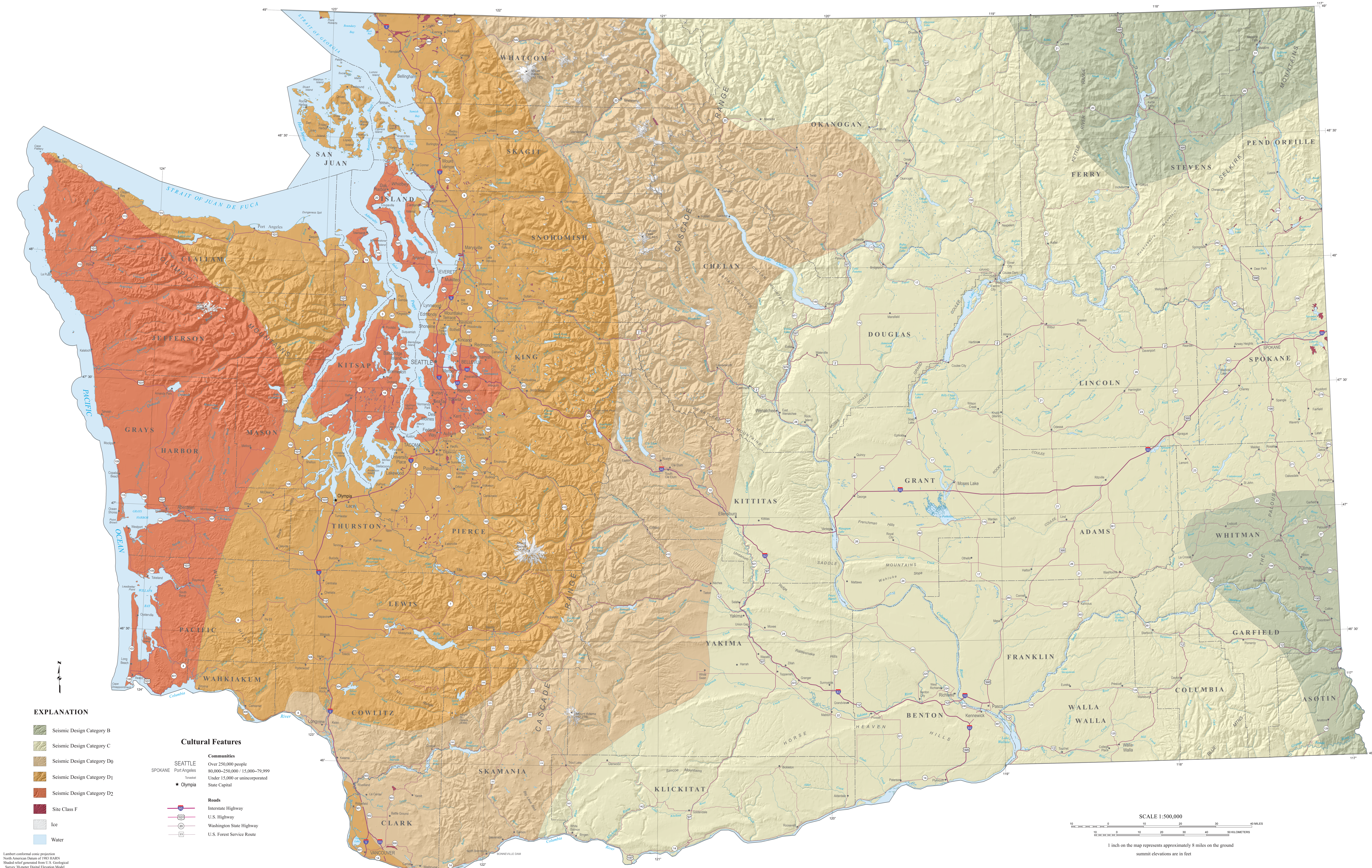
WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands
Division of Geology and Earth Resources
Ron Teissere - State Geologist

Seismic Design Category Maps for Residential Construction in Washington

by Recep Cakir and Timothy J. Walsh

November 2007



Lambert conformal conic projection
North American Datum of 1983 HARN
Shaded relief generated from U.S. Geological Survey 30-meter Digital Elevation Model
Vertical exaggeration 2x
Digital cartography by Anne C. Heinitz, Rebecca A. Niggemann and Elizabeth E. Thompson

Sheet 1—Site Class D Assumed Statewide

SCALE 1:500,000

1 inch on the map represents approximately 8 miles on the ground

summit elevations are in feet

The 2003 International Residential Code (2003 IRC) (International Code Council, 2003) was adopted in 2004 by the Washington State Legislature as the official state building code for detached one- and two-family dwellings and townhouses not more than three stories in height with separate means of egress. Poelstra and Palmer (2004) prepared seismic design category maps, based on the 1996 National Seismic Hazard Maps (Frankel and others, 1996) for residential construction in Washington, to assist local building officials, property owners, and developers. However, the recently published 2006 IRC (International Code Council, 2006b), adopted for use in Washington beginning on July 1, 2007, requires changes in seismic design categories (see Table 2). In the 2006 IRC, compared to the 2003 IRC, the former category D_1 is subdivided into categories D_0 and D_1 (see Table 2), as defined in Section R301.2.2, specifically in Table R301.2.2.1.1, of the 2006 IRC. Accordingly, we have prepared two new seismic design category maps for Washington State, incorporating this category change and using updated spectral acceleration values provided by the U.S. Geological Survey (USGS).

A generalized map of seismic design categories for the conterminous United States is shown in Figure R301.2(2) of the 2006 IRC. This map was prepared based on default site class D, as defined in Table 1613.5.2 of the 2006 International Building Code (2006 IBC) (International Code Council, 2006a), and on calculated short-period design spectral response acceleration values, S_{DS}, as defined in Section 1613.5.3 and 1613.5.4 (2006 IBC). We provide two new seismic design category maps for Washington: Sheet 1, which is equivalent to the map given in Figure R301.2(2) of the 2006 IRC in that it assumes site class D for the entire state (see shaded row in Table 1); and Sheet 2, for which we used the site class map of Washington State (Palmer and others, 2004) to identify specific site classes across the state.

In the creation of our seismic design category maps, we calculated S_{DS} values at 5 percent critical damping, using as inputs the 2003 revision of the U.S. Geological Survey's 2002 short-period (0.2 sec.) accelerations (S_S) having a 2 percent probability of exceedance in 50 years (Frankel and others, 2002; Nicolas Luco, USGS, written commun., 2007), which represent the maximum considered earthquake (MCE) of standard ASCE/SEI 7-05 (American Society of Civil Engineers, 2006). These 0.05 decimal-degree gridded S_S values can be downloaded in ASCII format from the USGS National Seismic Hazard Maps (NSHM) website at http://earthquake.usgs.gov/research/hazmaps/products_data/48_States/index.php.

The methodology described in the 2006 IBC and 2006 IRC and used to generate Sheets 1 and 2 can be summarized as follows. (Scripts and further documentation relevant to the process steps are provided as an attachment to this publication.) The maximum considered earthquake (MCE) spectral response acceleration for short periods (S_{MS}) is determined using the following equation:

$$S_{MS} = F_a S_S$$

where S_S is the mapped spectral acceleration for short periods (0.2 sec.), as described above and shown in Figure 1613.5(1) of the 2006 IBC, and F_a is the site coefficient defined in Table 1613.5.3(1) of the 2006 IBC (included below as Table 1). For Sheet 2, where we used the site class map for Washington State (Palmer and others, 2004) to determine site class, we converted mixed classifications on the site class map to single-letter representations by conservatively assigning the site class representing lower-bound shear-wave velocities, such as converting 'B-C' to 'C', 'C-D' to 'D', and 'D-E' to 'E'.

Table 1. Values of site coefficient F_a as a function of site class and mapped spectral response acceleration at short periods (S_S) (from Table 1613.5.3(1) of the 2006 IBC).

	Mapped spectral response acceleration at short periods				
Site class	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	*	*	*	*	*

* Site-specific ground motion procedures are required and values shall be determined in accordance with Section 11.4.7 of standard ASCE/SEI 7-05 (American Society of Civil Engineers, 2006).

The 5 percent damped design spectral response acceleration (S_{DS}) at short periods, according to section 1613.5.4 of the 2006 IBC, is determined from the following equation:

$$S_{DS} = \frac{2}{3} S_{MS}$$

Finally, seismic design categories can be determined based on calculated S_{DS} values in accordance with Table R301.2.2.1.1 of the 2006 IRC (given as Table 2 below).

Table 2. Seismic design category determination (from Table R301.2.2.1.1 of the 2006 IRC).

Seismic Design Category	Calculated S_{DS} (g)
A	$S_{DS} \le 0.17$
B	$0.17 < S_{DS} \le 0.33$
C	$0.33 < S_{DS} \le 0.50$
D_0	$0.50 < S_{DS} \le 0.67$
D_1	$0.67 < S_{DS} \le 0.83$
D_2	$0.83 < S_{DS} \le 1.17$
E	$S_{DS} > 1.17$

Disclaimer

The maps presented in Sheets 1 and 2 are not a substitute for site-specific investigation to assess the actual ground conditions and potential for amplified ground shaking, as measured by the site class or other more quantitative analyses. These products are provided 'as is' without warranty of any kind, either expressed or implied, including, but not limited to, the implied warranties of merchantability and fitness for a particular use. The Washington State Department of Natural Resources and the authors of these products will not be liable to the user of these products for any activity involving the products with respect to the following: (a) lost profits, lost savings, or any other consequential damages; (b) the fitness of the product for a particular purpose; or (c) use of the products or results obtained from the use of the products.

Acknowledgments

The authors thank Art Frankel, Kenneth S. Rukstales, and Nicolas Luco of the U.S. Geological Survey for sharing their views about the early version of Sheet 2. We also thank Karen Meyers for editing the text, and Chuck Caruthers, Liz Thompson, and Anne Heinitz for their GIS technical support and cartographic work.

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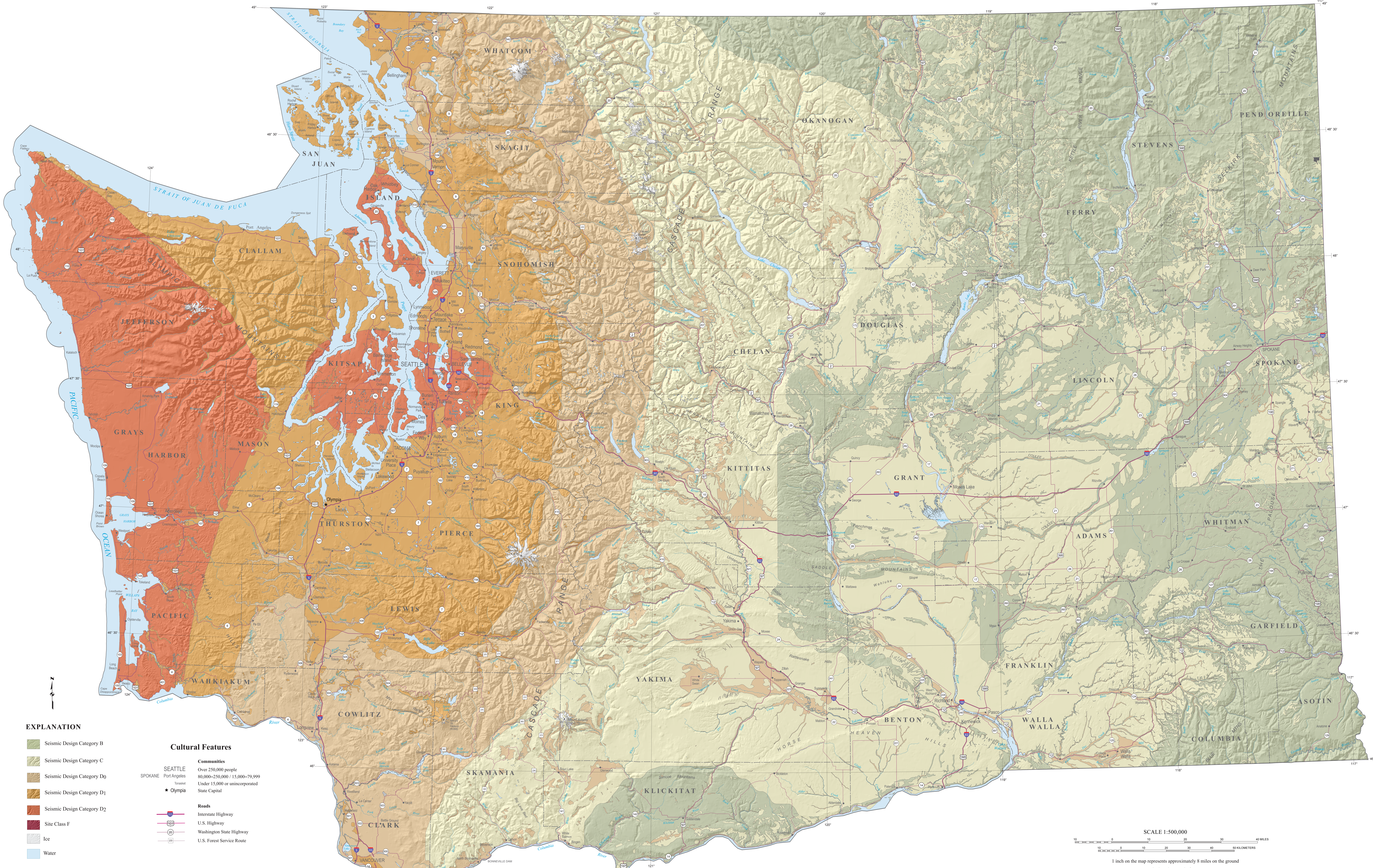

EXPLANATION

- Seismic Design Category B
- Seismic Design Category C
- Seismic Design Category D_0
- Seismic Design Category D_1
- Seismic Design Category D_2
- Site Class F
- Ice
- Water

Cultural Features

Communities

SEATTLE	Over 250,000 people
SPOKANE Port Angeles	80,000–250,000 / 15,000–79,999
Tonasket	Under 15,000 or unincorporated
★ Olympia	State Capital

Roads

90	Interstate Highway
101	U.S. Highway
20	Washington State Highway
23	U.S. Forest Service Route

Lambert conformal conic projection
North American Datum of 1983 HARN
Shaded relief generated from U.S. Geological Survey 30-meter Digital Elevation Model
Vertical exaggeration 2x
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SCALE 1:500,000

10 0 10 20 30 40 MILES

10 0 10 20 30 40 50 KILOMETERS

1 inch on the map represents approximately 8 miles on the ground

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Sheet 2—Seismic Design Categories Based on Statewide Site Class Maps

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