EARTHQUAKE SCENARIO AND PROBABILISTIC GROUND SHAKING MAPS FOR THE SALT LAKE CITY, UTAH, METROPOLITAN AREA

FINAL TECHNICAL REPORT
PROGRAM ELEMENT II EVALUATE URBAN HAZARD AND RISK

By

Ivan Wong[1], Walter Silva[2], Susan Olig[1], Patricia Thomas[1], Douglas Wright[1], Francis Ashland[3], Nick Gregor[2], James Pechmann[4], Mark Dober[1], Gary Christenson[3], and Robyn Schapiro[1]

26 October 2001

[1] Seismic Hazards Group, URS Corporation, 500 12th Street, Suite 200, Oakland, CA 94607
[2] Pacific Engineering & Analysis, 311 Pomona Avenue, El Cerrito, CA 94530
[3] Utah Geological Survey, 1594 W. North Temple, Salt Lake City, UT 84116
[4] Seismograph Stations, University of Utah, Salt Lake City, UT 84112

This research was supported by the U. S. Geological Survey (USGS), Department of the Interior, under USGS award number 98HQGR1038. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied of the U.S. Government.

ABSTRACT

The Salt Lake City metropolitan area is one of the most seismically hazardous urban areas in the interior of the western U.S. because of its location within the Intermountain Seismic Belt and its position adjacent to the active Wasatch fault. The elapsed time since the last large earthquake on the Salt Lake City segment of the Wasatch fault is approaching the mean recurrence interval based on the short-term paleoseismic record. In order to help raise the awareness of the general public and to help reduce earthquake risk in this area, we have developed nine microzonation maps showing surficial ground-shaking hazard. The maps are GIS-based and incorporate the site response effects of the unconsolidated sediments that underlie most of the metropolitan area within Salt Lake Valley. These nine maps, at a scale of 1:75,000, make up three sets, each consisting of three maps that display color-contoured ground motions in terms of (1) peak horizontal acceleration, (2) horizontal spectral acceleration at a period of 0.2 sec (5 Hz) and, (3) horizontal spectral acceleration at a period of 1.0 sec (1 Hz). One set of maps consists of deterministic or "scenario" maps for a moment magnitude (**M**) 7.0 earthquake on the Salt Lake City segment of the Wasatch fault. The two other sets are probabilistic maps for the two return periods of building code relevance, 500 and 2,500 years.

In the probabilistic seismic hazard analysis, a total of 35 faults were characterized in terms of their probability of activity, geometry, rupture behavior (including segmentation), maximum earthquake magnitude, recurrence model, and recurrence rates. Large variations in fault slip rates or recurrence intervals were incorporated into the input wherever appropriate using a variety of approaches, including time-dependent analyses. Background earthquakes (**M** $\leq$ 6½) were also included in the hazard analysis through the use of an areal source zone and Gaussian smoothing of the historical seismicity.

For both the scenario earthquake and the probabilistic analysis, ground motions on rock were calculated using a combination of state-of-the-art empirical attenuation relationships, which were generally applicable to extensional tectonic regimes, and a stochastic numerical modeling approach. Because of Salt Lake City's location in a sedimentary basin, site response effects on ground motions can be significant. To include these effects, five generalized site response units were defined from lithologic characteristics and shear-wave velocities. Based on a suite of *in situ* shear-wave profiles and dynamic material properties for each unit, amplification factors were calculated as a function of input rock motion and thickness of each site response unit. These amplification factors, some of which are less than 1.0 (signifying deamplification), were multiplied by the input rock motions to arrive at the surficial ground motions.

The resulting hazard maps dramatically show the frequency-dependent amplification of unconsolidated sediments in the Salt Lake Valley. The pattern of both amplification and deamplification in the map area is clearly a function of the distribution and thickness of the surficial geologic units. Hanging wall effects are also evident on the hazard maps but are masked to a large extent by the site effects. Peak horizontal accelerations for the scenario earthquake

range up to and exceed 1.0 g. For the 500- and 2,500-year return period maps, the maximum peak accelerations are 0.5 and 1.1 g, respectively.

These maps are not intended to be a substitute for site-specific studies for engineering design nor to replace standard maps commonly referenced in building codes. Rather, we hope that these maps will be used as a guide by government agencies, the engineering, urban planning, and emergency preparedness and response communities, and the general public as part of an overall program to reduce earthquake risk and losses in Utah.