Earthquake Risks and Mitigation in Oregon

Yumei Wang, Oregon Dept. of Geology and Mineral Industries, summary of offprint from "Environmental, Groundwater and Engineering Geology: Applications from Oregon", 1998.

I. Introduction

A. Oregon and earthquakes
1. all parts of state have potential for earthquakes
2. Oregon lies at juncture of Cascadia Subduction Zone
    a. Juan de Fuca plate subducts beneath N. America

B. Earthquake types
1. Intraplate quakes - within the Juan de Fuca plate
2. Crustal quakes - within the over-riding N. American plate
    a. faults in Oregon
3. Subduction-Zone quakes - at interface between subducting and over-riding slabs
    a. trench-slip faulting
4. Volcanic-related quakes
    a. Cascade volcanic arc
    b. magmatic injection into crust

C. Seismic Records
1. limited historic seismicity
2. surface traces of active faults limited

D. Moral of Story:
1. moderate level of historic record for quakes but...
2. significant risk in Oregon

II. Earthquake Sources in Pacific Northwest

A. Convergent Plate Tectonic Setting
1. Cascadia subduction

2. Paleoseismic record
    a. last major subduction zone quake ~300 yrs ago
    b. several large magnitude quakes in past several 1000 yrs

3. maximum magnitude quakes expected: 8.5-9.0 (wow!!)

B. Quake Types
1. Deep Intraplate
    a. depth 40-60 km, within interior of Juan de Fuca plate
    b. max magnitude ~7.5
    c. micro-earthquakes common
2. Shallow Crustal earthquakes
    a. depth 10-25 km, in N. American crust
        (1) e.g. Klamath Falls 1993 (M5.9-6.3)

3. Volcanic Quakes
    a. max Magnitude ~5.5
    b. e.g. Mt. St. Helens 1980

III. Seismic Risk in Oregon

A. Historic seismicity is low frequency (not much historic activity)
  1. problem - complacency
  2. Explanations for low seismic frequency in Cascadia Subduction Zone
    a. convergence rate = 0 cm/yr
      (1) known: convergence rate = 3-4 cm/yr
      (2) slow subduction due to proximity to hot, buoyant Juan de Fuca spreading center
    b. converging slip accommodated aseismically
      (1) ductile deformation of plate
    c. Pacific Northwest is in major seismic gap, with major locked plate segments
      (1) "the big one is coming"

B. Risk Factors for Oregon
  1. Population increase, > population density
  2. low public awareness
  3. poor zoning / building regulations

C. History of Seismic Work in Oregon
  1. Trojan Nuclear Plant Siting
  2. Bonneville Power Administration - dam work

D. Current Seismic Data Set
  1. prehistoric earthquake record
    a. Native American legends
      (1) Tsunamis
      (2) landslides
    b. Japanese historic documents
  2. Instrument-recorded data
    a. GPS ground motion measurements
    b. seismic analysis
  3. Geologic Records
    a. earthquake-induced landslides
      (1) Bridge of Gods / Columbia River gorge
    b. buried forests / marsh soils resulting from coseismic subsidence
      (1) recurrence interval estimates for great quakes: 400-800 yrs
    c. tsunamic sand deposits in back bay aeras
    d. liquefaction features
    e. turbidites
    f. offshore submarine landslides

IV. Hazards Mitigation and Risk Analysis
  A. Terms Defined
    1. hazard - probability of ground shaking (or any event)
    2. risk - potential for death / destruction associated with hazard
  B. Earthquake Hazards Mapping Program

V. Hazards Maps
  A. Hazards Associations
    1. Liquefaction potential
      a. unstable saturated soils, during shaking
    2. Amplification of Shaking
      a. unconsolidated, fine-grained soils
    3. Landsliding

  B. Key Data / Spatial Associations
    1. Bedrock Geology
    2. Topographic Slope
    3. Surficial Geology
      a. Soils Distribution
      b. Alluvial Sediments
    4. Groundwater Conditions
      a. Depth to Water
      b. Unconsolidated Aquifers

  C. Map Products
    1. Liquefaction Susceptibility
      a. high susceptibility: loos, saturated sands / silt below water table
      b. low susceptibility: consolidated bedrock, compacted gravels
      c. Result of Liquefaction - structural failures
      d. e.g. Scale
        (1) 0 - no suscept. = bedrock
        (2) 1 - < 6ft of liq. material
        (3) 5 - > 25 ft of liq. material

    2. Amplification Susceptibility
      a. defined - materials intensification of groundshaking energy
        (1) "ground motion amplification"
      b. most susceptible: thick deposits soft, low density unconsolidated soils
        (1) low shear wave velocity = high damage
      c. e.g. Scale
        (1) 0 - no suscept. / bedrock
        (2) 5 - low density soils/ unconsolidated

    3. Landslide Susceptibility
      a. earthquake induced shaking / landslides
      b. Factors
        (1) slope / gradient
        (2) groundwater saturation

(3) vegetative cover
(4) colluvial thickness / easily weathered rocks
(5) bedrock structure
(a) bedding planes
(b) joints

c. e.g. scale - slope angle
(1) 1 - low susceptibility (slopes < 6 degrees)
(2) 4 - high susc (slopes > 22 degrees)

4. Relative Earthquake Hazard: based on above 3 criteria

a. Primary Analytical Tools
(1) Surface Mapping / Public Record
(a) Bedrock Geologic Maps
(b) Surficial Geology Maps
(c) Soils Survey Maps
(2) Geographic Information Systems
(a) Computer - Based Spatial Analysis
i) Maps + Database

Category of Quake Hazard	Liquefaction	Amplification	Landsliding
0 (low)	0	1	0
1	1	1	1
2	1	2	1
3	2	2	2
4	3	3	3
5(high)	3	3	3

(0 = low, 3 = highest)

D. Case Example of Earthquake Hazard Map - Monmouth / Independence

1. Intermediate to High Hazard for Earthquake Damage
a. Geologic Setting
(1) Willamette River sediments / Willamette Valley
(2) flat valley bottom
(3) Shallow depths to groundwater / saturated sediments
b. Hazard Ratings
(1) Liquefaction: High
(2) Amplification: Intermediate to High
(3) landslide potential: Low
(4) Net Rating: Intermediate to High

IMS-7

Relative Earthquake Hazard Maps
for Selected Urban Areas in Western Oregon

By Ian P. Madin and Zhenming Wang

MONMOUTH-INDEPENDENCE

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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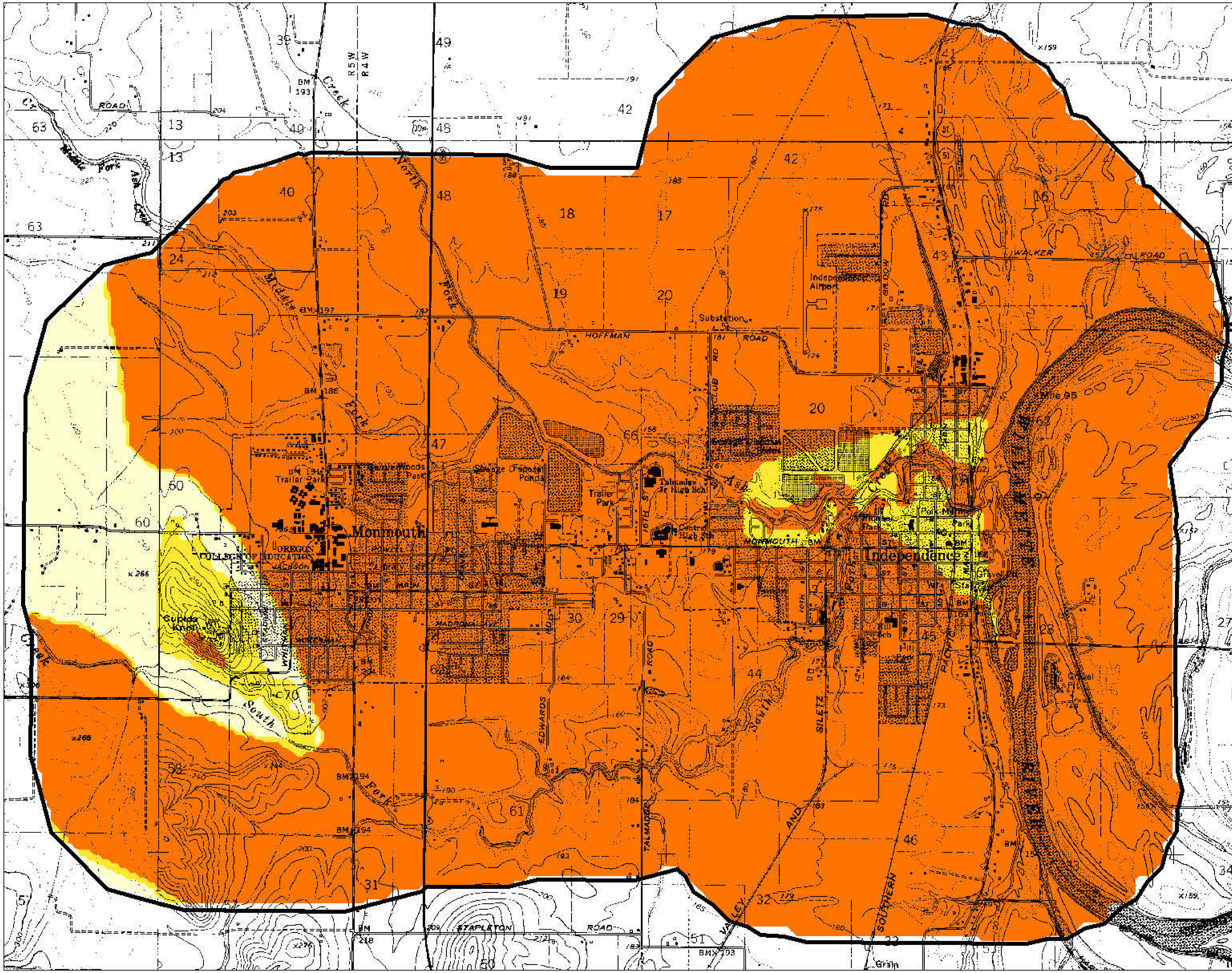
Monmouth-Independence Urban Area



Relative Earthquake Hazard Map

Hazard zones are based on the combined effects of ground shaking amplification, liquefaction, and earthquake-induced landsliding.

- Zone A -- Highest hazard
- Zone B -- Intermediate to high hazard
- Zone C -- Low to intermediate hazard
- Zone D -- Lowest hazard

See the accompanying text for an explanation of how these zones were defined and what the various levels of hazard mean.

IMPORTANT NOTICE

This map depicts earthquake hazard zones that are the result of combining the maps of individual hazards and are based on limited geologic and geophysical data. These hazards and data are described in the accompanying report. At any given site in the map area, site-specific data could give results that differ from those shown on this map. This map cannot replace site-specific investigations. Some appropriate uses are discussed in the accompanying report.
This map shows areas that are relatively more or less hazardous due to local geological conditions within a community. For a complete understanding of the earthquake hazard, see also GMS-100, Earthquake Hazard Maps for Oregon.

0 0.5 1 Mile

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