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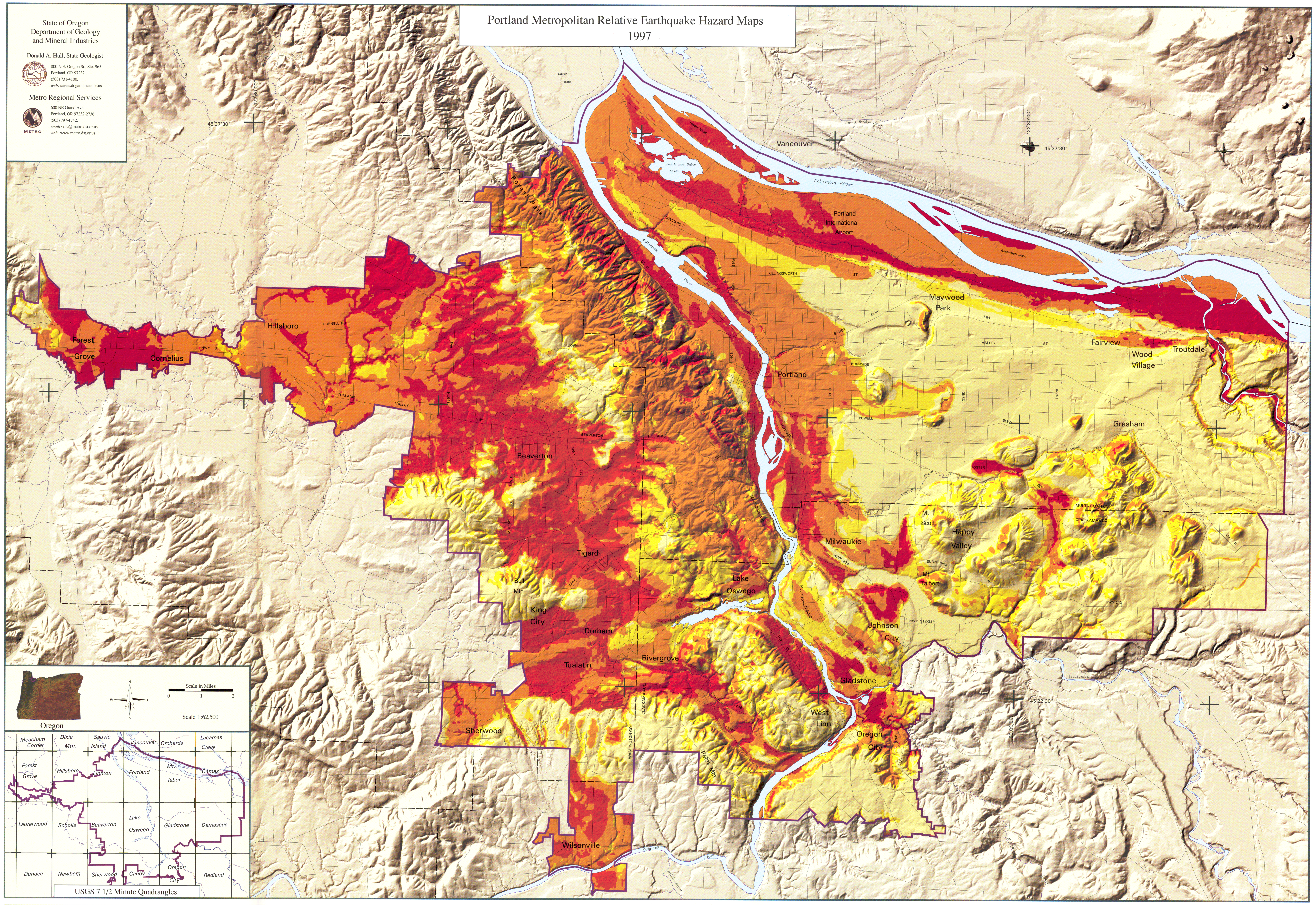
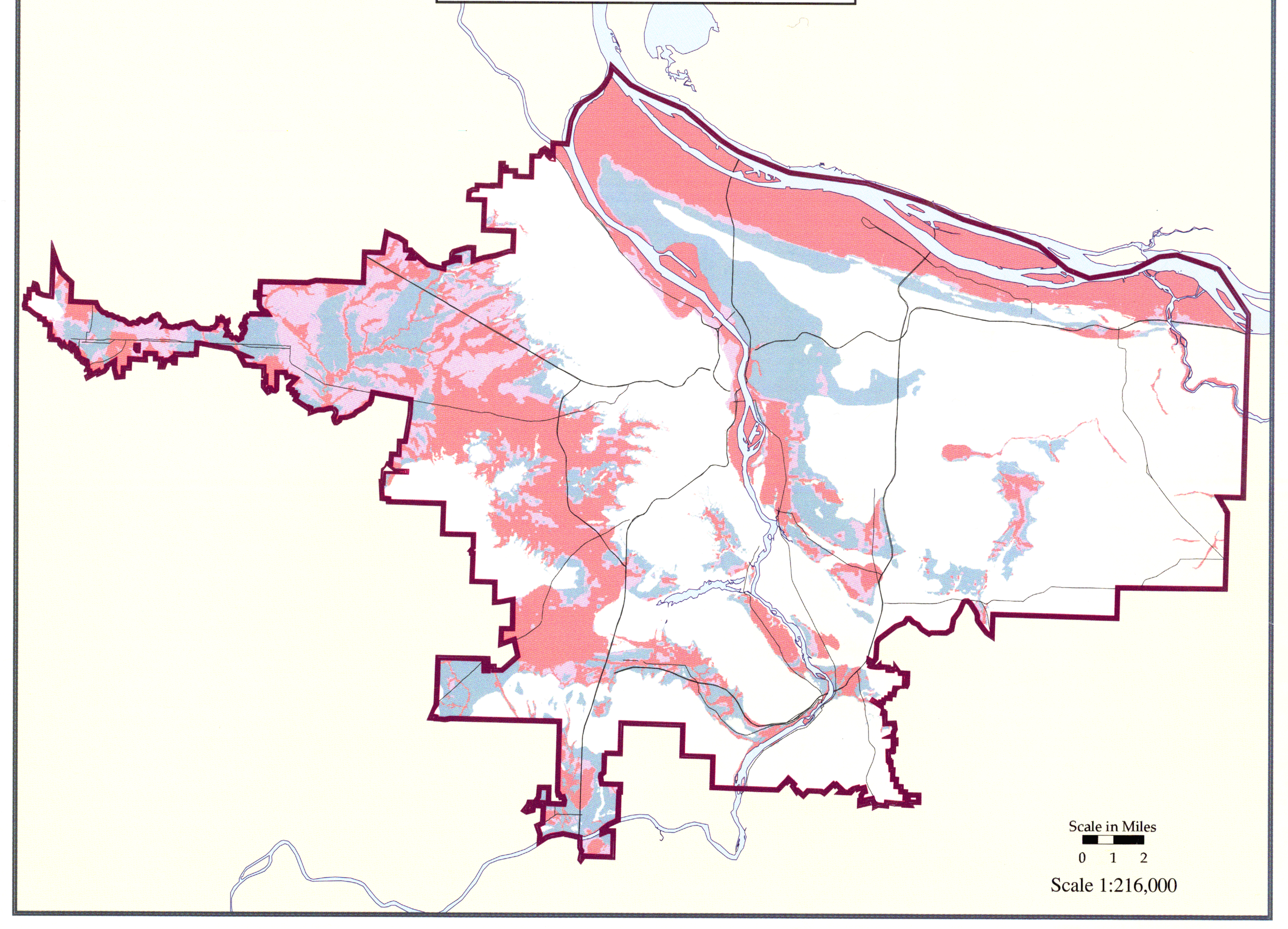
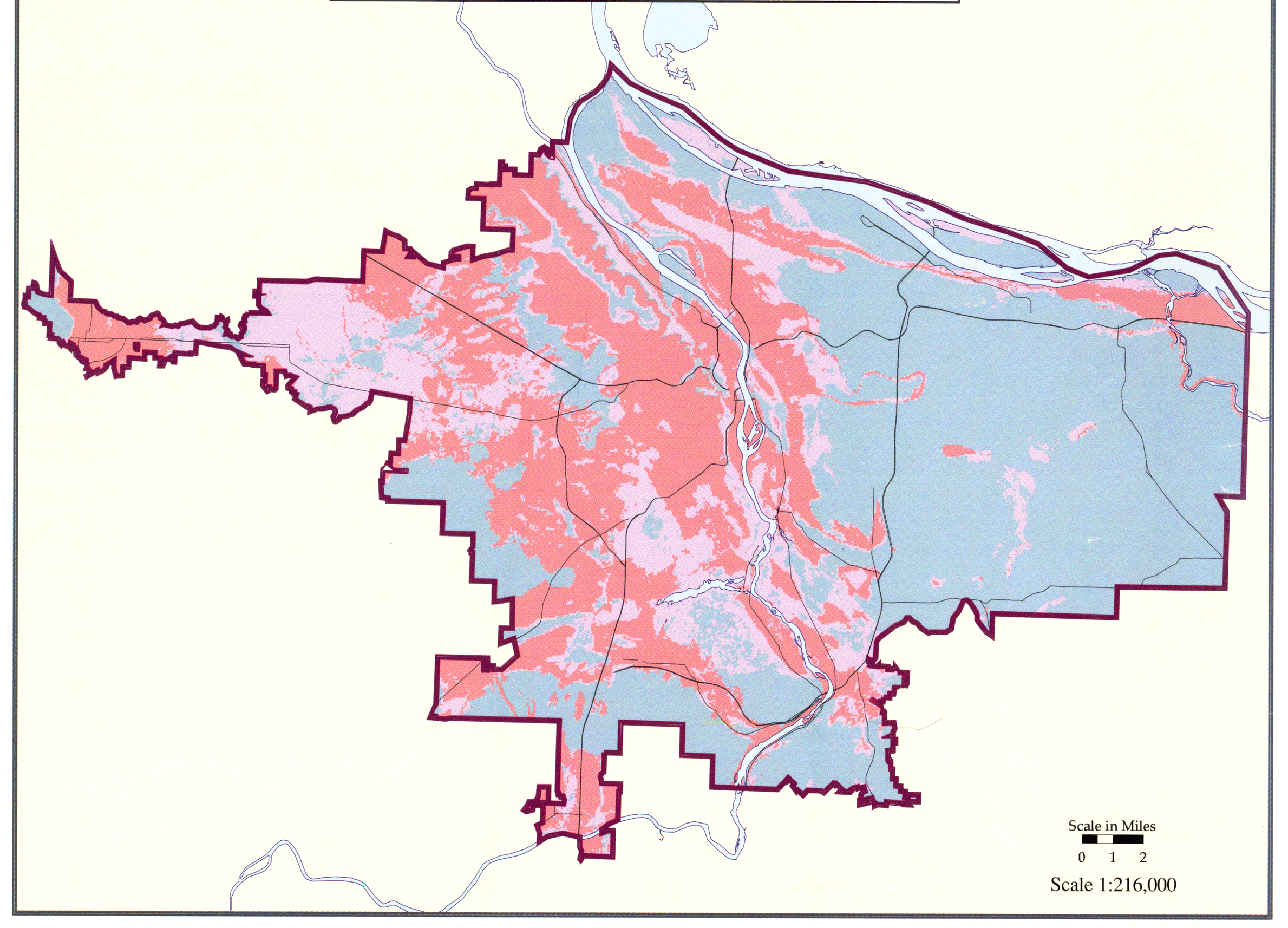
Portland Metropolitan Relative Earthquake Hazard Maps
1997



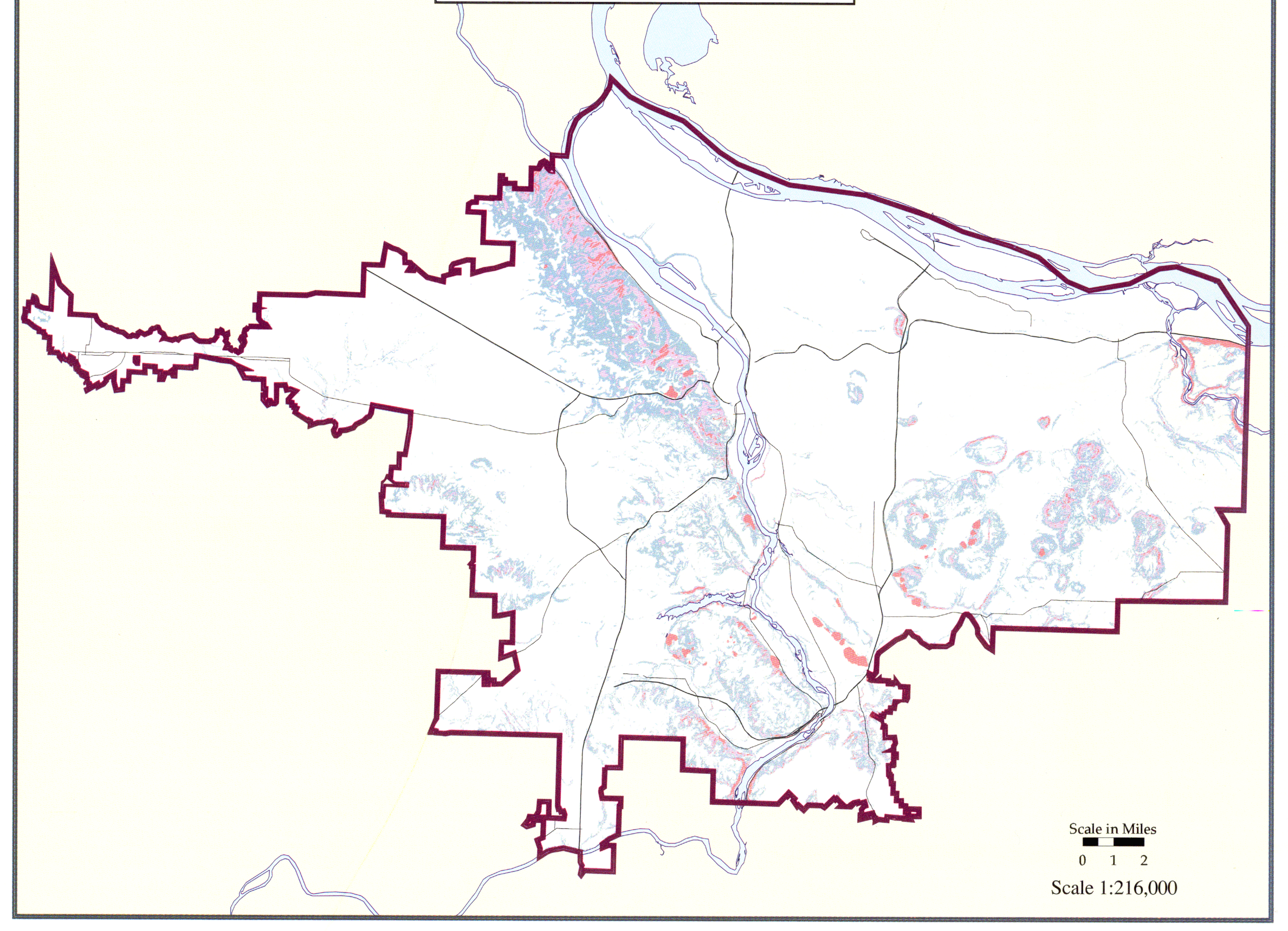
Relative Liquefaction Hazard



Relative Amplification of Peak Ground Acceleration



Relative Slope Instability Hazard



Rivers and Lakes

Metro Boundary

County Boundaries

Zone A | Zone C

Zone B | Zone D

Relative Earthquake Hazards Explanation

(see accompanying text for complete explanation)

The relative earthquake hazard zones shown above range from zone A, which shows areas of greatest hazard, to zone D, which shows areas of least hazard. The degree of relative hazard was based on the factors of ground motion amplification, liquefaction, and slope instability, shown on smaller scale maps on the right margin of this map.

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INTRODUCTION

The scientific understanding of the earthquake hazard in the Portland metropolitan area has increased significantly since the late 1980's. As a result, it is now widely accepted that damaging earthquakes larger than any in the historical record are likely. To minimize losses that may occur in an earthquake, mitigation measures are necessary. Mitigation efforts, to be effective, must be based on the best possible assessment of the likely extent and distribution of earthquake damage.
Damage to a structure during an earthquake will depend on the size, type, and location of the earthquake, the response of the soil and geologic materials at the site, and the characteristics of the particular structure. Earth scientists do not yet know enough about earthquake sources to assess the size, frequency, and location of future earthquakes. We can, however, evaluate the behavior of geologic units.
These maps are an interpretation of the relative earthquake hazards within the Portland metropolitan area. It does not depict the absolute degree of earthquake hazard at any site, which means that in any given earthquake it is possible that damage in even the highest relative hazard category will be light. Conversely, in a severe earthquake even the lowest relative hazard category could experience severe damage. It depicts how the ground is expected to respond during an earthquake and is based on local geologic conditions. It does not take into account cultural features (e.g. types of buildings), the probability that an earthquake may occur, or the nature of an earthquake should one occur. The analysis is based on data from scattered boreholes and the best available geologic mapping and state-of-practice geotechnical analysis. This map is not a substitute for site specific data collection and analysis.

EARTHQUAKE HAZARDS AND EFFECTS

Three types of earthquakes threaten the metropolitan area. The few moderate earthquakes that have originated in Portland in its brief recorded history have been relatively shallow (depths of 6-10 mi) crustal earthquakes. Intraplate earthquakes are the type that severely rocked the Puget Sound area in 1949 and 1965. These earthquakes occur within the remains of ocean floor that has been shoved (subducted) beneath North America. It is now thought that intraplate earthquakes could occur directly beneath Portland at depths of 25-35 mi. Finally, great subduction zone earthquakes occur around the world in subduction zones, where continent sized pieces of the earth's crust are shoved deep into the body of the earth. These earthquakes consistently have magnitudes of 8 to 9. The Cascadia Subduction Zone has been recognized off the Oregon and Washington coasts, but it has not ruptured during our 200-year historical record. There is abundant geologic evidence that it has ruptured in the past, most recently about 300 years ago. The best evidence suggests that these great earthquakes have occurred, on average, every 300 to 600 years, and there is every reason to believe that they will continue to occur in the future.
All three types of earthquakes threaten Portland, and what is certain is that damaging earthquakes will be a part of Portland's future. These maps provide an evaluation of the influence of site geology on potential earthquake damage and are not dependant on the location or magnitude of an earthquake.
Severe damage done by an earthquake is commonly concentrated in limited areas, and results from one or more of the following phenomena:

* Amplification of ground shaking by a "soft" soil column.
* Liquefaction of water-saturated sand, creating areas of "quicksand".
* Instability of slopes triggered by the shaking of the earthquake.

The Relative Earthquake Hazard Map of the Portland Metropolitan Area is a composite hazard map depicting the relative hazard at any site due to the combination of all three effects. It delineates areas that likely will experience the greatest effects from any earthquake. The map predicts the tendency of a site to have greater or lesser damage than other sites in the area. The zones depicted should not be used as the sole basis for any type of restrictive or exclusionary policy.

HAZARD MAPS

The relative earthquake hazard map integrates three separate earthquake hazard components: ground shaking amplification, liquefaction, and earthquake-induced landsliding. Each of these phenomena is a distinct and separate hazard and in concert with others can increase the severity of the total hazard at a given locality. A brief discussion of the production of each layer follows.
Ground Shaking Amplification. The soils and soft sedimentary rocks near the surface can modify bedrock ground shaking caused by an earthquake. This modification can increase the strength of shaking (or alternatively decrease it), duration of shaking, or change the frequency of the shaking. The nature of these modifications is determined by the thickness of the geologic materials and their physical properties such as shear-wave velocity. With these parameters the effects of the local geology on ground shaking including areas where the ground shaking will be strongest can be identified.
Three amplification hazard categories were defined for the Portland metropolitan area:
(1) Areas with amplification less than 1.25
(2) Areas with amplification between 1.25 and 1.50
(3) Areas with amplification greater that 1.50

Liquefaction Analysis. Liquefaction is a phenomenon in which shaking a soil causes it to rapidly change its material properties so that it begins to behave as a liquid. Liquefaction typically occurs in young, loose, granular soils (e.g. sands) that are saturated with water. Vertical and lateral displacements resulting from liquefaction can range from inches to feet. Pipelines can be ruptured, light objects such as underground storage tanks can float, and heavy objects such as buildings can sink. Soils that are prone to liquefaction can be identified, as can their thickness and influence on the severity of earthquake effects.
Four liquefaction hazard categories were defined as follows:
(0) Areas not liquefiable or liquefiable only due to unusual local conditions.
(1) Areas with materials that are liquefiable when they are intermittently saturated.
(2) Areas with a thickness of liquefiable material less than 20 ft where the water table is 15-30 ft.
(3) Areas with a thickness of liquefiable material greater than 30 ft where the water table is 15-30 ft deep or areas with liquefiable material where the water table is less than 15 ft.
Landslide Analysis. Shaking resulting from an earthquake can cause existing landslides to move as well as generating forces that create new landslides. The steepness of a slope is one of the primary indicators of the stability of a slope, and this factor has been used to estimate the depicted landslide hazard.
Four landslide hazard categories were defined as:
(0) Slope instability only in unusual localized conditions.
(1) Slopes between 15 percent (8.5 °) and 30 percent (16.7°).
(2) Slopes between 30 percent (16.7°) and 45 percent (24.2°).
(3) Slopes greater than 45 percent (24.2°) and existing landslides.
Relative Earthquake Hazard Map: The relative earthquake hazard map was created to show which areas will have the greatest tendency to experience damage due to any of, or a combination of, these hazards. On the individual hazard maps, areas were categorized as zones 0, 1, 2, or 3, with 3 being the greatest hazard. For every point on the map, the zone rating for each individual hazard (amplification, liquefaction, and landslide) was squared, and the resulting numbers were added together. Then the square root of this sum was calculated and rounded to the nearest whole number. A result of 4 or 5 is assigned to category A, a result of 3 is assigned to category B, a result of 2 is assigned to category C, and a result of 0 or 1 is assigned to category D.

HAZARD MAP METHODOLOGY

The basis for earthquake hazard assessment is a good geologic model. The geologic model for the Portland metropolitan area was produced by integrating the data from hundreds of boreholes drilled for water wells and foundation investigations with the best available geologic mapping and geophysics. This information was used to define the nature of the soil and rock column beneath any site on the map so that its effect on ground response could be assessed.
In addition to a geologic model, knowledge of the engineering characteristics of the various geologic units is required. Many of the required measurements, such as the Standard Penetration Tests (SPT), are acquired in the normal course of a foundation investigation and are available from many of the same sources as thickness information. Other data are obtained by running laboratory tests of borehole samples.
Shear-wave velocities of the geologic units are also required for the assessment technique. These were obtained from measurements at dozens of carefully selected sites by using both conventionally drilled boreholes and cone penetrometer techniques.
All of the information is combined to give a detailed computer model of what lies beneath the surface throughout the map area. With this information, the response to earthquake shaking at a specific location can be assessed.
For those interested in a detailed description of the construction of these maps, please see:
Mabey, M.A., Madin, I.P., Youd, T.L., and Jones, C.F., 1993, Earthquake hazard maps of the Portland quadrangle, Multnomah and Washington counties, Oregon, and Clark County, Washington: Oregon Department of Geology and Mineral Industries Geologic Map Series GMS-79.
Relative earthquake hazard maps at scales of 1:24,000 are available from DOGAMI for the Portland, Mount Tabor, Beaverton, Lake Oswego, Gladstone, and Linnton quadrangles.

SOURCES:

Street Centerline Map
U.S. Geological Survey (USGS) and Oregon Department of Transportation (ODOT), 1988.

Shaded Relief
derived from U.S. Geological Survey (USGS) 7.5 minute contour lines, 1975-1979, depending on quadrangle.

Lambert conformal conic projection. 1983 North American Datum.
Oregon State Plane Coordinate System, north zone.

Hazard and base map data available in digital formats

3 | 1

2 | No Hazard

Relative hazard categories are arranged so that the highest number (3) indicates greatest hazard and lowest number (1) indicates least hazard. White indicates areas where slope instability or liquefaction is possible only where there are unusual localized conditions. See text for explanation.

IMS-1

Relative Earthquake Hazard Map of the Portland Metro Region, Clackamas, Multnomah, and Washington Counties, Oregon

By M.A. Mabey and others

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