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October 31, 2000
Project No. 340-1

Mr. Tom McClung
St. Agatha Church Building Committee
1516 SE Miller Street
Portland, Oregon 97202

SEISMIC HAZARDS REPORT
PROPOSED ST. AGATHA SCHOOL
[redacted]
PORTLAND, OREGON

Dear Mr. McClung:

This report presents the results of a seismic hazards investigation for your new school building. The purpose of my seismic hazards investigation was to evaluate the regional geologic and seismic setting and provide design information on seismic sources and recommendations for design earthquake ground motions. In addition, landsliding, fault surface rupture, and liquefaction hazards were evaluated.

This work was performed in general accordance with our agreement dated July 28, 2000. A geotechnical investigation report for the project was issued separately, dated October 23, 2000.

SITE CONDITIONS

Surface Conditions

Regionally, the site is located in southern Multnomah County, Oregon, in the Sellwood neighborhood of Portland (Figure 1). The 100-foot wide by 200-foot long property is east of SE 15th Avenue between SE Miller and Nehalem Streets. Topographically, the site slopes very gently to the southeast. Relief across the site is about 6 feet. The property is currently used as an asphalt-paved playground for the existing St. Agatha School.

Subsurface Geologic Conditions

The site is mantled with fine and coarse-grained Quaternary glacial flood deposits and underlain at depth by Tertiary Basalt of Waverly Heights and associated undifferentiated sedimentary rocks.

Results of four soil borings drilled on the site indicate that the Quaternary Flood Deposits consist of 6½ feet of firm to stiff silts and silty sands underlain by dense to very dense gravels in a silt to coarse sand matrix. Madin (1990) indicates that the thickness of the gravel deposits under the site likely ranges between about 150 feet and 450 feet. Burns (1997) indicates that the thickness of the gravel deposits likely ranges between 100 meters (330 feet) to 199 meters (650 feet).

The likely bedrock formation underlying the gravel deposits is the Eocene age Basalt of Waverly Heights and associated undifferentiated sedimentary rocks. Madin (1990) describes this unit as consisting of a sequence of subaerial basaltic lava flows and associated sediments. Thickness of this unit is not known, but is assumed to extend to considerable depth (Beeson and others, 1989).

Groundwater

It is estimated based on review of water well logs filed with the State of Oregon that groundwater is located at least 30 to 50 feet below the ground surface. Several groundwater wells in the Sellwood area have been installed in the gravel deposits.

SEISMIC SITE HAZARD ANALYSIS

Regional Tectonic Setting

Earthquakes in the Pacific Northwest occur as a result of the collision of two of the earth's crustal plates, the Juan de Fuca oceanic plate, and the North American continental plate. The Juan de Fuca plate is being thrust under the North American plate along a giant fault called the Cascadia Subduction Zone (CSZ). Seismicity along the margins of the Juan de Fuca plate suggest that the subduction process is active, with an estimated long-term convergence rate of 20 to 45 millimeters per year (Engebretson and others, 1985; DeMets and others, 1990).

Historic Seismicity

Historic Seismicity within a 12-mile radius of the site from 1833 through October 25, 1993 is shown on Figure 2. Records were poorly kept before 1950 and since that time, only two major (greater than Magnitude 5) events have occurred in the Portland-Salem region. Data published by DOGAMI (OFR O-94-04, 1994) indicates that earthquakes with magnitudes as great as 5 and earthquakes with intensities as great as VII have occurred within 12 miles of the site. Intensity is a qualitative description of the effects caused by an earthquake and can be applied to historical accounts to estimate the strength of an earthquake that occurred prior to the development of seismic instruments. For example, an intensity II earthquake may cause some suspended objects to swing while an intensity VII earthquake may cause some negligible damage in buildings of good design. No earthquakes equal to or greater in size than the design earthquakes discussed below have been recorded near the site.

Earthquake Sources and Magnitudes

The collision of the Juan de Fuca Plate and the North American Plate generates crustal stresses, which result in periodic earthquake activity. Earthquake activity in the Pacific Northwest can be divided into three basic categories for the purposes of source characterization and the estimation of seismic risk: (1) large magnitude earthquakes that occur due to slip along the seismogenic part of the interface between the subducting Juan de Fuca Plate and the North American Plate (interface earthquakes); (2) large, deep earthquakes originating in the subducted Juan de Fuca Plate (intraplate earthquakes), and (3) moderate to large size, shallow crustal earthquakes generated by either known or currently hidden local faults (crustal earthquakes).

Cascadia Subduction Zone Interface Earthquakes

The Cascadia Subduction Zone (CSZ) is an approximately 1,100-kilometer long, 115-kilometer wide thrust fault extending from northern California to mid-Vancouver Island. Along Oregon, the CSZ ranges approximately 55 to 115 kilometers off the coastline (Geomatrix, 1995). Although it is located off the Oregon coast, the CSZ is so large that it is a major source of damaging earthquakes in the Portland area (Baska and others, 1998; Wong and others, 2000a).

Scientific findings of the last several years have shown that the CSZ has repeatedly produced large earthquakes during the last 11,000 years. While there have been no historic CSZ earthquakes, many converging lines of evidence suggest that the last great earthquake on the Cascadia Subduction Zone occurred 300 years ago in January 1700. Evidence for the occurrence of a CSZ interface is summarized below.

Darienzo and Peterson (1995) used radiocarbon dating on buried peats from seven estuaries along 200 kilometers of northern Oregon coast to infer the extent of earthquake-induced subsidence, earthquake magnitudes, and average recurrence intervals for subduction zone earthquakes during last 3,000 years. Their findings indicate an average recurrence interval between 400 and 600 years. Considerable research is underway to improve the estimated recurrence interval, but it is clear from many sites that past intervals between events have been as short as or shorter than 200 years (Madin, 1993). Inferred magnitudes of five of the last six earthquakes are greater than 8.0 (Darienzo and Peterson, 1995).

Although researchers do not agree on the likely magnitude, most believe that earthquakes of at least moment magnitude 8.5 are possible. Atwater and others (1995) indicate that earthquakes of this size would probably rupture an area on the interface 50 to 80 kilometers wide and 200 to 600 kilometers long. A magnitude 9 earthquake could result if the entire 1,100-kilometer length ruptured. Rupture would probably occur 5 to 26 kilometers below the surface. The duration of strong ground shaking is estimated to last 1½ to 4 minutes.

For purposes of design, Section 1804.2.1.1 of the Oregon Amended UBC requires that a scenario earthquake of at least magnitude 8.5 be considered for this source. For purpose of our analysis, a M_W 8.5 has been assumed. The closest approach distance to the interface source area is assumed to be approximately 100 kilometers at a depth of 25 kilometers. The estimated recurrence interval for megathrust interface earthquakes in the Pacific Northwest is thought to be about 250 to 600 years (Wong, 2000).

Intraplate Earthquakes

Intraplate earthquakes originate deep from within the subducting Juan de Fuca plate. These earthquakes occur 40 to 70 kilometers beneath the surface, and are never associated with visible faults. Historically, intraplate earthquakes have been as large as magnitude 7.1 (Olympia, 1949) and magnitude 6.5 (Seattle-Tacoma, 1965) in the Puget Sound area. Since the deployment of the modern seismograph network in Oregon in the 1970's, numerous small intraplate earthquakes have been recorded beneath western Oregon in a swath beneath the Coast Range extending as far south as Corvallis. An estimated magnitude 6.7 earthquake in 1873 near Port Orford was probably Oregon's largest intraplate earthquake (Madin, 1993).

The overall rate of deep seismicity is orders of magnitude lower in Oregon than in Washington (Madin, 1993). In the Puget Sound region, the recurrence of magnitude 7.0 earthquakes has been calculated as 110 years, and 330 years for magnitude 7.5 (Rasmussen and Crosson, 1979). It has only been possible to distinguish intraplate earthquakes in western Oregon for a few decades, so the frequency of large events is poorly constrained. The geologic structure capable of producing magnitude 6.5 to 7.5 earthquakes is present beneath western Oregon.

For purposes of design, Section 1804.2.1.1 of the Oregon Amended UBC requires that a scenario earthquake of at least magnitude 7.0 be considered for this source. Our analysis we have assumed a probable design focal distance of 58 kilometers. The estimated recurrence interval for a magnitude 7.0 and greater intraplate earthquake in the Portland region is thought to be about 800 to 900 years (Wong, 1997). The duration of strong ground motion for such an event is estimated to be between approximately 16 to 32 seconds (Chang and Krizinsky, 1977).

Crustal Earthquakes

Crustal earthquakes are shallow, generally occurring within approximately 30 kilometers of the surface. The maximum earthquake generating potential of crustal faults in Oregon is yet unknown, however, worldwide experience has shown that earthquakes up to about magnitude 6.5 can occur at locations where active faulting is not known. Oregon has recently experienced two, relatively large crustal earthquakes: the Scotts Mills earthquake (magnitude 5.6) that occurred March 25, 1993, and the Klamath Falls earthquake (magnitude 5.9) that occurred September 20, 1993.

Review of available published geologic maps (Beeson and others, 1991; Madin, 1990, Wong, 2000) indicates that no known faults are mapped on the site. Thus, the potential for fault surface rupture at the site appears to be low. Three faults capable of producing strong earthquakes are mapped within 10 kilometers (6 miles) of the site. Figure 3 shows the location of Portland Hills fault zone, the Oatfield fault, and the Eastbank fault.

The closest known fault to the site is the Portland Hills fault zone trends northwest along the east slope of the Portland Hills. The main trend of the zone is inferred to be located approximately 0.6 kilometers northeast of the site. The overall length of the fault zone ranges from 28 kilometers (the length associated with significant relief), to 40 kilometers (the length of mapped fault traces), to 62 kilometers (the total length of mapped fault traces and possible associated lineaments). The Portland Hills fault zone is considered structurally complex, composed of several series of offsetting faults ranging from high-angle normal to blind, southwest-dipping reverse fault in character. Some faults in the Portland Hills fault zone have possibly deformed Late Pleistocene (20,000 years ago) sediments (Beeson and others, 1991; Geomatrix, 1994). Geomatrix (1994) estimates that the fault zone has a likely geologic slip rate between 0.05 and 0.2 mm/yr. and could produce an earthquake with a maximum magnitude of between 6.6 to 7.1.

Two other faults near the site have recently been mapped. The Oatfield fault is mapped 3 kilometers to the southwest. Wong (2000) identifies the northwest trending fault as having a total length of 40 kilometers, dipping 70 degrees northeast, and a slip rate between 0.05 and 0.4 mm/yr. Wong estimates that the fault has a structure capable of producing magnitude M_W 6.5 to 6.9 earthquakes.

The closest trace of the Eastbank fault is mapped 6 kilometers northeast of the site. Wong (2000) identifies that northwest trending fault as having a total length of 55 kilometers, dipping 70 to 90 degrees northeast, and a slip rate between 0.05 and 0.4 mm/yr. Wong estimates that the fault has a structure capable of producing magnitude M_W 6.8 to 7.1 earthquakes.

An evaluation of earthquake recurrence in the Portland-Vancouver basin by Bott and Wong (1993) suggests that a local crustal earthquake of magnitude 5.5 or larger should occur every 100 to 150 years in the region, a magnitude 6.0 or larger should occur somewhere in the region every 300-350 years, and an event of magnitude 61/2 or larger about every 800-900 years.

Based on this information, it seems prudent to assume that a magnitude 6¼ earthquake occurring at a random location no closer than 10 kilometers from the site could be used to conservatively represent about a 1 in 500 year event. This event has an encounter probability of 10 percent over a 50-year period. This probability level is similar to that associated with ground motions which modern code-designed buildings should be able to resist without collapse.

Estimated Ground Motion Parameters

The bedrock acceleration (considered to be the basalt at a depth of approximately 300 feet) has been estimated at the site using the above described seismic sources, assumed design magnitudes, and empirical distance-attenuation relationships developed by Joyner & Boore (1988) and Sadigh et al (1997) for crustal events; and Youngs et.al. (1997) and Geomatrix

(1995) for intraslab and interface subduction events. The following table presents estimated peak bedrock accelerations at the site from different earthquake sources.

As required by Amended Section 1804.2.1.1 of the Oregon Structural Specialty Code, the minimum design earthquakes shall include: (1) a minimum design crustal earthquake of magnitude 6.0 and shall have a minimum peak bedrock acceleration of not less than the Seismic Zone Factor Z of UBC Table No. 16-I; (2) a deep earthquake with a M_W 7 on the seismogenic part of the subducting plate of the Cascadia Subduction Zone; and (3) an earthquake on the seismogenic part of the interface between the Juan de Fuca Plate and the North American Plate on the Cascadia Subduction Zone with a minimum Moment magnitude of 8.5.

Design Earthquake	Magnitude	Focal Depth (km)	Closest Distance to Rupture Zone (km)	Mean Peak Bedrock Acceleration (g)
Subduction Zone	8.5 (M_W)	25	100	0.12
Subcrustal	7.0 (M_W)	50	30	0.15
Crustal	6¼ (M_W)	10	10	0.23

Wong (2000) developed probabilistic ground shaking maps for the Portland region. The maps depict ground shaking at the ground surface and thus incorporate the site response effects of soils. The most up-to-date information on seismic sources, including characteristics of the potential rupture plane for the Cascadia megathrust earthquake and crustal faults within the Portland region, has been incorporated into the analysis. Probabilistic maps for approximate return periods of 500 and 2,500 years (10% and 2% probability of exceedence in 50 years, respectively).

For a 500-year return period, Wong estimates that the peak ground surface acceleration at the site will be between 0.3g and 0.35g. For a 2,500-year return period, Wong estimates that the peak ground surface acceleration at the site will be between 0.8g and 0.9g.

The "Relative Earthquake Hazard Map of the Lake Oswego Quadrangle", prepared by Oregon Department of Geology and Mineral Industries (DOGAMI), has mapped the site as Category 3, with Category 1 being the areas with less than 1.25 amplification and Category 3 being areas with greater than 1.5 amplification. Category 3 amplification of 1.5 is consistent with the difference between estimated 500-year peak ground surface accelerations of 0.3 to 0.35g and anticipated bedrock accelerations of 0.15 to 0.23g.

Fault Rupture Hazards

Review of published geologic maps indicates that the closest mapped fault to the site is the Portland Hills Fault. located approximately 1,900 feet (0.6 kilometers) to the northeast. Based on published data it appears the probability of surface rupture on this fault is low.

Wong (2000b) estimates that the return period for rupture-causing earthquakes on crustal faults in the Portland area ranges between several thousand and ten thousand years. To date, there is no published evidence for surface rupture on crustal faults in the Portland area. Ground shaking from an earthquake on the fault is considered a much greater risk than actual surface rupture.

UBC Seismic Coefficient

The current edition of the UBC places the Portland region in seismic zone 3. Current UBC methodology is to characterize the soil profile stiffness within 100 feet of the ground surface and designate a soil profile type based on average soil engineering properties. Average SPT N-values, undrained shear strengths, or shear wave velocities may be used to characterize the dynamic stiffness of the soil profile.

The following soil N-value and shear wave velocity profile is estimated based on our field explorations and review of published geologic reports:

Depth (ft)	SOIL/ROCK TYPE	SPT N-VALUE (bpf)	EST. SHEAR WAVE VELOCITY (ft/sec)
0 – 6½	Silt	11	700
6½ - 300?	Gravel	50+	1700
300+ - ?	Basalt	100+	2500

Using UBC Equation 36-1, the average shear wave velocity of the above profile is approximately 1,556 feet per second. This average shear wave velocity is within the range of soil profile type S_C, with an interpreted seismic response coefficient C_a of 0.33.

Liquefaction Potential

The site is underlain by dense gravels and does not have a shallow permanent groundwater table. Liquefaction is not a seismic hazard at the site.

Earthquake-Induced Settlements

Ground settlement can occur after strong earthquakes on sites underlain by loose, dry sands. Since the site is underlain by thick deposits of dense gravels, there appears to be no risk of seismic-induced settlement.

Seismic-Induced Landsliding

The site is flat and is not at risk from landsliding.

CLOSURE

Geotechnical engineering and the geologic sciences are characterized by uncertainty. Professional judgments presented are based partly on an understanding of the proposed construction, and partly on general experience. The engineering work performed and judgments rendered for this study meet current professional standards; no other warranties, either expressed or implied, are made.

It has been a pleasure assisting you on this phase of the project. Please call if you have questions.

Sincerely,

ALDER GEOTECHNICAL SERVICES

REGISTERED PROFESSIONAL ENGINEER 13507 PE OREGON MARCH 19, 1987 JOHN N. CUNNINGHAM EXP. 12-31-01

John N. Cunningham, P.E.
Geotechnical Engineer

Attachments

(2) Addressee
(6) DiLoreto Architects
(1) Librarian, Oregon Department of Geology and Mineral Industries

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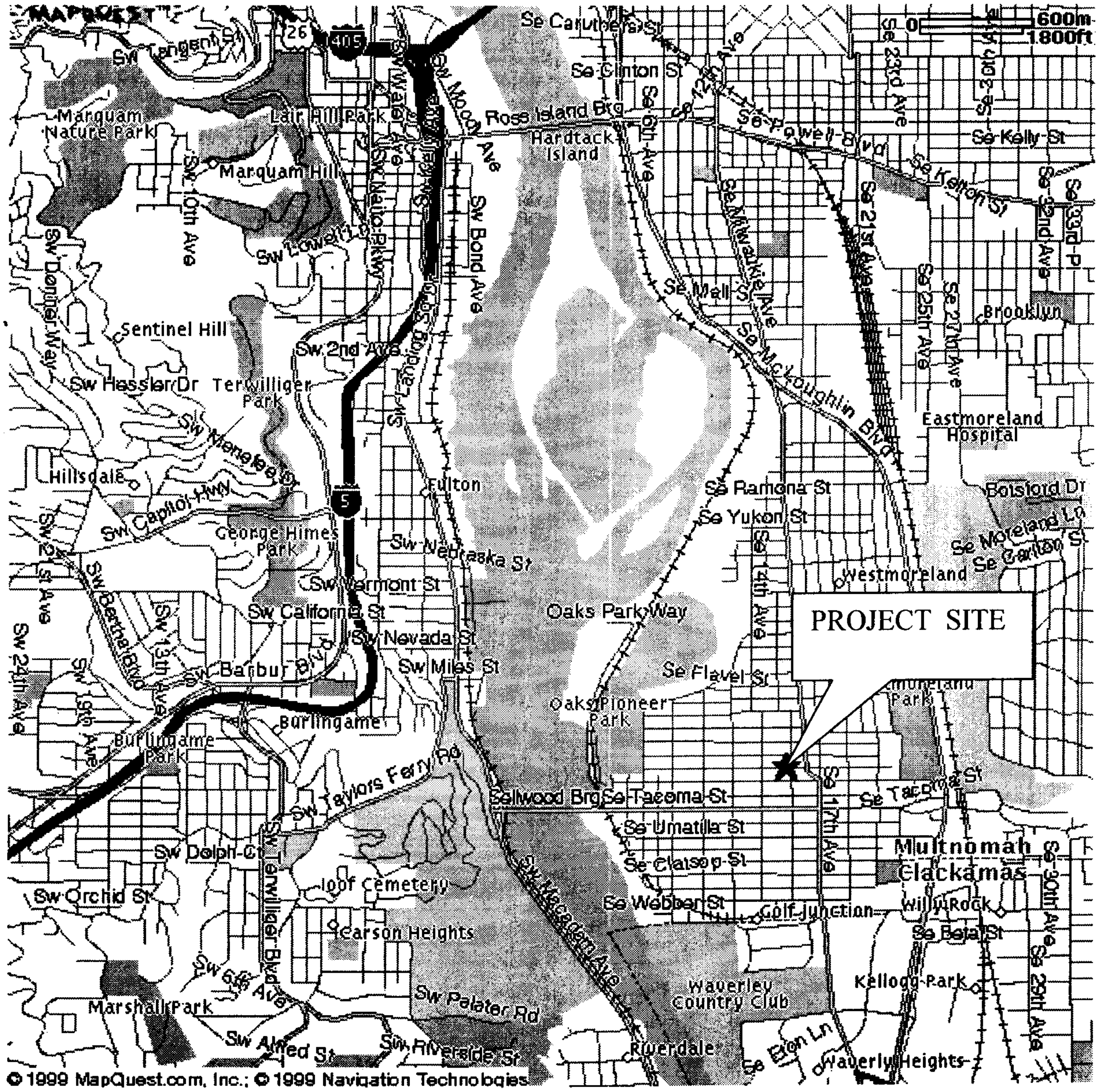

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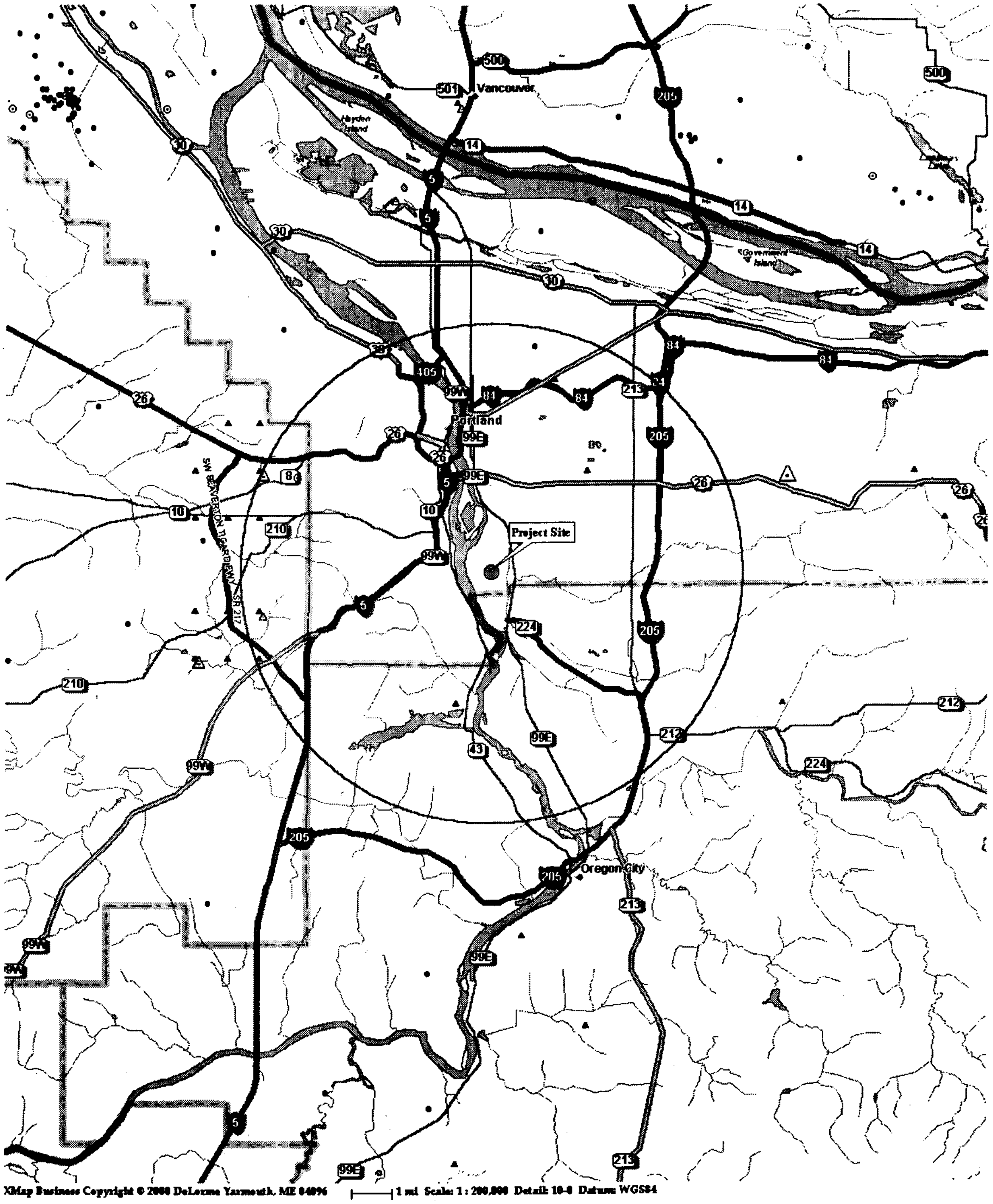
Figure 1
Vicinity Map



Magnitude	Intensity
0.0 – 2.0	1-4
3.0 – 3.9	5
4.0 – 4.9	6
5.0 – 5.9	
6.0 – 6.9	

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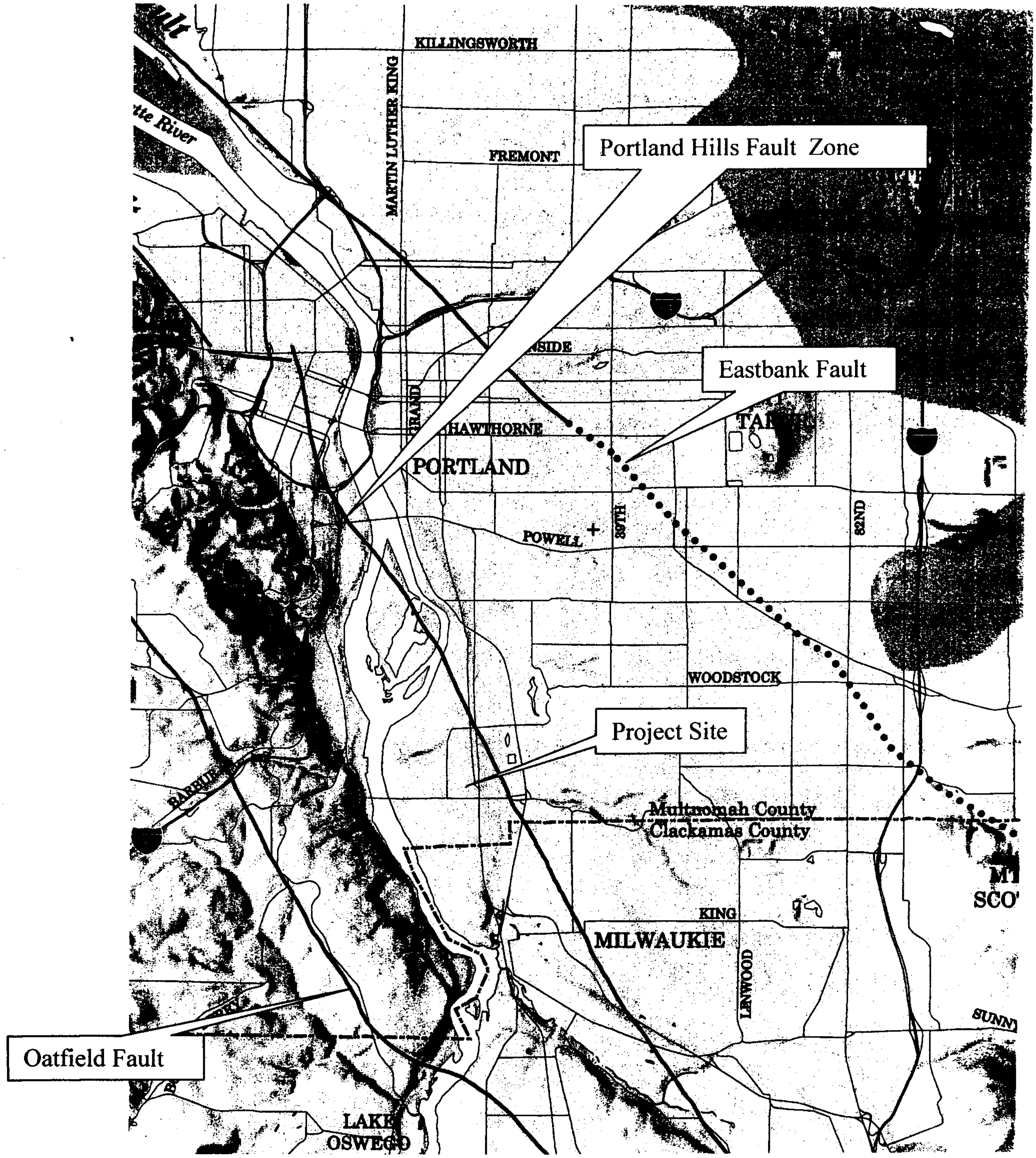
Fig. 2
Epicenter Map



Base Map: DOGAMI IMS –16 (Wong, 2000)

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Figure 3
Fault Map