OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
INTERPRETIVE MAP SERIES 24

GEOLOGIC HAZARDS, EARTHQUAKE AND LANDSLIDE HAZARD MAPS, AND FUTURE EARTHQUAKE DAMAGE ESTIMATES FOR SIX COUNTIES IN THE MID/SOUTHERN WILLAMETTE VALLEY INCLUDING YAMHILL, MARION, POLK, BENTON, LINN, AND LANE COUNTIES AND THE CITY OF ALBANY, OREGON

APPENDIX F:
POLK COUNTY

CRUSTAL EARTHQUAKE SCENARIO DETAILS FOR POLK COUNTY

Crustal Earthquake Scenario: A magnitude 6.7 earthquake on the Mill Creek Fault.

For the magnitude 6.9 earthquake on the Mill Creek Fault scenario, we defined the fault source using the "deterministic seismic source" option within HAZUS-MH (Figure F1) (FEMA, 2003b) The fault and earthquake event were chosen by examination of USGS (2004) data and data in the Geomatrix Consultants, Inc. (1995) *Seismic Design Mapping, State of Oregon* report prepared for the Oregon Department of Transportation. In general, a likely worst-case scenario was selected. Figure F1 has the location of the fault, shown as the dark line, and the census tracts within Polk County. Figure F2 displays the peak ground acceleration (PGA) for the crustal scenario.

Scenario Name	Mill Creek M6.7
Type of Earthquake	Source
Fault Name	Mill Creek Fault
Historical Epicenter ID #	70
Probabilistic Return Period	NA
Longitude of Epicenter	–123.015
Latitude of Epicenter	44.7428
Earthquake Magnitude	6.7
Depth (Km)	0.00
Rupture Length (Km)	27.11
Rupture Orientation (degrees)	0.00
Attenuation Function	Reverse-Slip

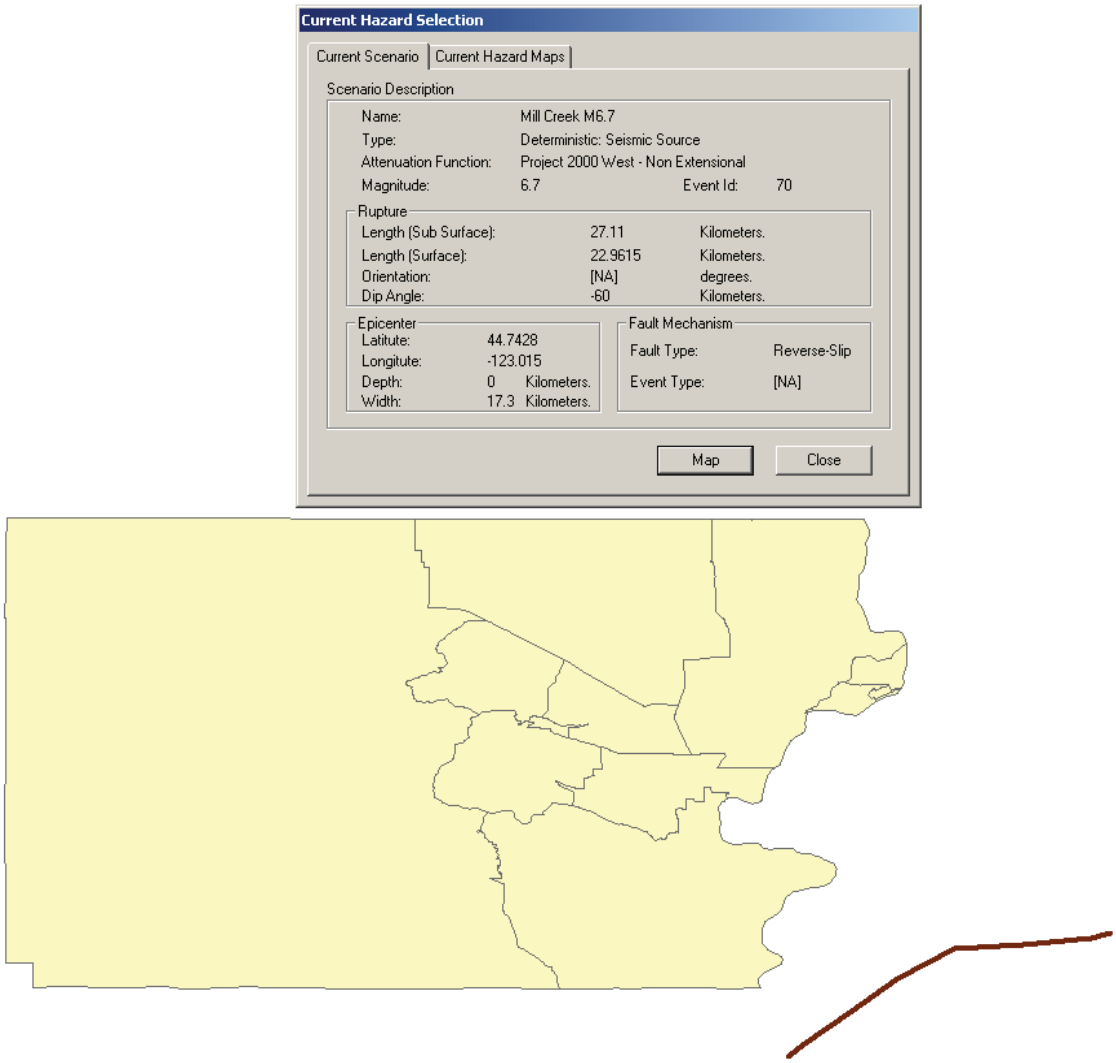

Figure F1. Mill Creek Fault details from HAZUS-MH (FEMA, 2003b). The location of the fault is shown as the dark line.

Crustal Earthquake Scenario Ground Motion Map

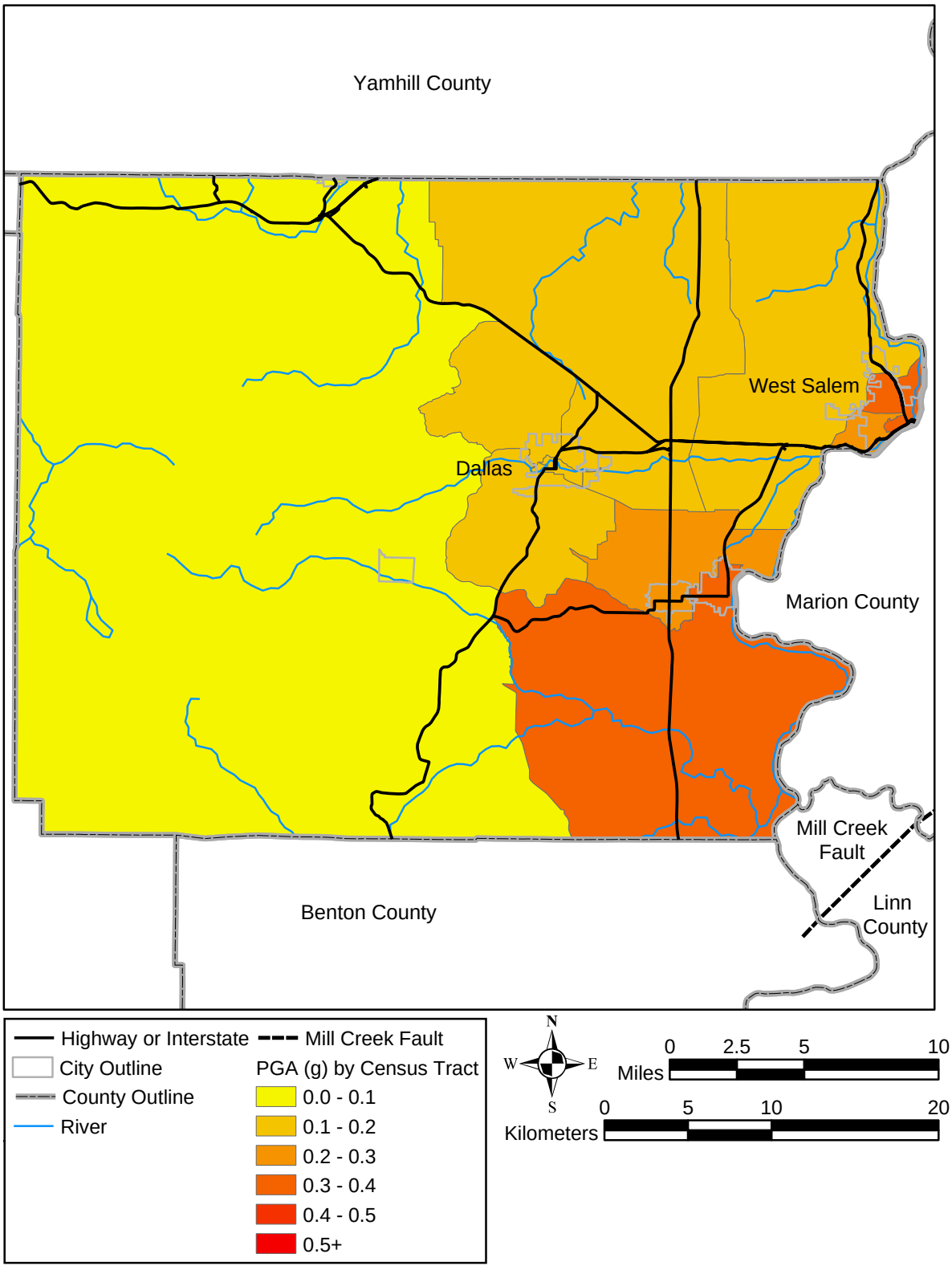

Figure F2. Peak ground acceleration (PGA) by census tracts map for the crustal earthquake scenario, Polk County, Oregon (FEMA, 2003b).

SUBDUCTION ZONE EARTHQUAKE SCENARIO DETAILS FOR POLK COUNTY

Subduction Zone Scenario: A magnitude 9.0 earthquake on the Cascadia Subduction Zone was selected for the subduction zone earthquake scenario.

For the Cascadia Subduction Zone earthquake scenario, we used the "user-defined event" option within HAZUS-MH to incorporate ground motion maps developed by the Cascadia Region Earthquake Workgroup (CREW, 2003) to model damage and loss from a magnitude 9.0 earthquake (Figure F3). The CREW maps were developed from ground motion data provided by the U.S. Geological Survey. The CREW earthquake scenario required the input of four sets of GIS files that are included within the HAZUS-MH study region: regional peak ground acceleration (PGA), peak ground velocity (PGV), and the spectral velocity at 0.3 s and 1.0 s (CREW, 2003). Figure F4 displays the PGA for the subduction zone scenario.

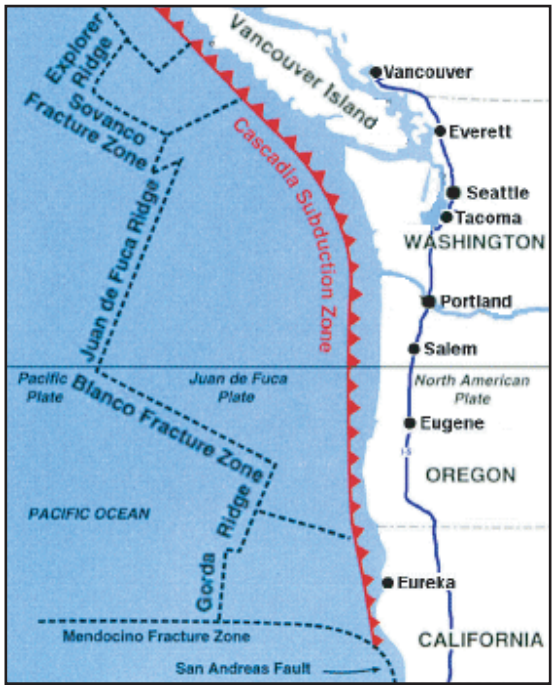

Figure F3. Location of the Cascadia Subduction Zone (CREW, 2003).

Subduction Zone Earthquake Scenario Ground Motion Map

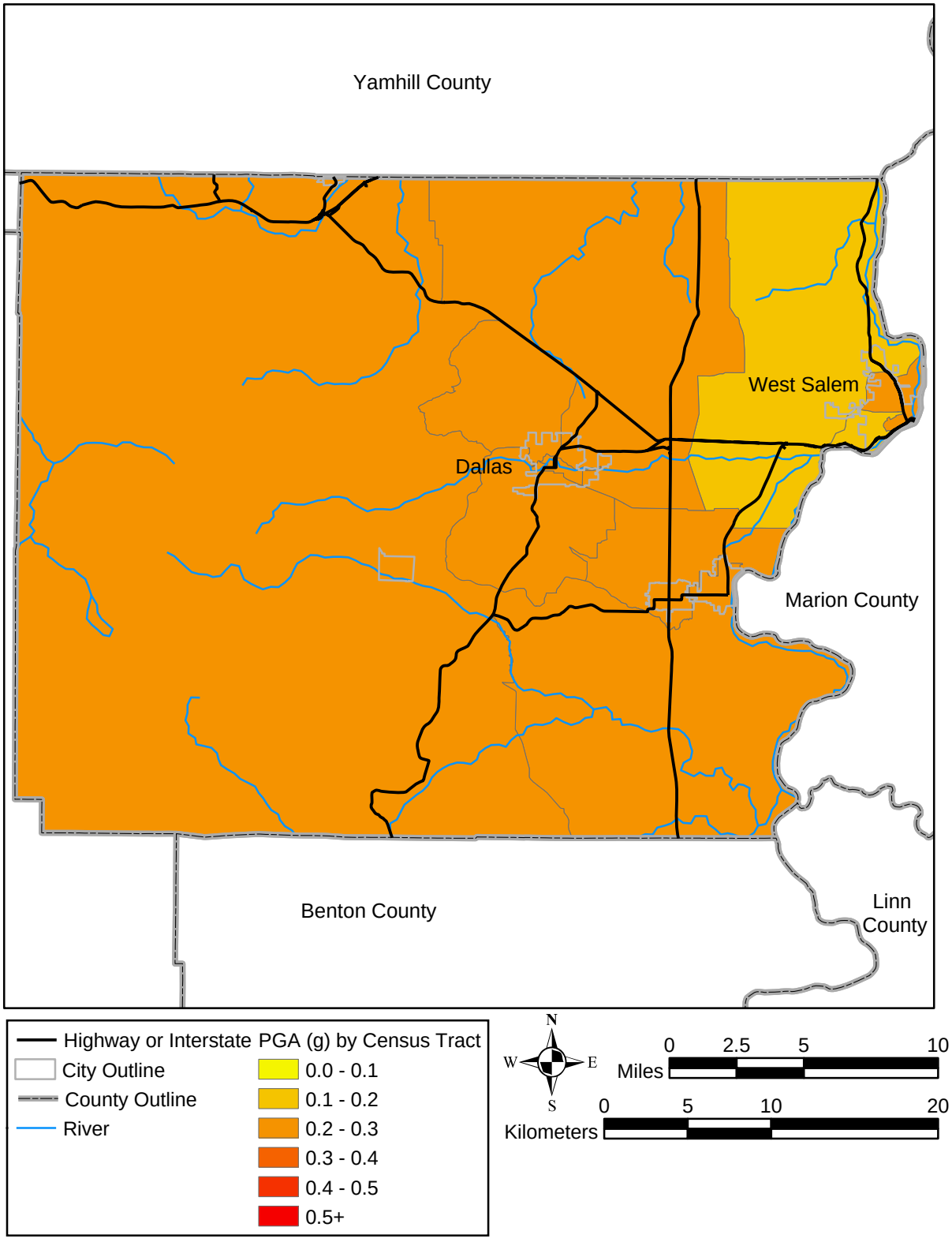

Figure F4. Peak ground acceleration (PGA) by census tracts map for the Cascadia Subduction Zone earthquake scenario, Polk County, Oregon (FEMA, 2003b).

GEOLOGIC HAZARD MAPS

Relative Ground-Shaking Amplification Susceptibility Map

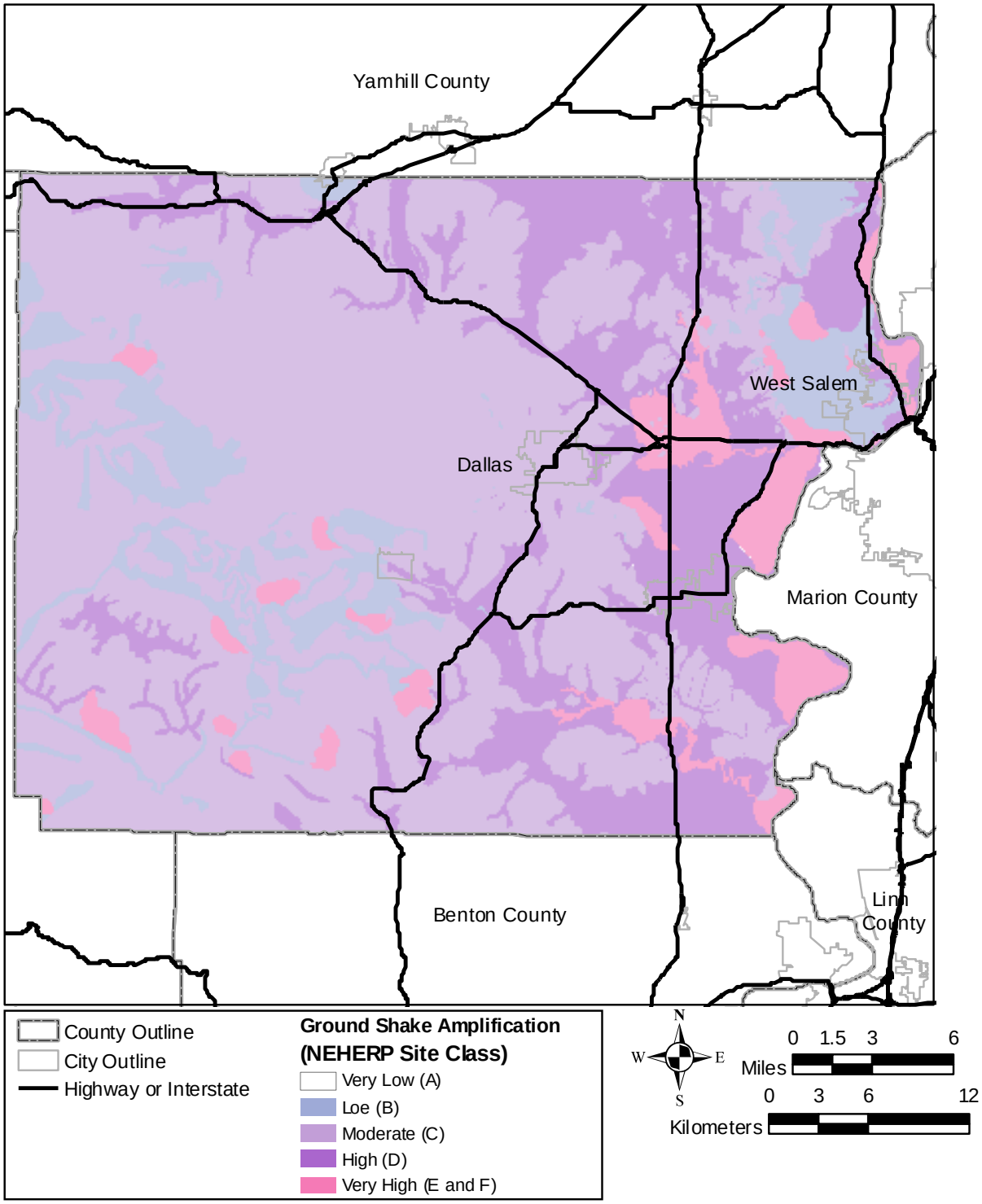

Figure F5. Relative ground-shaking amplification susceptibility map for Polk County, Oregon.

Relative Liquefaction Hazard Susceptibility Map

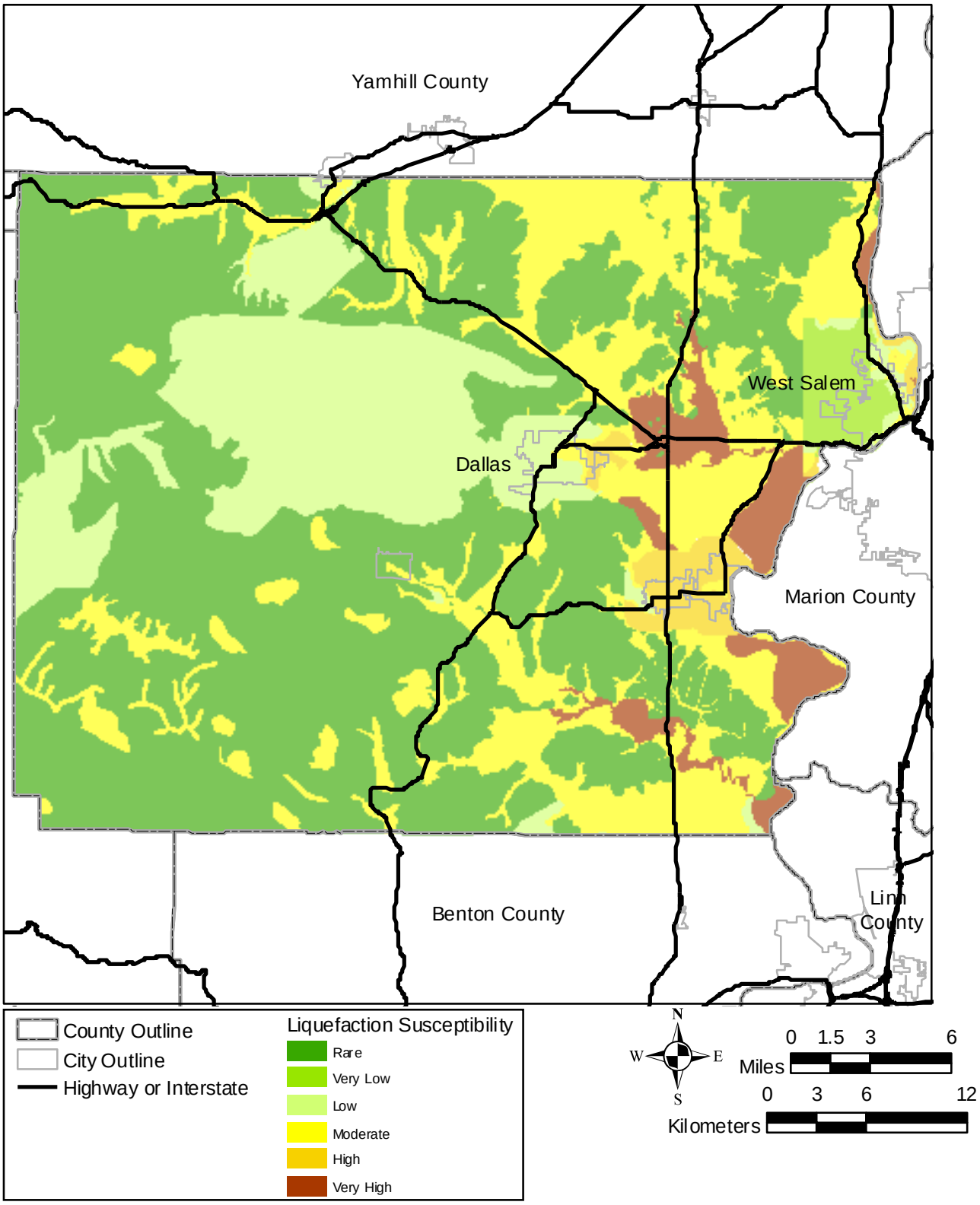

Figure F6. Relative liquefaction susceptibility map for Polk County, Oregon.

Relative Earthquake-Induced Landslide Susceptibility Map

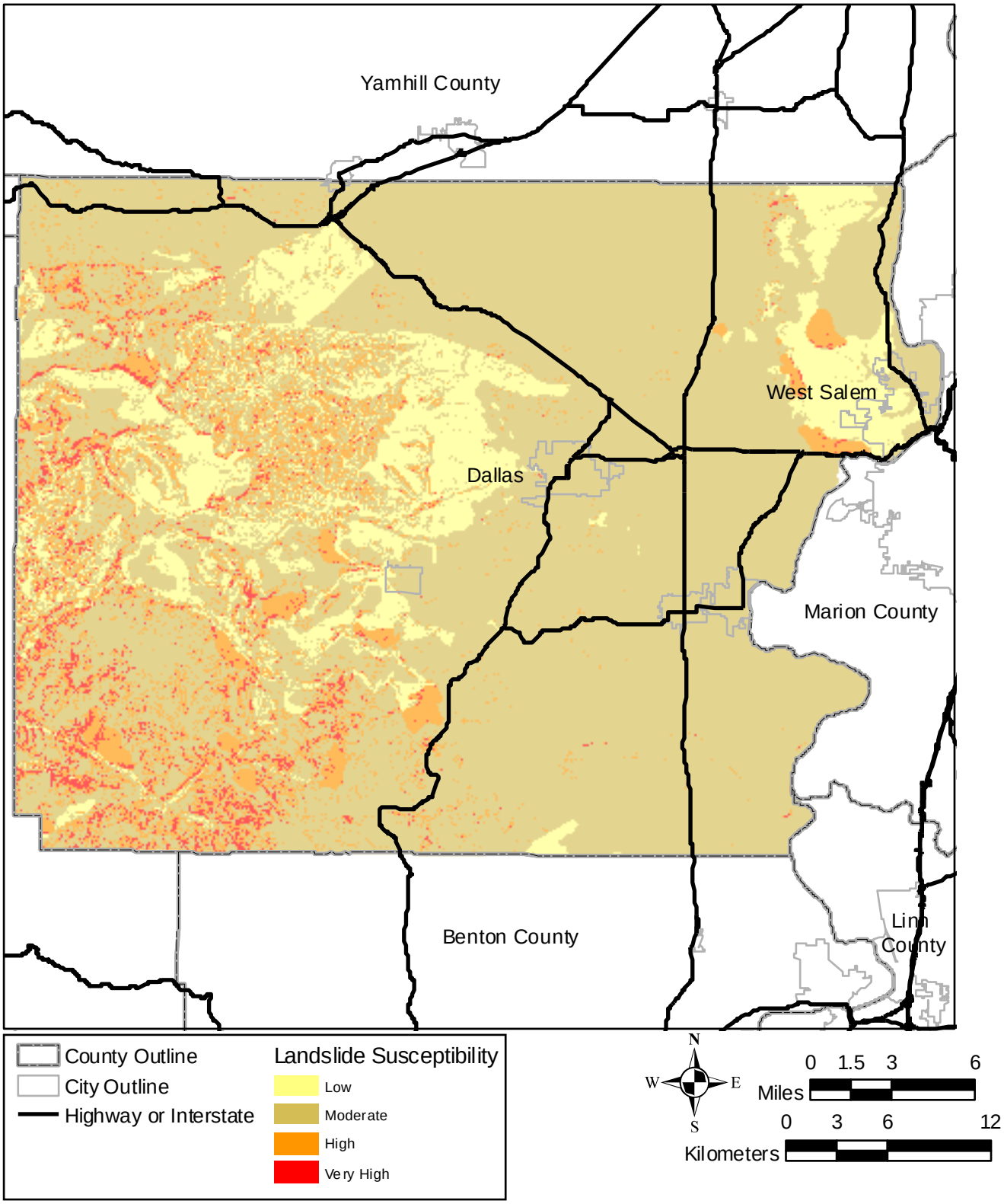

Figure F7. Relative earthquake-induced landslide susceptibility map for Polk County, Oregon.

Identified Landslide Areas Map

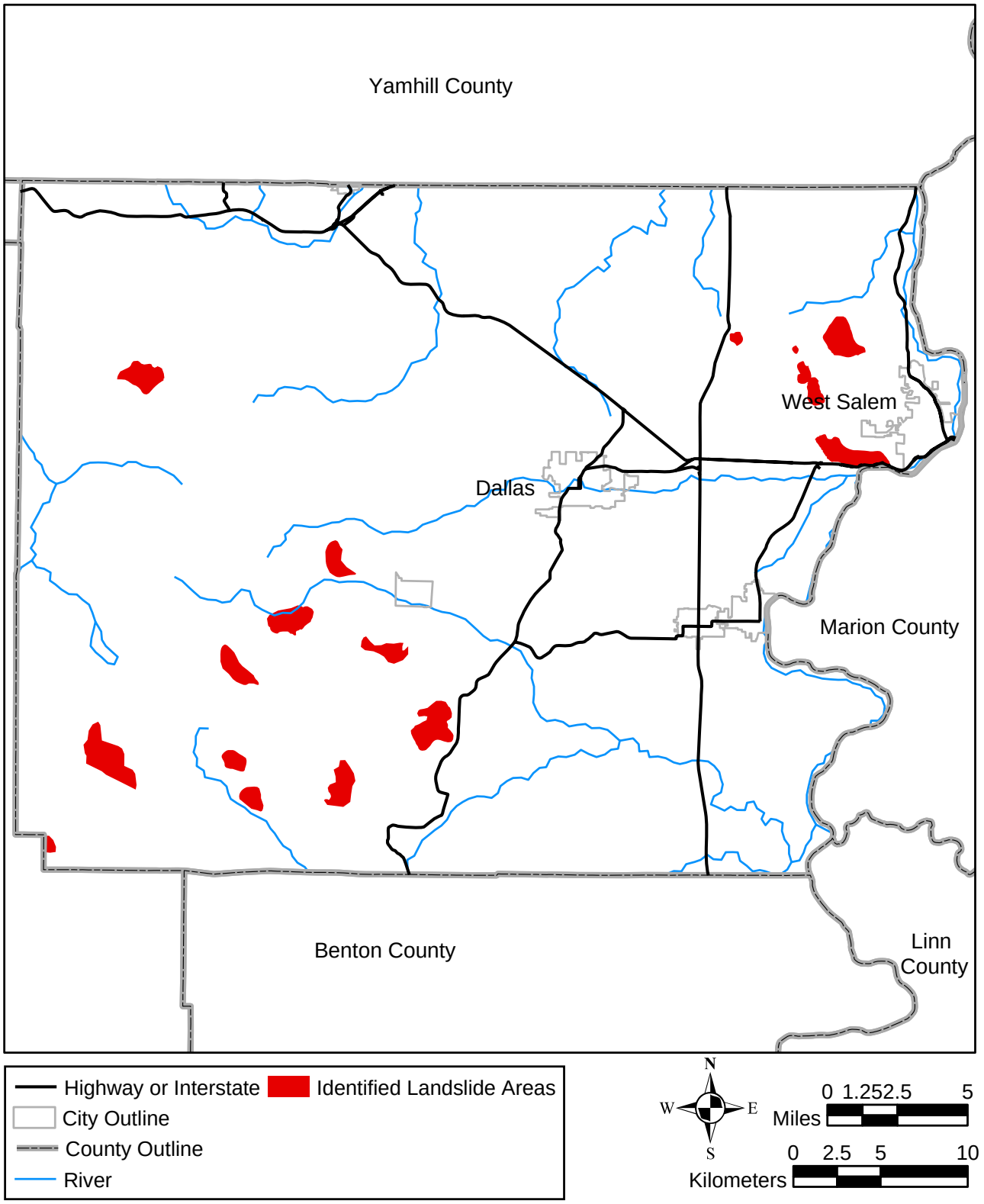

Figure F8. Identified landslide map for Polk County, Oregon.

HAZUS-MH: Earthquake Event Report

Region Name: ***Polk Crustal***

Earthquake Scenario: ***Mill Creek M6.7***

Print Date: ***March 14, 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.

Table of Contents

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):

Oregon

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

The geographical size of the region is 742.30 square miles and contains 12 census tracts. There are over 23 thousand households in the region and has a total population of 62,380 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 21 thousand buildings in the region with a total building replacement value (excluding contents) of 3,467 (millions of dollars). Approximately 100.00 % of the buildings (and 92.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,555 and 538 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 21 thousand buildings in the region which have an aggregate total replacement value of 3,467 (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 86% 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 1 hospitals in the region with a total bed capacity of 44 beds. There are 29 schools, 3 fire stations, 4 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 28 dams identified within the region. Of these, 1 of the dams are classified as 'high hazard'. The inventory also includes 12 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 2,093.00 (millions of dollars). This inventory includes over 185 kilometers of highways, 107 bridges, 6,868 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	107	632.30
	Segments	37	573.30
	Tunnels	0	0.00
		Subtotal	**1,205.60**
Railways	Bridges	0	0.00
	Facilities	0	0.00
	Segments	32	60.60
	Tunnels	0	0.00
		Subtotal	**60.60**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	0	0.00
		Subtotal	**0.00**
Ferry	Facilities	0	0.00
		Subtotal	**0.00**
Port	Facilities	0	0.00
		Subtotal	**0.00**
Airport	Facilities	7	43.10
	Runways	7	245.80
		Subtotal	**289.00**
		Total	**1,555.20**

Table 3: Utility System Lifeline inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	68.70
	Facilities	1	37.60
	Pipelines	0	0.00
		Subtotal	**106.30**
Waste Water	Distribution Lines	NA	41.20
	Facilities	5	376.30
	Pipelines	0	0.00
		Subtotal	**417.50**
Natural Gas	Distribution Lines	NA	27.50
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**27.50**
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**0.00**
Electrical Power	Facilities	1	124.30
		Subtotal	**124.30**
Communication	Facilities	4	0.50
		Subtotal	**0.50**
		Total	**676.00**

Earthquake Scenario

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

Scenario Name	Mill Creek M6.7
Type of Earthquake	Source
Fault Name	Mill Creek Fault
Historical Epicenter ID #	70
Probabilistic Return Period	NA
Longitude of Epicenter	-123.01
Latitude of Epicenter	44.74
Earthquake Magnitude	6.70
Depth (Km)	0.00
Rupture Length (Km)	22.96
Rupture Orientation (degrees)	0.00
Attenuation Function	Project 2000 West - Non Extensional

Building Damage

Building Damage

HAZUS estimates that about 4,197 thousand buildings will be at least moderately damaged. This is over 20.00 % of the total number of buildings in the region. There are an estimated 940 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 4 below 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	(%)
Agriculture	1	0.01	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	26	0.21	14	0.31	18	0.71	11	1.58	9	0.95
Education	0	0.00	0	0.00	0	0.01	0	0.02	0	0.03
Government	5	0.04	2	0.05	2	0.09	1	0.13	1	0.06
Industrial	3	0.02	2	0.04	3	0.10	2	0.25	1	0.15
Other Residential	1,283	10.13	597	13.60	668	26.07	299	42.98	216	23.01
Religion	2	0.02	1	0.01	0	0.02	0	0.02	0	0.00
Single Family	11,341	89.58	3,776	85.99	1,870	73.00	383	55.01	713	75.81
Total	**12,661**		**4,392**		**2,562**		**695**		**940**	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	24	0.01	1	0.01	1	0.04	1	0.08	1	0.05
MH*	1,015	8.02	465	10.60	575	22.46	263	37.76	168	17.86
Precast	5	0.02	1	0.02	2	0.07	2	0.25	1	0.11
RM*	3	0.02	1	0.02	2	0.07	2	0.23	1	0.10
Steel	18	0.02	1	0.03	3	0.13	4	0.52	3	0.28
UM*	100	0.79	48	1.10	54	2.10	34	4.89	35	3.76
Wood	11,496	90.76	3851	87.70	1,892	73.85	372	53.50	718	76.31
Total	**12,661**		**4,392**		**2,562**		**695**		**940**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 44 hospital beds available for use. On the day of the earthquake, the model estimates that only 30 hospital beds (70.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 93.00% 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		
		Least Moderate Damage > 50%	Complete Damage > 50%	# likely Functional on day 1
Hospitals	1	0	0	1
Schools	29	0	0	29
EOCs	0	0	0	0
PoliceStations	4	0	0	4
FireStations	3	0	0	3

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	37	0	0	37	37
	Bridges	107	10	2	99	104
	Tunnels	0	0	0	0	0
Railways	Segments	32	0	0	32	32
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	7	2	0	7	7
	Runways	7	0	0	7	7

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	5	2	0	2	5
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	1	1	0	0	1
Communication	4	1	0	4	4

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	3,434	93	93
Waste Water	2,061	73	74
Natural Gas	1,374	79	79
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	23,058	666	9	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 3 ignitions that will burn about 0.03 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 12 people and burn about 0 (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 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 46.00% 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 (1,412 households to be displaced due to the earthquake. Of these, 361 people (out of a total population of 62,380 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
2 AM	Commercial	1	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	2	1	0	0
	Other-Residential	100	26	3	5
	Single Family	149	35	2	4
	Total	**253**	**61**	**5**	**10**
2 PM	Commercial	91	27	4	8
	Commuting	0	0	0	0
	Educational	64	19	3	6
	Hotels	0	0	0	0
	Industrial	16	4	1	1
	Other-Residential	15	4	0	1
	Single Family	24	6	0	1
	Total	**211**	**60**	**9**	**17**
5 PM	Commercial	101	30	5	9
	Commuting	5	7	12	2
	Educational	17	5	1	2
	Hotels	0	0	0	0
	Industrial	10	3	0	1
	Other-Residential	38	10	1	2
	Single Family	60	14	1	2
	Total	**232**	**69**	**20**	**18**

Economic Loss

The total economic loss estimated for the earthquake is 519.40 (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 409.43 (millions of dollars); 9 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 82 % 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
Income Loses							
	Wage	0.00	1.18	6.74	0.30	0.54	8.76
	Capital-Related	0.00	0.50	6.10	0.18	0.15	6.93
	Rental	7.14	8.09	2.66	0.09	0.23	18.22
	Relocation	0.80	0.22	0.14	0.01	0.07	1.24
	Subtotal	**7.94**	**9.99**	**15.65**	**0.59**	**0.99**	**35.15**
Capital Stock Loses							
	Structural	39.10	13.75	6.39	1.87	1.78	62.88
	Non_Structural	148.88	62.99	18.14	6.21	5.20	241.42
	Content	39.85	13.76	8.36	3.84	2.85	68.67
	Inventory	0.00	0.00	0.32	0.91	0.09	1.31
	Subtotal	**227.83**	**90.50**	**33.20**	**12.83**	**9.92**	**374.28**
	Total	**235.77**	**100.49**	**48.85**	**13.42**	**10.90**	**409.43**

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	573.33	$4.74	0.83
	Bridges	632.28	$30.99	4.90
	Tunnels	0.00	$0.00	0.00
	Subtotal	**1205.60**	**35.70**	
Railways	Segments	60.59	$0.18	0.30
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**60.60**	**0.20**	
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	**0.00**	**0.00**	
Bus	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Airport	Facilities	43.11	$9.18	21.30
	Runways	245.84	$1.83	0.74
	Subtotal	**289.00**	**11.00**	
	Total	**1555.20**	**46.90**	

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	37.60	$1.21	3.21
	Distribution Line	68.70	$2.24	3.26
	Subtotal	**106.32**	**$3.45**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	376.30	$35.38	9.40
	Distribution Line	41.20	$1.77	4.30
	Subtotal	**417.50**	**$37.15**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Line	27.50	$1.89	6.89
	Subtotal	**27.47**	**$1.89**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Electrical Power	Facilities	124.30	$20.52	16.51
	Subtotal	**124.30**	**$20.52**	
Communication	Facilities	0.50	$0.05	10.69
	Subtotal	**0.45**	**$0.05**	
	Total	**676.04**	**$63.05**	

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

	LOSS	Total	%
First Year			
	Employment Impact	0	0.00
	Income Impact	(25)	-4.55
Second Year			
	Employment Impact	0	0.00
	Income Impact	(33)	-5.96
Third Year			
	Employment Impact	0	0.00
	Income Impact	(36)	-6.55
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(36)	-6.55
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(36)	-6.55
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(36)	-6.55

Appendix A: County Listing for the Region

Polk, OR

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Oregon	Polk	62,380	3,187	280	3,467
Total State		**62,380**	**3,187**	**280**	**3,467**
Total Region		**62,380**	**3,187**	**280**	**3,467**

HAZUS-MH: Earthquake Event Report

Region Name: ***Polk Cascadia***

Earthquake Scenario: ***Cascadia M8.5***

Print Date: ***March 14, 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.

Table of Contents

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):

Oregon

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

The geographical size of the region is 742.30 square miles and contains 12 census tracts. There are over 23 thousand households in the region and has a total population of 62,380 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 21 thousand buildings in the region with a total building replacement value (excluding contents) of 3,467 (millions of dollars). Approximately 100.00 % of the buildings (and 92.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 1,555 and 538 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 21 thousand buildings in the region which have an aggregate total replacement value of 3,467 (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 86% 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 1 hospitals in the region with a total bed capacity of 44 beds. There are 29 schools, 3 fire stations, 4 police stations and 0 emergency operation facilities. With respect to HPL facilities, there are 28 dams identified within the region. Of these, 1 of the dams are classified as 'high hazard'. The inventory also includes 12 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 2,093.00 (millions of dollars). This inventory includes over 185 kilometers of highways, 107 bridges, 6,868 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	107	632.30
	Segments	37	573.30
	Tunnels	0	0.00
		Subtotal	**1,205.60**
Railways	Bridges	0	0.00
	Facilities	0	0.00
	Segments	32	60.60
	Tunnels	0	0.00
		Subtotal	**60.60**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	0	0.00
		Subtotal	**0.00**
Ferry	Facilities	0	0.00
		Subtotal	**0.00**
Port	Facilities	0	0.00
		Subtotal	**0.00**
Airport	Facilities	7	43.10
	Runways	7	245.80
		Subtotal	**289.00**
		Total	**1,555.20**

Table 3: Utility System Lifeline inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	68.70
	Facilities	1	37.60
	Pipelines	0	0.00
		Subtotal	**106.30**
Waste Water	Distribution Lines	NA	41.20
	Facilities	5	376.30
	Pipelines	0	0.00
		Subtotal	**417.50**
Natural Gas	Distribution Lines	NA	27.50
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**27.50**
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**0.00**
Electrical Power	Facilities	1	124.30
		Subtotal	**124.30**
Communication	Facilities	4	0.50
		Subtotal	**0.50**
		Total	**676.00**

Earthquake Scenario

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

Scenario Name	Cascadia M8.5
Type of Earthquake	User-defined
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	8.50
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Building Damage

HAZUS estimates that about 6,195 thousand buildings will be at least moderately damaged. This is over 29.00 % of the total number of buildings in the region. There are an estimated 1,510 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 4 below 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	(%)
Agriculture	0	0.00	0	0.00	0	0.01	0	0.01	0	0.01
Commercial	4	0.05	7	0.12	18	0.54	22	1.66	27	1.78
Education	0	0.00	0	0.00	0	0.00	0	0.02	1	0.03
Government	1	0.01	1	0.01	2	0.07	3	0.24	4	0.26
Industrial	0	0.01	1	0.01	2	0.07	3	0.22	4	0.23
Other Residential	307	3.39	389	6.47	733	21.71	842	64.27	792	52.44
Religion	1	0.01	0	0.01	1	0.02	1	0.05	1	0.05
Single Family	8,736	96.54	5,607	93.37	2,618	77.58	439	33.53	683	45.19
Total	**9,049**		**6,005**		**3,374**		**1,311**		**1,511**	

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

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	3	0.00	0	0.00	1	0.02	1	0.10	2	0.12
MH*	112	1.24	244	4.05	636	18.85	791	60.35	704	46.58
Precast	0	0.00	0	0.01	2	0.05	3	0.20	3	0.23
RM*	0	0.01	0	0.01	2	0.05	3	0.21	3	0.21
Steel	1	0.00	0	0.00	1	0.03	3	0.22	9	0.59
UM*	25	0.27	35	0.59	65	1.92	62	4.76	84	5.59
Wood	8,907	98.42	5717	95.19	2,640	78.24	408	31.10	653	43.25
Total	**9,049**		**6,005**		**3,374**		**1,311**		**1,511**	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 44 hospital beds available for use. On the day of the earthquake, the model estimates that only 3 hospital beds (7.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 28.00% of the beds will be back in service. By 30 days, 76.00% will be operational.

Table 6: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		Least Moderate Damage > 50%	Complete Damage > 50%	# likely Functional on day 1
Hospitals	1	1	0	0
Schools	29	0	0	29
EOCs	0	0	0	0
PoliceStations	4	0	0	4
FireStations	3	0	0	3

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	37	0	0	37	37
	Bridges	107	19	0	88	95
	Tunnels	0	0	0	0	0
Railways	Segments	32	0	0	32	32
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	7	0	0	7	7
	Runways	7	0	0	7	7

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	5	0	0	0	5
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	1	0	0	1	1
Communication	4	0	0	4	4

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

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	3,434	273	141
Waste Water	2,061	216	112
Natural Gas	1,374	231	120
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	23,058	2,346	617	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 3 ignitions that will burn about 0.03 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 12 people and burn about 0 (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 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 39.00% 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 (1,822 households to be displaced due to the earthquake. Of these, 464 people (out of a total population of 62,380 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
2 AM	Commercial	3	1	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	1	0	0	0
	Industrial	7	2	0	1
	Other-Residential	224	60	7	13
	Single Family	154	35	2	4
	Total	**389**	**98**	**10**	**19**
2 PM	Commercial	263	80	13	26
	Commuting	0	0	1	0
	Educational	153	48	8	16
	Hotels	0	0	0	0
	Industrial	50	15	2	5
	Other-Residential	40	11	1	2
	Single Family	27	6	1	1
	Total	**534**	**160**	**26**	**49**
5 PM	Commercial	273	83	14	26
	Commuting	7	10	16	3
	Educational	34	11	2	4
	Hotels	0	0	0	0
	Industrial	31	9	2	3
	Other-Residential	85	23	3	5
	Single Family	61	14	1	2
	Total	**491**	**150**	**37**	**43**

Economic Loss

The total economic loss estimated for the earthquake is 767.37 (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 624.43 (millions of dollars); 11 % 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
Income Loses							
	Wage	0.00	2.64	15.55	0.72	1.31	20.22
	Capital-Related	0.00	1.12	14.12	0.43	0.35	16.02
	Rental	7.91	13.80	6.27	0.20	0.70	28.88
	Relocation	0.91	0.37	0.32	0.02	0.17	1.79
	Subtotal	**8.82**	**17.94**	**36.26**	**1.36**	**2.53**	**66.91**
Capital Stock Loses							
	Structural	42.32	28.69	16.70	4.16	5.06	96.92
	Non_Structural	162.29	117.55	47.24	14.38	14.00	355.46
	Content	42.54	23.75	20.36	8.57	6.81	102.02
	Inventory	0.00	0.00	0.82	2.09	0.21	3.12
	Subtotal	**247.14**	**169.99**	**85.11**	**29.19**	**26.08**	**557.52**
	Total	**255.96**	**187.93**	**121.38**	**30.56**	**28.60**	**624.43**

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	573.33	$9.49	1.66
	Bridges	632.28	$49.88	7.89
	Tunnels	0.00	$0.00	0.00
	Subtotal	**1205.60**	**59.40**	
Railways	Segments	60.59	$0.40	0.66
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**60.60**	**0.40**	
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	**0.00**	**0.00**	
Bus	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Airport	Facilities	43.11	$9.94	23.06
	Runways	245.84	$4.03	1.64
	Subtotal	**289.00**	**14.00**	
	Total	**1555.20**	**73.70**	

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	37.60	$3.04	8.07
	Distribution Line	68.70	$3.92	5.71
	Subtotal	**106.32**	**$6.96**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	376.30	$47.51	12.63
	Distribution Line	41.20	$3.10	7.53
	Subtotal	**417.50**	**$50.61**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Line	27.50	$3.32	12.07
	Subtotal	**27.47**	**$3.32**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Electrical Power	Facilities	124.30	$8.26	6.65
	Subtotal	**124.30**	**$8.26**	
Communication	Facilities	0.50	$0.05	11.19
	Subtotal	**0.45**	**$0.05**	
	Total	**676.04**	**$69.19**	

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

	LOSS	Total	%
First Year			
	Employment Impact	0	0.00
	Income Impact	(27)	-4.87
Second Year			
	Employment Impact	0	0.00
	Income Impact	(38)	-6.95
Third Year			
	Employment Impact	0	0.00
	Income Impact	(43)	-7.82
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(43)	-7.82
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(43)	-7.82
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(43)	-7.82

Appendix A: County Listing for the Region

Polk, OR

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Oregon	Polk	62,380	3,187	280	3,467
Total State		**62,380**	**3,187**	**280**	**3,467**
Total Region		**62,380**	**3,187**	**280**	**3,467**