		<b>1.10</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	11	58.20
	Runways	13	391.90
	Subtotal		<b>450.10</b>
		Total	<b>1,736.00</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	87.40
	Facilities	1	32.30
	Pipelines	0	0.00
	Subtotal		<b>119.70</b>
<b>Waste Water</b>	Distribution Lines	NA	52.40
	Facilities	4	258.40
	Pipelines	0	0.00
	Subtotal		<b>310.90</b>
<b>Natural Gas</b>	Distribution Lines	NA	35.00
	Facilities	4	4.20
	Pipelines	0	0.00
	Subtotal		<b>39.20</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	8	0.80
	Subtotal		<b>0.80</b>
	Total		<b>577.30</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>	Rampart M7 Arapahoe CEUS Event
<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>	-104.92
<b>Latitude of Epicenter</b>	39.06
<b>Earthquake Magnitude</b>	7.00
<b>Depth (Km)</b>	10.00
<b>Rupture Length (Km)</b>	42.66
<b>Rupture Orientation (degrees)</b>	171.00
<b>Attenuation Function</b>	CEUS Event

## Building Damage

### Building Damage

HAZUS estimates that about 42,105 buildings will be at least moderately damaged. This is over 28.00 % of the total number of buildings in the region. There are an estimated 2,830 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 summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries 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>	2	0.00	1	0.00	1	0.00	1	0.00	0	0.01
<b>Commercial</b>	693	0.99	356	0.98	555	1.99	369	3.26	144	5.08
<b>Education</b>	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00
<b>Government</b>	12	0.02	7	0.02	13	0.05	9	0.08	3	0.11
<b>Industrial</b>	71	0.10	27	0.07	36	0.13	19	0.17	6	0.20
<b>Other Residential</b>	2,387	3.40	1,714	4.71	1,830	6.55	924	8.15	253	8.95
<b>Religion</b>	37	0.05	20	0.05	26	0.09	18	0.16	6	0.23
<b>Single Family</b>	67,085	95.44	34,303	94.16	25,487	91.19	9,988	88.18	2,418	85.43
<b>Total</b>	<b>70,287</b>		<b>36,428</b>		<b>27,948</b>		<b>11,327</b>		<b>2,830</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>	55,487	78.94	31,048	85.23	18,449	66.01	3,937	34.76	467	16.50
<b>Steel</b>	240	0.34	101	0.28	204	0.73	164	1.45	79	2.78
<b>Concrete</b>	213	0.30	124	0.34	197	0.71	134	1.18	44	1.55
<b>Precast</b>	105	0.15	44	0.12	89	0.32	81	0.72	31	1.08
<b>RM</b>	12,256	17.44	3,744	10.28	7,022	25.13	5,662	49.98	1,436	50.74
<b>URM</b>	1,166	1.66	799	2.19	1,068	3.82	793	7.00	625	22.10
<b>MH</b>	821	1.17	568	1.56	918	3.29	557	4.91	148	5.24
<b>Total</b>	<b>70,287</b>		<b>36,428</b>		<b>27,948</b>		<b>11,327</b>		<b>2,830</b>	

\*Note:

RM Reinforced Masonry  
URM Unreinforced Masonry  
MH Manufactured Housing

## Essential Facility Damage

Before the earthquake, the region had 1,034 hospital beds available for use. On the day of the earthquake, the model estimates that only 134 hospital beds (13.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 38.00% of the beds will be back in service. By 30 days, 82.00% 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	5	5	0	0
Schools	181	0	0	67
EOCs	0	0	0	0
PoliceStations	9	0	0	3
FireStations	12	0	0	7

## 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	41	0	0	41	41
	Bridges	290	14	0	276	284
	Tunnels	1	0	0	1	1
Railways	Segments	31	0	0	31	31
	Bridges	10	0	0	10	10
	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	1	0	0	1	1
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	11	0	0	11	11
	Runways	13	0	0	13	13

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	1	1	0	0	1
Waste Water	4	3	0	0	4
Natural Gas	4	1	0	1	4
Oil Systems	1	1	0	0	1
Electrical Power	1	1	0	0	1
Communication	8	4	0	8	8

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	4,371	249	62
Waste Water	2,622	197	49
Natural Gas	1,748	210	53
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	190,909	374	0	0	0	0
Electric Power		0	0	0	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 31 ignitions that will burn about 0.23 sq. mi 0.03 % of the region's total area.) The model also estimates that the fires will displace about 1,089 people and burn about 68 (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 9,250 households to be displaced due to the earthquake. Of these, 2,191 people (out of a total population of 487,967 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	31	8	1	3
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	7	2	0	0
	Industrial	18	5	1	1
	Other-Residential	403	91	11	22
	Single Family	1,098	254	35	70
	<b>Total</b>	<b>1,557</b>	<b>360</b>	<b>49</b>	<b>96</b>
<b>2 PM</b>	Commercial	1,700	461	73	143
	Commuting	1	1	1	0
	Educational	203	55	9	17
	Hotels	1	0	0	0
	Industrial	133	34	5	10
	Other-Residential	73	17	2	4
	Single Family	180	42	6	11
	<b>Total</b>	<b>2,292</b>	<b>610</b>	<b>96</b>	<b>186</b>
<b>5 PM</b>	Commercial	1,192	323	51	100
	Commuting	21	26	46	9
	Educational	25	7	1	2
	Hotels	2	1	0	0
	Industrial	83	21	3	6
	Other-Residential	154	35	4	8
	Single Family	430	100	14	27
	<b>Total</b>	<b>1,907</b>	<b>513</b>	<b>121</b>	<b>152</b>

## Economic Loss

The total economic loss estimated for the earthquake is 3,835.78 (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 3,741.97 (millions of dollars); 15 % 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 67 % 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	6.61	156.48	2.60	4.11	169.81
	Capital-Related	0.00	2.81	141.58	1.60	1.12	147.12
	Rental	68.54	69.47	75.17	0.92	2.08	216.19
	Relocation	7.19	1.55	4.11	0.09	0.66	13.60
	<b>Subtotal</b>	<b>75.73</b>	<b>80.45</b>	<b>377.34</b>	<b>5.21</b>	<b>7.98</b>	<b>546.71</b>
<b>Capital Stock Losses</b>							
	Structural	348.78	80.93	150.23	12.34	15.76	608.04
	Non_Structural	1,111.71	417.57	373.83	36.57	39.57	1,979.25
	Content	291.95	92.34	171.24	22.94	18.07	596.55
	Inventory	0.00	0.00	6.03	5.10	0.30	11.42
	<b>Subtotal</b>	<b>1,752.45</b>	<b>590.83</b>	<b>701.34</b>	<b>76.95</b>	<b>73.69</b>	<b>3,195.26</b>
	<b>Total</b>	<b>1,828.18</b>	<b>671.28</b>	<b>1,078.68</b>	<b>82.16</b>	<b>81.67</b>	<b>3,741.97</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	840.14	\$0.00	0.00
	Bridges	392.21	\$13.56	3.46
	Tunnels	0.26	\$0.01	4.31
	Subtotal	<b>1232.60</b>	<b>13.60</b>	
Railways	Segments	50.38	\$0.00	0.00
	Bridges	1.92	\$0.02	1.15
	Tunnels	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	<b>52.30</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	1.06	\$0.31	29.05
	Subtotal	<b>1.10</b>	<b>0.30</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	58.15	\$9.24	15.89
	Runways	391.92	\$0.00	0.00
	Subtotal	<b>450.10</b>	<b>9.20</b>	
	<b>Total</b>	<b>1736.00</b>	<b>23.10</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	32.30	\$6.14	19.01
	Distribution Line	87.40	\$1.12	1.28
	Subtotal	119.71	\$7.26	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	258.40	\$39.30	15.21
	Distribution Line	52.40	\$0.88	1.69
	Subtotal	310.85	\$40.18	
Natural Gas	Pipelines	0.00	\$0.00	0.00
	Facilities	4.20	\$0.60	14.19
	Distribution Line	35.00	\$0.95	2.70
	Subtotal	39.19	\$1.55	
Oil Systems	Pipelines	0.00	\$0.00	0.00
	Facilities	0.10	\$0.02	20.31
	Subtotal	0.10	\$0.02	
Electrical Power	Facilities	106.70	\$21.55	20.20
	Subtotal	106.70	\$21.55	
Communication	Facilities	0.80	\$0.11	14.65
	Subtotal	0.78	\$0.11	
	Total	577.33	\$70.67	

**Table 15. Indirect Economic Impact with outside aid**

(Employment as # of people and Income in millions of \$)

LOSS	Total	%

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

Arapahoe, CO

**Appendix B: Regional Population and Building Value Data**

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Arapahoe	487,967	24,792	5,126	29,919
Total State		487,967	24,792	5,126	29,919
Total Region		487,967	24,792	5,126	29,919

# HAZUS-MH: Earthquake Event Report

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**Region Name:** *Arapahoe County*

**Earthquake Scenario:** *RMA M6.25 Arapahoe CEUS Event*

**Print Date:** *June 28, 2005*

***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 804.43 square miles and contains 121 census tracts. There are over 190 thousand households in the region and has a total population of 487,967 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 148 thousand buildings in the region with a total building replacement value (excluding contents) of 29,919 (millions of dollars). Approximately 98.00 % of the buildings (and 83.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,736 and 402 (millions of dollars) , respectively.

## Building and Lifeline Inventory

### Building Inventory

HAZUS estimates that there are 148 thousand buildings in the region which have an aggregate total replacement value of 29,919 (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 5 hospitals in the region with a total bed capacity of 1,034 beds. There are 181 schools, 12 fire stations, 9 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 18 dams identified within the region. Of these, 6 of the dams are classified as 'high hazard'. The inventory also includes 22 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 2,138.00 (millions of dollars). This inventory includes over 228 kilometers of highways, 290 bridges, 8,741 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	290	392.20
	Segments	41	840.10
	Tunnels	1	0.30
	Subtotal		<b>1,232.60</b>
<b>Railways</b>	Bridges	10	1.90
	Facilities	0	0.00
	Segments	31	50.40
	Tunnels	0	0.00
	Subtotal		<b>52.30</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	1	1.10
	Subtotal		<b>1.10</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	11	58.20
	Runways	13	391.90
	Subtotal		<b>450.10</b>
		Total	<b>1,736.00</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	87.40
	Facilities	1	32.30
	Pipelines	0	0.00
	Subtotal		<b>119.70</b>
<b>Waste Water</b>	Distribution Lines	NA	52.40
	Facilities	4	258.40
	Pipelines	0	0.00
	Subtotal		<b>310.90</b>
<b>Natural Gas</b>	Distribution Lines	NA	35.00
	Facilities	4	4.20
	Pipelines	0	0.00
	Subtotal		<b>39.20</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	8	0.80
	Subtotal		<b>0.80</b>
	Total		<b>577.30</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>	RMA M6.25 Arapahoe CEUS Event
<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>	-104.90
<b>Latitude of Epicenter</b>	39.90
<b>Earthquake Magnitude</b>	6.25
<b>Depth (Km)</b>	10.00
<b>Rupture Length (Km)</b>	11.89
<b>Rupture Orientation (degrees)</b>	130.00
<b>Attenuation Function</b>	CEUS Event

## Building Damage

### Building Damage

HAZUS estimates that about 30,676 buildings will be at least moderately damaged. This is over 21.00 % of the total number of buildings in the region. There are an estimated 1,264 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 summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries 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>	3	0.00	1	0.00	1	0.00	0	0.00	0	0.01
<b>Commercial</b>	1,076	1.24	334	1.07	428	1.95	222	2.97	59	4.65
<b>Education</b>	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00
<b>Government</b>	17	0.02	7	0.02	11	0.05	7	0.09	2	0.15
<b>Industrial</b>	106	0.12	20	0.07	21	0.10	9	0.12	2	0.14
<b>Other Residential</b>	2,932	3.38	1,656	5.28	1,641	7.47	707	9.49	171	13.51
<b>Religion</b>	55	0.06	18	0.06	21	0.09	11	0.14	3	0.21
<b>Single Family</b>	82,573	95.17	29,344	93.51	19,839	90.33	6,495	87.18	1,029	81.33
<b>Total</b>	<b>86,762</b>		<b>31,381</b>		<b>21,962</b>		<b>7,450</b>		<b>1,265</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>	65,681	75.70	26,112	83.21	14,360	65.39	2,908	39.03	327	25.85
<b>Steel</b>	377	0.43	99	0.32	171	0.78	104	1.40	35	2.79
<b>Concrete</b>	319	0.37	123	0.39	163	0.74	87	1.17	19	1.52
<b>Precast</b>	166	0.19	43	0.14	73	0.33	55	0.74	14	1.07
<b>RM</b>	17,189	19.81	3,610	11.50	5,513	25.10	3,356	45.04	452	35.72
<b>URM</b>	1,808	2.08	841	2.68	932	4.24	555	7.45	315	24.87
<b>MH</b>	1,223	1.41	552	1.76	749	3.41	386	5.18	103	8.17
<b>Total</b>	<b>86,762</b>		<b>31,381</b>		<b>21,962</b>		<b>7,450</b>		<b>1,265</b>	

\*Note:

RM Reinforced Masonry  
URM Unreinforced Masonry  
MH Manufactured Housing

## Essential Facility Damage

Before the earthquake, the region had 1,034 hospital beds available for use. On the day of the earthquake, the model estimates that only 282 hospital beds (27.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 60.00% of the beds will be back in service. By 30 days, 93.00% 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	5	1	0	0
Schools	181	0	0	72
EOCs	0	0	0	0
PoliceStations	9	0	0	3
FireStations	12	0	0	7

## 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	41	0	0	41	41
	Bridges	290	0	0	290	290
	Tunnels	1	0	0	1	1
Railways	Segments	31	0	0	31	31
	Bridges	10	0	0	10	10
	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	1	0	0	1	1
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	11	0	0	11	11
	Runways	13	0	0	13	13

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	1	1	0	0	1
Waste Water	4	2	0	1	4
Natural Gas	4	1	0	3	4
Oil Systems	1	1	0	0	1
Electrical Power	1	1	0	0	1
Communication	8	4	0	8	8

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	4,371	105	26
Waste Water	2,622	83	21
Natural Gas	1,748	89	22
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	190,909	0	0	0	0	0
Electric Power		0	0	0	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 31 ignitions that will burn about 0.25 sq. mi 0.03 % of the region's total area.) The model also estimates that the fires will displace about 1,302 people and burn about 81 (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 6,595 households to be displaced due to the earthquake. Of these, 1,645 people (out of a total population of 487,967 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	14	3	1	1
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	5	1	0	0
	Industrial	7	2	0	0
	Other-Residential	303	62	7	13
	Single Family	640	127	15	29
	<b>Total</b>	<b>969</b>	<b>195</b>	<b>23</b>	<b>44</b>
<b>2 PM</b>	Commercial	798	195	29	57
	Commuting	0	0	0	0
	Educational	98	24	3	7
	Hotels	1	0	0	0
	Industrial	50	11	2	3
	Other-Residential	57	12	1	2
	Single Family	113	23	3	5
	<b>Total</b>	<b>1,118</b>	<b>266</b>	<b>38</b>	<b>74</b>
<b>5 PM</b>	Commercial	571	140	21	41
	Commuting	6	7	13	2
	Educational	13	3	0	1
	Hotels	2	0	0	0
	Industrial	31	7	1	2
	Other-Residential	116	24	3	5
	Single Family	251	50	6	11
	<b>Total</b>	<b>989</b>	<b>232</b>	<b>44</b>	<b>62</b>

## Economic Loss

The total economic loss estimated for the earthquake is 2,626.60 (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 2,543.69 (millions of dollars); 13 % 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 72 % 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	4.62	90.96	1.27	2.57	99.41
	Capital-Related	0.00	1.96	80.83	0.77	0.64	84.20
	Rental	44.84	56.30	44.51	0.40	1.29	147.34
	Relocation	4.71	1.30	2.46	0.05	0.39	8.90
	<b>Subtotal</b>	<b>49.55</b>	<b>64.18</b>	<b>218.76</b>	<b>2.48</b>	<b>4.89</b>	<b>339.86</b>
<b>Capital Stock Losses</b>							
	Structural	218.03	64.05	83.43	5.79	8.96	380.26
	Non_Structural	756.83	356.81	211.27	19.05	23.10	1,367.06
	Content	231.94	84.79	108.39	12.62	11.98	449.72
	Inventory	0.00	0.00	3.68	2.92	0.19	6.80
	<b>Subtotal</b>	<b>1,206.80</b>	<b>505.65</b>	<b>406.77</b>	<b>40.38</b>	<b>44.23</b>	<b>2,203.83</b>
	<b>Total</b>	<b>1,256.36</b>	<b>569.83</b>	<b>625.53</b>	<b>42.86</b>	<b>49.12</b>	<b>2,543.69</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	840.14	\$0.00	0.00
	Bridges	392.21	\$5.32	1.36
	Tunnels	0.26	\$0.01	3.03
	Subtotal	<b>1232.60</b>	<b>5.30</b>	
Railways	Segments	50.38	\$0.00	0.00
	Bridges	1.92	\$0.00	0.08
	Tunnels	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	<b>52.30</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	1.06	\$0.31	29.31
	Subtotal	<b>1.10</b>	<b>0.30</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	58.15	\$9.70	16.67
	Runways	391.92	\$0.00	0.00
	Subtotal	<b>450.10</b>	<b>9.70</b>	
	<b>Total</b>	<b>1736.00</b>	<b>15.30</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	32.30	\$6.66	20.63
	Distribution Line	87.40	\$0.47	0.54
	Subtotal	119.71	\$7.14	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	258.40	\$39.04	15.11
	Distribution Line	52.40	\$0.38	0.72
	Subtotal	310.85	\$39.42	
Natural Gas	Pipelines	0.00	\$0.00	0.00
	Facilities	4.20	\$0.45	10.66
	Distribution Line	35.00	\$0.40	1.15
	Subtotal	39.19	\$0.85	
Oil Systems	Pipelines	0.00	\$0.00	0.00
	Facilities	0.10	\$0.02	18.56
	Subtotal	0.10	\$0.02	
Electrical Power	Facilities	106.70	\$20.06	18.80
	Subtotal	106.70	\$20.06	
Communication	Facilities	0.80	\$0.10	12.99
	Subtotal	0.78	\$0.10	
	Total	577.33	\$67.58	

**Table 15. Indirect Economic Impact with outside aid**

(Employment as # of people and Income in millions of \$)

LOSS	Total	%

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

Arapahoe, CO



**Appendix B: Regional Population and Building Value Data**

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Arapahoe	487,967	24,792	5,126	29,919
Total State		487,967	24,792	5,126	29,919
Total Region		487,967	24,792	5,126	29,919

# HAZUS-MH: Earthquake Event Report

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**Region Name:** *Arapahoe County*

**Earthquake Scenario:** *Ute Pass M7.0 Arapahoe CEUS Event*

**Print Date:** *June 30, 2005*

***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 804.43 square miles and contains 121 census tracts. There are over 190 thousand households in the region and has a total population of 487,967 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 148 thousand buildings in the region with a total building replacement value (excluding contents) of 29,919 (millions of dollars). Approximately 98.00 % of the buildings (and 83.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,736 and 402 (millions of dollars) , respectively.

## Building and Lifeline Inventory

### Building Inventory

HAZUS estimates that there are 148 thousand buildings in the region which have an aggregate total replacement value of 29,919 (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 5 hospitals in the region with a total bed capacity of 1,034 beds. There are 181 schools, 12 fire stations, 9 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 18 dams identified within the region. Of these, 6 of the dams are classified as 'high hazard'. The inventory also includes 22 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 2,138.00 (millions of dollars). This inventory includes over 228 kilometers of highways, 290 bridges, 8,741 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	290	392.20
	Segments	41	840.10
	Tunnels	1	0.30
	Subtotal		<b>1,232.60</b>
<b>Railways</b>	Bridges	10	1.90
	Facilities	0	0.00
	Segments	31	50.40
	Tunnels	0	0.00
	Subtotal		<b>52.30</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	1	1.10
	Subtotal		<b>1.10</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	11	58.20
	Runways	13	391.90
	Subtotal		<b>450.10</b>
		Total	<b>1,736.00</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	87.40
	Facilities	1	32.30
	Pipelines	0	0.00
	Subtotal		<b>119.70</b>
<b>Waste Water</b>	Distribution Lines	NA	52.40
	Facilities	4	258.40
	Pipelines	0	0.00
	Subtotal		<b>310.90</b>
<b>Natural Gas</b>	Distribution Lines	NA	35.00
	Facilities	4	4.20
	Pipelines	0	0.00
	Subtotal		<b>39.20</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	8	0.80
	Subtotal		<b>0.80</b>
	Total		<b>577.30</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>	Ute Pass M7.0 Arapahoe CEUS Event
<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>	-105.00
<b>Latitude of Epicenter</b>	38.92
<b>Earthquake Magnitude</b>	7.00
<b>Depth (Km)</b>	10.00
<b>Rupture Length (Km)</b>	42.66
<b>Rupture Orientation (degrees)</b>	152.00
<b>Attenuation Function</b>	CEUS Event



## Building Damage

### Building Damage

HAZUS estimates that about 25,828 buildings will be at least moderately damaged. This is over 17.00 % of the total number of buildings in the region. There are an estimated 956 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 summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries 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>	3	0.00	1	0.00	1	0.00	0	0.01	0	0.01
<b>Commercial</b>	1,008	1.09	372	1.23	462	2.49	224	3.56	51	5.34
<b>Education</b>	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00
<b>Government</b>	18	0.02	8	0.03	11	0.06	6	0.09	1	0.12
<b>Industrial</b>	96	0.10	24	0.08	26	0.14	11	0.17	2	0.20
<b>Other Residential</b>	3,390	3.66	1,633	5.39	1,465	7.89	535	8.49	84	8.77
<b>Religion</b>	53	0.06	19	0.06	22	0.12	11	0.17	2	0.23
<b>Single Family</b>	88,123	95.07	28,242	93.21	16,584	89.30	5,515	87.52	816	85.33
<b>Total</b>	<b>92,693</b>		<b>30,299</b>		<b>18,571</b>		<b>6,301</b>		<b>956</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>	72,403	78.11	24,776	81.77	10,492	56.50	1,595	25.31	123	12.89
<b>Steel</b>	359	0.39	115	0.38	188	1.01	99	1.58	27	2.79
<b>Concrete</b>	312	0.34	135	0.45	170	0.91	81	1.28	14	1.44
<b>Precast</b>	155	0.17	47	0.16	80	0.43	57	0.90	11	1.18
<b>RM</b>	16,535	17.84	3,723	12.29	5,835	31.42	3,588	56.94	438	45.81
<b>URM</b>	1,777	1.92	869	2.87	956	5.15	555	8.80	295	30.81
<b>MH</b>	1,152	1.24	635	2.10	850	4.58	327	5.19	49	5.07
<b>Total</b>	<b>92,693</b>		<b>30,299</b>		<b>18,571</b>		<b>6,301</b>		<b>956</b>	

\*Note:

RM Reinforced Masonry  
URM Unreinforced Masonry  
MH Manufactured Housing

## Essential Facility Damage

Before the earthquake, the region had 1,034 hospital beds available for use. On the day of the earthquake, the model estimates that only 263 hospital beds (25.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 58.00% of the beds will be back in service. By 30 days, 93.00% 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	5	0	0	0
Schools	181	0	0	124
EOCs	0	0	0	0
PoliceStations	9	0	0	6
FireStations	12	0	0	8

## 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	41	0	0	41	41
	Bridges	290	3	0	288	290
	Tunnels	1	0	0	1	1
Railways	Segments	31	0	0	31	31
	Bridges	10	0	0	10	10
	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	1	0	0	1	1
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	11	0	0	11	11
	Runways	13	0	0	13	13

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	1	0	0	0	1
Waste Water	4	0	0	1	4
Natural Gas	4	0	0	4	4
Oil Systems	1	1	0	0	1
Electrical Power	1	1	0	0	1
Communication	8	1	0	8	8

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	4,371	108	27
Waste Water	2,622	86	21
Natural Gas	1,748	92	23
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	190,909	0	0	0	0	0
Electric Power		0	0	0	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 25 ignitions that will burn about 0.21 sq. mi 0.03 % of the region's total area.) The model also estimates that the fires will displace about 1,075 people and burn about 67 (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 4,351 households to be displaced due to the earthquake. Of these, 1,043 people (out of a total population of 487,967 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	14	3	0	1
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	3	1	0	0
	Industrial	8	2	0	0
	Other-Residential	191	37	4	8
	Single Family	517	102	13	25
	<b>Total</b>	<b>734</b>	<b>145</b>	<b>18</b>	<b>35</b>
<b>2 PM</b>	Commercial	776	184	27	52
	Commuting	0	0	0	0
	Educational	89	21	3	6
	Hotels	1	0	0	0
	Industrial	60	13	2	4
	Other-Residential	35	7	1	1
	Single Family	85	17	2	4
	<b>Total</b>	<b>1,046</b>	<b>242</b>	<b>35</b>	<b>67</b>
<b>5 PM</b>	Commercial	545	129	19	36
	Commuting	7	9	15	3
	Educational	11	3	0	1
	Hotels	1	0	0	0
	Industrial	37	8	1	2
	Other-Residential	73	14	2	3
	Single Family	202	40	5	10
	<b>Total</b>	<b>876</b>	<b>203</b>	<b>43</b>	<b>55</b>

## Economic Loss

The total economic loss estimated for the earthquake is 2,106.05 (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 2,044.41 (millions of dollars); 15 % 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 67 % 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	3.46	91.27	1.44	2.40	98.58
	Capital-Related	0.00	1.47	81.50	0.88	0.64	84.50
	Rental	37.63	38.31	45.23	0.50	1.15	122.82
	Relocation	3.94	0.88	2.48	0.06	0.37	7.73
	<b>Subtotal</b>	<b>41.57</b>	<b>44.13</b>	<b>220.48</b>	<b>2.89</b>	<b>4.56</b>	<b>313.62</b>
<b>Capital Stock Losses</b>							
	Structural	189.69	44.97	84.02	6.74	8.64	334.06
	Non_Structural	592.49	230.42	190.34	17.95	19.98	1,051.19
	Content	172.86	56.10	89.92	11.26	9.54	339.68
	Inventory	0.00	0.00	3.18	2.53	0.16	5.87
	<b>Subtotal</b>	<b>955.05</b>	<b>331.48</b>	<b>367.47</b>	<b>38.47</b>	<b>38.32</b>	<b>1,730.79</b>
	<b>Total</b>	<b>996.62</b>	<b>375.61</b>	<b>587.95</b>	<b>41.36</b>	<b>42.87</b>	<b>2,044.41</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	840.14	\$0.00	0.00
	Bridges	392.21	\$6.14	1.57
	Tunnels	0.26	\$0.01	3.06
	Subtotal	<b>1232.60</b>	<b>6.10</b>	
Railways	Segments	50.38	\$0.00	0.00
	Bridges	1.92	\$0.01	0.29
	Tunnels	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	<b>52.30</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	1.06	\$0.26	24.34
	Subtotal	<b>1.10</b>	<b>0.30</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	58.15	\$6.23	10.71
	Runways	391.92	\$0.00	0.00
	Subtotal	<b>450.10</b>	<b>6.20</b>	
	<b>Total</b>	<b>1736.00</b>	<b>12.60</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	32.30	\$4.59	14.22
	Distribution Line	87.40	\$0.49	0.56
	Subtotal	119.71	\$5.08	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	258.40	\$25.57	9.90
	Distribution Line	52.40	\$0.39	0.73
	Subtotal	310.85	\$25.96	
Natural Gas	Pipelines	0.00	\$0.00	0.00
	Facilities	4.20	\$0.41	9.69
	Distribution Line	35.00	\$0.41	1.18
	Subtotal	39.19	\$0.82	
Oil Systems	Pipelines	0.00	\$0.00	0.00
	Facilities	0.10	\$0.02	16.19
	Subtotal	0.10	\$0.02	
Electrical Power	Facilities	106.70	\$17.05	15.98
	Subtotal	106.70	\$17.05	
Communication	Facilities	0.80	\$0.08	10.45
	Subtotal	0.78	\$0.08	
	Total	577.33	\$49.01	

**Table 15. Indirect Economic Impact with outside aid**

(Employment as # of people and Income in millions of \$)

LOSS	Total	%

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

Arapahoe, CO

**Appendix B: Regional Population and Building Value Data**

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Arapahoe	487,967	24,792	5,126	29,919
Total State		487,967	24,792	5,126	29,919
Total Region		487,967	24,792	5,126	29,919

# HAZUS-MH: Earthquake Event Report

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**Region Name:** *Arapahoe County*

**Earthquake Scenario:** *Walnut Creek M6.0 CEUS Event*

**Print Date:** *June 30, 2005*

***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 804.43 square miles and contains 121 census tracts. There are over 190 thousand households in the region and has a total population of 487,967 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 148 thousand buildings in the region with a total building replacement value (excluding contents) of 29,919 (millions of dollars). Approximately 98.00 % of the buildings (and 83.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,736 and 402 (millions of dollars) , respectively.

## Building and Lifeline Inventory

### Building Inventory

HAZUS estimates that there are 148 thousand buildings in the region which have an aggregate total replacement value of 29,919 (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 5 hospitals in the region with a total bed capacity of 1,034 beds. There are 181 schools, 12 fire stations, 9 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 18 dams identified within the region. Of these, 6 of the dams are classified as 'high hazard'. The inventory also includes 22 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 2,138.00 (millions of dollars). This inventory includes over 228 kilometers of highways, 290 bridges, 8,741 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	290	392.20
	Segments	41	840.10
	Tunnels	1	0.30
	Subtotal		<b>1,232.60</b>
<b>Railways</b>	Bridges	10	1.90
	Facilities	0	0.00
	Segments	31	50.40
	Tunnels	0	0.00
	Subtotal		<b>52.30</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	1	1.10
	Subtotal		<b>1.10</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	11	58.20
	Runways	13	391.90
	Subtotal		<b>450.10</b>
		<b>Total</b>	<b>1,736.00</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	87.40
	Facilities	1	32.30
	Pipelines	0	0.00
	Subtotal		<b>119.70</b>
<b>Waste Water</b>	Distribution Lines	NA	52.40
	Facilities	4	258.40
	Pipelines	0	0.00
	Subtotal		<b>310.90</b>
<b>Natural Gas</b>	Distribution Lines	NA	35.00
	Facilities	4	4.20
	Pipelines	0	0.00
	Subtotal		<b>39.20</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	8	0.80
	Subtotal		<b>0.80</b>
	Total		<b>577.30</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>	Walnut Creek M6.0 CEUS Event
<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>	-105.15
<b>Latitude of Epicenter</b>	39.88
<b>Earthquake Magnitude</b>	6.00
<b>Depth (Km)</b>	10.00
<b>Rupture Length (Km)</b>	7.76
<b>Rupture Orientation (degrees)</b>	31.00
<b>Attenuation Function</b>	CEUS Event

## Building Damage

### Building Damage

HAZUS estimates that about 13,690 buildings will be at least moderately damaged. This is over 9.00 % of the total number of buildings in the region. There are an estimated 228 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 summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries 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>	4	0.00	1	0.00	0	0.00	0	0.01	0	0.01
<b>Commercial</b>	1,424	1.26	306	1.40	280	2.59	95	3.59	13	5.47
<b>Education</b>	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00
<b>Government</b>	25	0.02	8	0.03	8	0.08	3	0.11	0	0.18
<b>Industrial</b>	123	0.11	16	0.07	14	0.13	4	0.17	0	0.21
<b>Other Residential</b>	4,450	3.93	1,397	6.39	1,003	9.27	236	8.94	21	9.20
<b>Religion</b>	73	0.06	16	0.07	13	0.12	4	0.16	0	0.21
<b>Single Family</b>	107,146	94.61	20,139	92.03	9,501	87.81	2,300	87.02	194	84.73
<b>Total</b>	<b>113,246</b>		<b>21,883</b>		<b>10,819</b>		<b>2,643</b>		<b>229</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>	85,659	75.64	17311	79.11	5,706	52.74	673	25.47	38	16.76
<b>Steel</b>	520	0.46	102	0.46	121	1.11	40	1.50	6	2.46
<b>Concrete</b>	449	0.40	119	0.54	108	1.00	33	1.23	3	1.15
<b>Precast</b>	222	0.20	41	0.19	56	0.52	28	1.07	3	1.13
<b>RM</b>	22,123	19.54	2968	13.56	3,545	32.77	1,424	53.87	59	25.97
<b>URM</b>	2,535	2.24	786	3.59	708	6.54	313	11.85	109	47.73
<b>MH</b>	1,738	1.53	555	2.54	576	5.33	132	5.00	11	4.80
<b>Total</b>	<b>113,246</b>		<b>21,883</b>		<b>10,819</b>		<b>2,643</b>		<b>229</b>	

\*Note:

RM Reinforced Masonry  
URM Unreinforced Masonry  
MH Manufactured Housing

## Essential Facility Damage

Before the earthquake, the region had 1,034 hospital beds available for use. On the day of the earthquake, the model estimates that only 505 hospital beds (49.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 81.00% 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	5	0	0	3
Schools	181	0	0	175
EOCs	0	0	0	0
PoliceStations	9	0	0	8
FireStations	12	0	0	11

## 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	41	0	0	41	41
	Bridges	290	0	0	290	290
	Tunnels	1	0	0	1	1
Railways	Segments	31	0	0	31	31
	Bridges	10	0	0	10	10
	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	1	0	0	1	1
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	11	0	0	11	11
	Runways	13	0	0	13	13

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	1	0	0	0	1
Waste Water	4	2	0	2	4
Natural Gas	4	0	0	4	4
Oil Systems	1	1	0	0	1
Electrical Power	1	1	0	0	1
Communication	8	4	0	8	8

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	4,371	31	8
Waste Water	2,622	25	6
Natural Gas	1,748	26	7
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	190,909	0	0	0	0	0
Electric Power		0	0	0	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 24 ignitions that will burn about 0.20 sq. mi 0.02 % of the region's total area.) The model also estimates that the fires will displace about 981 people and burn about 62 (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 1,833 households to be displaced due to the earthquake. Of these, 456 people (out of a total population of 487,967) 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	5	1	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	1	0	0	0
	Industrial	3	1	0	0
	Other-Residential	92	14	1	2
	Single Family	214	33	3	6
	<b>Total</b>	<b>315</b>	<b>49</b>	<b>5</b>	<b>9</b>
<b>2 PM</b>	Commercial	282	55	7	13
	Commuting	0	0	0	0
	Educational	30	5	1	1
	Hotels	0	0	0	0
	Industrial	21	4	0	1
	Other-Residential	17	3	0	0
	Single Family	37	6	1	1
	<b>Total</b>	<b>387</b>	<b>73</b>	<b>9</b>	<b>17</b>
<b>5 PM</b>	Commercial	197	39	5	9
	Commuting	1	1	2	0
	Educational	4	1	0	0
	Hotels	0	0	0	0
	Industrial	13	2	0	1
	Other-Residential	35	5	0	1
	Single Family	83	13	1	2
	<b>Total</b>	<b>333</b>	<b>62</b>	<b>9</b>	<b>14</b>

## Economic Loss

The total economic loss estimated for the earthquake is 1,245.01 (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 1,185.34 (millions of dollars); 12 % 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 71 % 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	1.50	41.00	0.64	1.17	44.30
	Capital-Related	0.00	0.64	36.19	0.39	0.29	37.51
	Rental	17.65	20.54	21.04	0.20	0.52	59.94
	Relocation	1.84	0.49	1.15	0.03	0.16	3.67
	<b>Subtotal</b>	<b>19.49</b>	<b>23.16</b>	<b>99.38</b>	<b>1.26</b>	<b>2.13</b>	<b>145.42</b>
<b>Capital Stock Losses</b>							
	Structural	86.77	24.08	36.58	2.90	3.75	154.08
	Non_Structural	337.22	162.26	99.18	10.68	10.75	620.09
	Content	136.30	50.56	60.72	7.48	6.73	261.79
	Inventory	0.00	0.00	2.10	1.75	0.11	3.96
	<b>Subtotal</b>	<b>560.29</b>	<b>236.90</b>	<b>198.57</b>	<b>22.81</b>	<b>21.34</b>	<b>1,039.92</b>
	<b>Total</b>	<b>579.78</b>	<b>260.07</b>	<b>297.95</b>	<b>24.06</b>	<b>23.48</b>	<b>1,185.34</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	840.14	\$0.00	0.00
	Bridges	392.21	\$1.47	0.38
	Tunnels	0.26	\$0.01	2.57
	Subtotal	<b>1232.60</b>	<b>1.50</b>	
Railways	Segments	50.38	\$0.00	0.00
	Bridges	1.92	\$0.00	0.04
	Tunnels	0.00	\$0.00	0.00
	Facilities	0.00	\$0.00	0.00
	Subtotal	<b>52.30</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	1.06	\$0.30	28.16
	Subtotal	<b>1.10</b>	<b>0.30</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	58.15	\$3.98	6.84
	Runways	391.92	\$0.00	0.00
	Subtotal	<b>450.10</b>	<b>4.00</b>	
	<b>Total</b>	<b>1736.00</b>	<b>5.80</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	32.30	\$4.66	14.41
	Distribution Line	87.40	\$0.14	0.16
	Subtotal	119.71	\$4.80	
Waste Water	Pipelines	0.00	\$0.00	0.00
	Facilities	258.40	\$29.24	11.32
	Distribution Line	52.40	\$0.11	0.21
	Subtotal	310.85	\$29.35	
Natural Gas	Pipelines	0.00	\$0.00	0.00
	Facilities	4.20	\$0.14	3.38
	Distribution Line	35.00	\$0.12	0.34
	Subtotal	39.19	\$0.26	
Oil Systems	Pipelines	0.00	\$0.00	0.00
	Facilities	0.10	\$0.02	18.14
	Subtotal	0.10	\$0.02	
Electrical Power	Facilities	106.70	\$19.41	18.19
	Subtotal	106.70	\$19.41	
Communication	Facilities	0.80	\$0.08	10.17
	Subtotal	0.78	\$0.08	
	Total	577.33	\$53.91	

**Table 15. Indirect Economic Impact with outside aid**

(Employment as # of people and Income in millions of \$)

LOSS	Total	%

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

Arapahoe, CO

**Appendix B: Regional Population and Building Value Data**

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Colorado	Arapahoe	487,967	24,792	5,126	29,919
Total State		487,967	24,792	5,126	29,919
Total Region		487,967	24,792	5,126	29,919