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August 19, 2014

**Revised Report of Probabilistic Seismic Hazard Analysis  
Main Athens Campus  
The University of Georgia  
Athens-Clarke County, Georgia  
Geo-Hydro Project Number 140288.00**

Dear Ms. Darden:

Geo-Hydro Engineers, Inc. has completed the authorized probabilistic seismic hazard analysis (PSHA) for the main campus of The University of Georgia in Athens-Clarke County. The scope of services for PSHA was outlined in our proposal number 16820.2 dated May 15, 2014. The main purpose of this analysis is to provide seismic hazard parameters that the University can provide to structural engineers for projects that will be designed under the International Building Code (IBC), 2012 Edition, with the 2014 Georgia Amendments. Please note that it is possible that future amendments to the 2012 IBC may require reevaluation of the parameters we present below. In our opinion, this analysis is valid for sites in the area outlined in red on the *UGA Area I - Main Campus* and *UGA Area II – South Milledge Precinct* Maps attached to this report.

**Site-Specific Probabilistic Seismic Hazard Analysis (PSHA)**

The following table presents seismic design values interpolated from applicable seismic hazard maps from the building code as well as values determined by the probabilistic seismic hazard analysis performed for this report.

Parameter	2012 IBC with GA Amendments	Probabilistic Hazard Analysis
$S_s$ (g)	0.210	0.193
$S_1$ (g)	0.094	0.080

The methodology for the PSHA is outlined in the following sections.

**Seismic Hazard Analysis Methodology**

**International Building Code 2012**

The International Code Council (ICC) is a collaboration of the three major model code groups in the United States. The ICC formed specifically for the purpose of developing a model code to be used throughout the country. The first edition of the IBC 2000 was published in March, 2000. The seismic provisions of IBC 2012 are based on the 2009 NEHRP *Recommended Provisions*.

The spectral response acceleration for the maximum considered earthquake ground motion is determined for short periods ( $S_S$ , typically calculated at 0.2 seconds) and at 1 second, ( $S_1$ ).  $S_S$  and  $S_1$  are interpolated from contour maps, or are calculated by a site specific hazard analysis. The  $S_S$  and  $S_1$  values are based on a risk-targeted maximum considered earthquake ( $MCE_R$ ) having a 1 percent in 50 years collapse risk target.

### Development of Seismic Hazard Maps

Contour maps of  $S_S$  and  $S_1$  used in the IBC 2012 and the 2009 NEHRP *Recommended Provisions* were developed with the goal of having the probability of exceeding the design ground motion be roughly the same for all parts of the country. These maps are consensus documents conceived with the notion that “judgment, engineering experience, and political wisdom are as necessary as science” (1994 NEHRP *Commentary*, Page 277).

The contour maps of  $S_S$  and  $S_1$  for the 2009 NEHRP *Recommended Provisions* were developed by the Building Seismic Safety Council (BSSC) based on National Seismic Hazard Maps developed by the U.S. Geological Survey (USGS). The USGS maps are intended to define the probabilistically calculated maximum considered earthquake ground motion based on a methodology developed by Frankel (1996). This methodology includes different models of seismic hazard combined with large background zones used to quantify hazard in areas with little or no historic seismic activity. The source catalog used for this mapping effort consisted of “merged catalogs from several different sources, and . . . fairly subjective criteria.” Similar to the mapping effort for the 1994 *Recommended Provisions*, modifications to the USGS maps were made using the engineering judgment of the Seismic Design Procedure Group (SDPG), a committee appointed by BSSC to produce the 2009 NEHRP maps of  $S_S$  and  $S_1$ .

### Site Specific Hazard Analysis

We performed a probabilistic seismic hazard analysis generally following a methodology described by Kramer (1996). This methodology first involves identification and characterization of earthquake sources and their recurrence characteristics. For this analysis, we used a catalog of seismic sources similar to the one used to produce the 2008 National Seismic Hazard Maps developed by the U.S. Geological Survey (USGS).

Attenuation equations are predictive relationships used to determine the probability of a particular ground motion at the site due to a particular earthquake some distance from the site. The ground motions predicted by the attenuation equation for each seismic source are then combined to predict the probable ground motion at the site for a given recurrence period. For this probabilistic hazard analysis, we considered attenuation equations developed by Toro et al. (1997); Campbell (2003); Silva (2002); Somerville (2001); Tavakoli-Pezeshk (2005); and Atkinson and Boore (2006).

### References

- Atkinson, G. M. and D. M. Boore (2006). Earthquake ground-motion prediction equations for eastern North America, *Bull. Seism. Soc. Am.* **96**, 2181--2205.
- Toro, G.R. (1999) Modification of the Toro et Al. (1997) “Attenuation Equations for Large Magnitudes and Short Distances,” Risk Engineering, Inc., website [www.riskeng.com](http://www.riskeng.com), pp. 4-1 to 4-10.

Somerville, P. et al (2001), "Ground Motion Attenuation Relations for the Central and Eastern United States," USGS Reports under award number 99HQGR0098, June 30, 2001, [http://erp-web.er.usgs.gov/reports/abstract/1999/cu/cu\\_abstr.htm](http://erp-web.er.usgs.gov/reports/abstract/1999/cu/cu_abstr.htm).

Campbell, K.W. (2003). "Prediction of Strong Ground Motion Using the Hybrid Empirical Method and Its Use in the Development of Ground-Motion (Attenuation) Relations in Eastern North America." *Bulletin Seismological Society of America*, Vol. 93, No. 3, pp. 1012-1033, June.

Silva, W.J. et al. "Development of Regional Hard Rock Attenuation Relations for Central and Eastern North America," website [www.pacificengineering.org](http://www.pacificengineering.org), January 16, 2002. pp. 1-24.

Behrooz Tavakoli and Shahram Pezeshk "Empirical-Stochastic Ground-Motion Prediction for Eastern North America", *Bulletin of the Seismological Society of America*; December 2005; v. 95; no. 6; p. 2283-2296

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We appreciate the opportunity to serve as your geotechnical consultant for this project, and are prepared to provide any additional services you may require. If you have any questions concerning this report or any of our services, please call us.

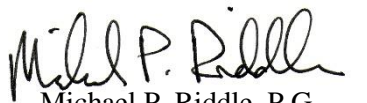
Sincerely,

GEO-HYDRO ENGINEERS, INC.

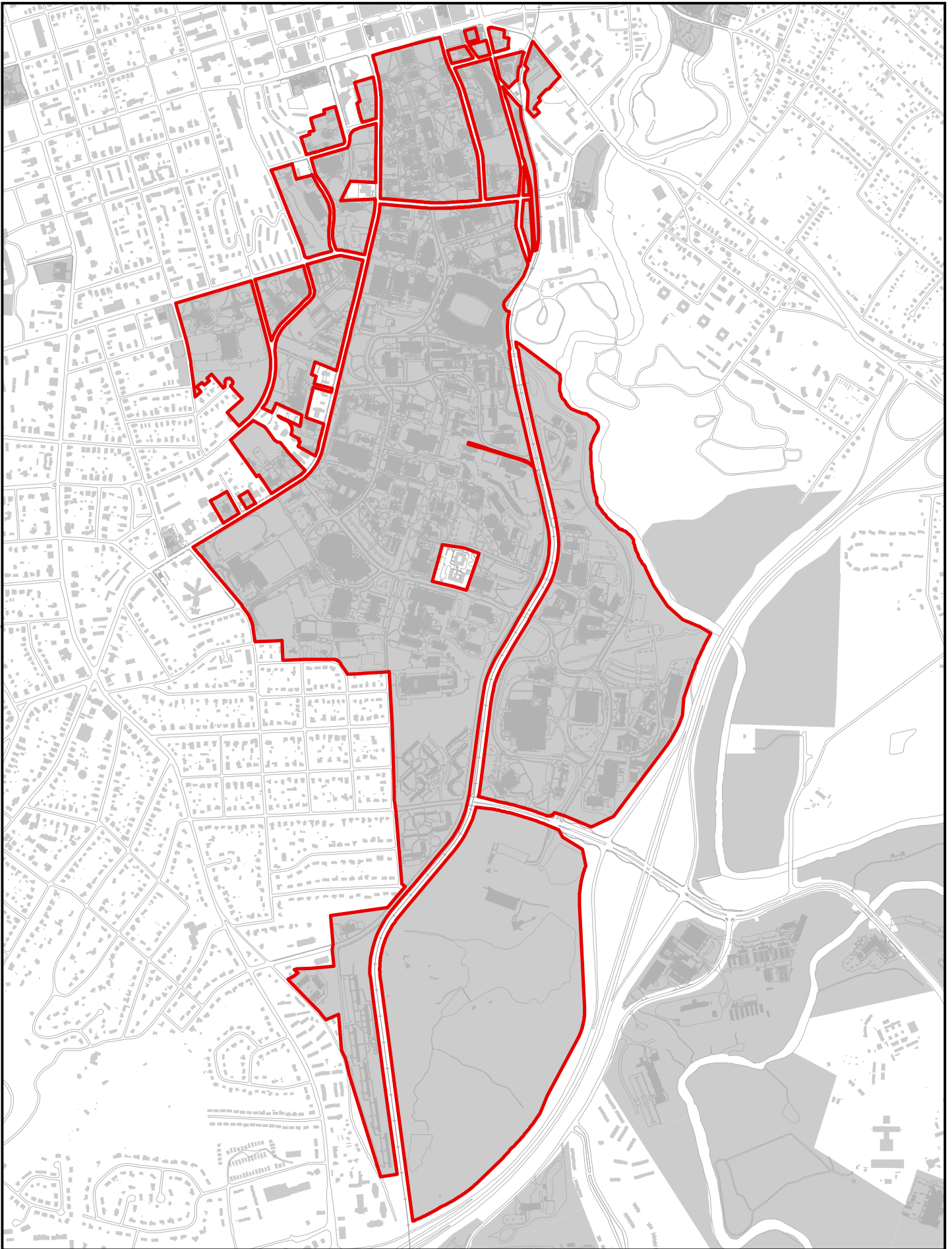
  
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# UGA Area 2 - South Milledge Precinct

July 2014

UNIVERSITY of GEORGIA CAMPUS MAP

