APPENDIX 12
HAZUS-MH Pilot Project Earthquake Assessment

Earthquake

The earthquake hazard was analyzed using the HAZUS-MH software. HAZUS-MH provided data were used for the general building stock and were updated with local inventory data for critical facilities. Population data were taken from HAZUS-MH and are based on the most recent census conducted in 2000 (FEMA 2004a).

For the earthquake hazard, a mixture of local and HAZUS-MH provided data were used to model two MRP events and annualized loss. HAZUS-MH provides a soil type assumption; this soil type was changed for the Louisville Metro risk assessment based on the team's knowledge and a partial soil map provided by the KGS (KGS 2004). The partial soil map data was not sufficient to modify the default landslide and liquefaction assumptions provided by HAZUS-MH. Therefore, the loss estimate for this pilot project assumes no landslide or liquefaction potential; however, available data on areas of potential liquefaction are mapped with infrastructure to identify areas at risk (see Figure 5-7).

> One might expect that the number of persons requiring shelter would be greater than number of displaced households because more than one person lives in each household. However, some individuals from displaced households do not require shelter because they stay

The earthquake model provides loss estimations for general building stock and estimates how much of the infrastructure would be affected by the hazard. The earthquake model also estimates affected population, including displaced households, shelter requirements, and injuries.

The widespread, regional nature of the earthquake hazard means that the entire area population is at risk. Therefore, exposure values for the number of households, general population, and socially vulnerable populations at risk are not provided (but are equal to the total population inventory discussed in Section 4). Estimated social impacts such as displaced households, shelter requirements, and injury were estimated and are summarized in Table 5-1 for the 100- and 500-year MRP events.

Table 5-1. Estimated Social Losses from Earthquake for Louisville Metro Study Area

Social Loss Parameter	100-year MRP Earthquake	500-year MRP Earthquake
Expected Displaced Households	-	250 to 300 households
Expected Persons Requiring Shelter	-	50 to 100 persons
Expected Minor Injuries	-	500 to 600 persons
Expected Major Injuries	-	50 to 100 persons

Note: Figures rounded to the nearest hundred. Major injuries are those that require hospitalization.
– indicates negligible (less than 1 person impacted).

Figures 5-1 through 5-3 show the extent of softer soils provided by the Kentucky Geological Survey (KGS) in relation to population density, elderly population density, and low-income population density, respectively. Because soil data were available for only part of the study area, these figures show the portion of the study area for which soil data were available (see upper left hand corner of each figure for the portion of the study area represented in the larger figure).

Figure 5-1. Distribution of General Population Density in Relation to the Earthquake Hazard

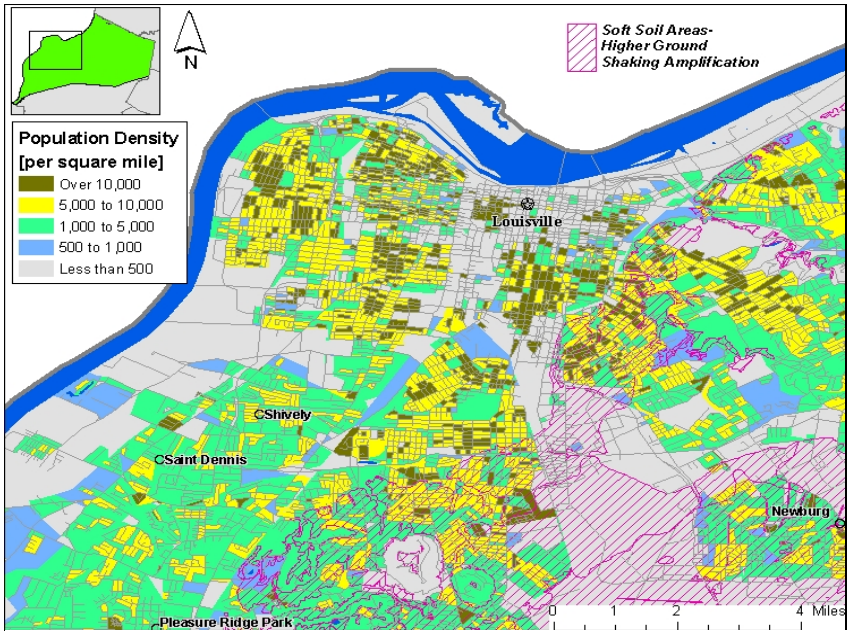


Figure 5-2. Distribution of Elderly Population Density in Relation to the Earthquake Hazard

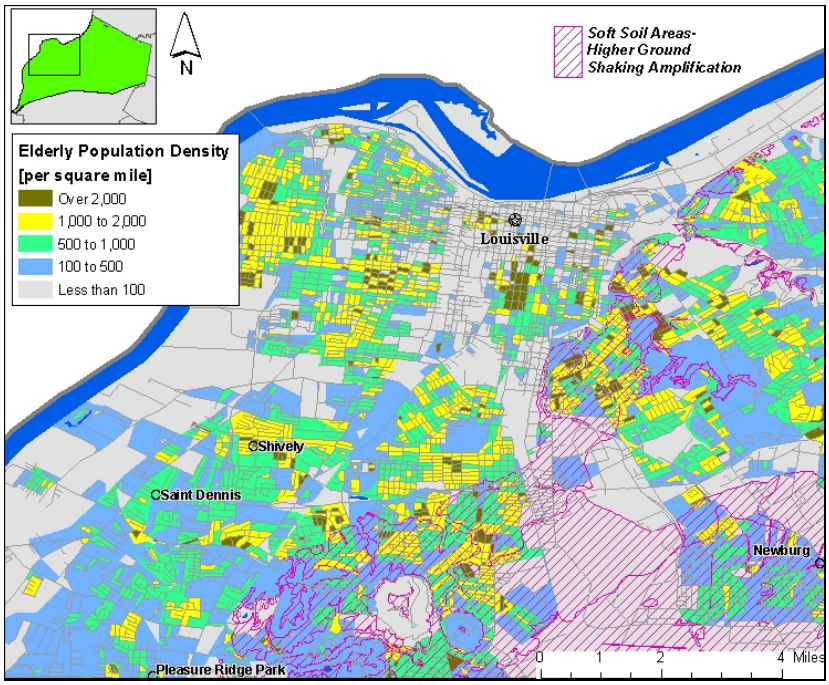
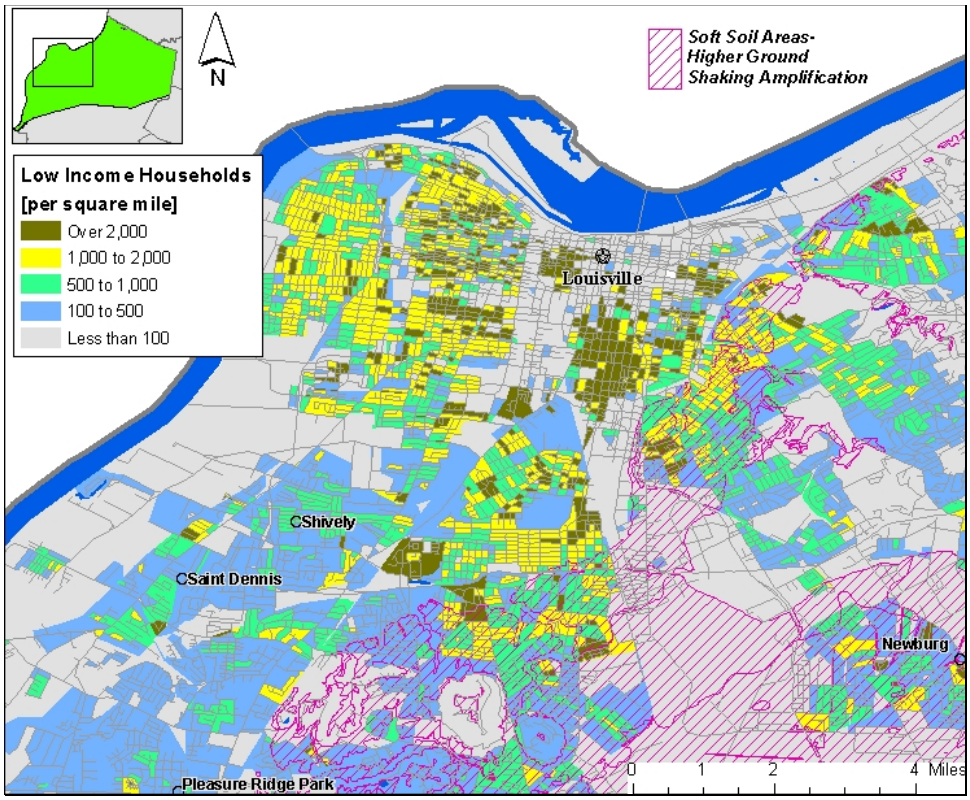


Figure 5-3. Distribution of Low-Income Population Density in Relation to the Earthquake Hazard



Estimated property damage and loss ratios are summarized in Table 5-2 for the 100- and 500-year MRP events. Damage estimates reflect the aggregated estimated loss based on impacts likely to occur to individual buildings.

The total estimated loss for an earthquake with a severity equal to a 500-year MRP is approximately $161.2 million. Commercial and residential buildings account for about 77 and 23 percent of the total losses for this event, respectively. The overall distribution of building value for the area is 82 percent residential and 18 percent commercial. For the earthquake hazard, the economic loss ratio for structures is higher than that for building content.

Notes: M indicates millions. Dollars rounded to the nearest hundred thousand.
- indicates negligible damages or loss (less $1,000). N/A indicates not applicable.

"Annualized loss" estimates consider all potential future hazard events to estimate the average annual loss that can be expected based on the individual events that may occur over time. The total estimated average annualized loss associated with the earthquake hazard is $1.5 million. The average annualized losses by occupancy class associated with the earthquake hazard are presented below.

Total average annualized losses of approximately $1.2 million for the residential occupancy class, or an annualized loss ratio of 0.003

Annualized loss is the estimated long-term value of losses to the general building stock averaged on an annual basis for a specific hazard type. Annualized loss considers all future losses for a specific hazard type resulting from possible hazard events with different magnitudes and return periods, averaged on a "per year" basis. Like other loss estimates, annualized loss is an

percent, including:

- $973,000 for residential structures, or an annualized loss ratio of 0.002 percent
- $176,000 for content loss for residential buildings, or an annualized loss ratio of less than 0.001percent

Table 5-2. Estimated Damages/Losses to General Building Stock from Earthquake

Occupancy Class	100-year MRP Earthquake		500-year MRP Earthquake	
	Estimated Damages	Economic Loss Ratio	Estimated Damages	Economic Loss Ratio
Residential Building Structure	-	N/A	$108.6 M	0.26%
Residential Building Content	-	N/A	$15.6 M	0.08%
Residential Building Total	-	N/A	$124.2 M	0.20%
Commercial Building Structure	-	N/A	$29.7 M	0.44%
Commercial Building Content	-	N/A	$7.3 M	0.10%
Commercial Building Total	-	N/A	$37.0 M	0.27%
Total for All Buildings	-	N/A	$161.2 M	0.21%

- Total average annualized losses of $329,000 for the commercial occupancy class or, an annualized loss ratio of 0.002 percent, including:
    - $259,000 for commercial structures, or an annualized loss ratio of 0.004 percent
    - $70,000 for content loss for commercial occupancy class, or an annualized loss ratio of less than 0.001 percent

Figures 5-4 and 5-5 show the dollar loss density for the earthquake hazard for the residential and commercial occupancy classes for 500-year MRP event. The dollar loss density indicates the loss in dollars per square mile of land.

Figure 5-4. Residential Dollar Loss Density for 500-Year MRP Earthquake Event

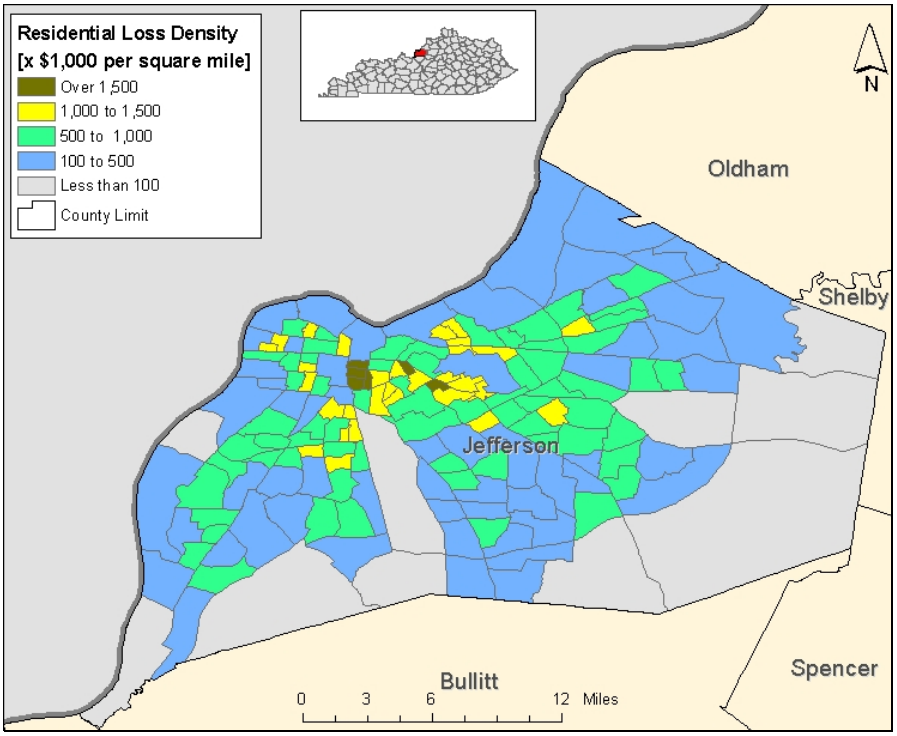
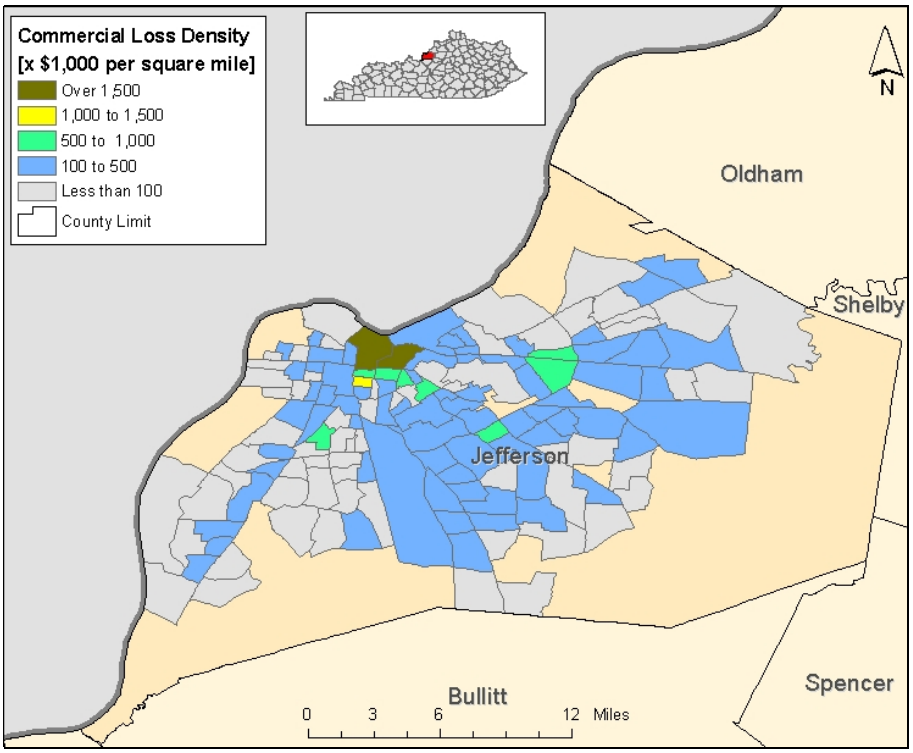


Figure 5-5. Commercial Dollar Loss Density for 500-Year Earthquake Event



Detailed descriptions of damage terms are described in the HAZUS-MH earthquake user's manual.

Critical facilities also were evaluated in terms of the probability of various levels of impact, including the following: no damage, slight damage, moderate damage, extensive damage, or complete damage. For the 100-year MRP earthquake event, there is less than a 0.2 percent probability that damage categorized from slight to complete would occur. For the 500-year MRP earthquake event, there is greater than a 4 percent probability that damage categorized as minor to complete would occur. However, the probability that extensive or complete damage would occur remains low for this event (less than a 0.3 percent probability).

Local soil data was available for about one-third of the study area. This soil data was used to modify the HAZUS-MH provided soil assumption from type D (stiff soil) to type C (moderate soil). Figure 5-6 shows the areas of softer soil in relation to essential facilities in the Louisville Metro study area (for the portion of the study area for which that data was provided).

PBS&J did not consider available liquefaction data sufficient to change the liquefaction assumption in HAZUS-MH. Therefore, no liquefaction was assumed for the earthquake analysis in this pilot project. However, available areas of liquefaction susceptibility were overlain with infrastructure to illustrate the vulnerability of infrastructure to liquefaction susceptibility (see Figures 5-7 and 5-8). Transportation and utility lifeline systems are overlain with liquefaction susceptibility maps, rather than soft soil maps, because major damage for these systems typically is related to liquefaction.

Figure 5-6. Distribution of Essential Facilities in Relation to the Earthquake Hazard

Note: The portion of the study region for which refined soil mapping data was obtained is shown in the upper left hand corner. That portion of the study region is then shown in the figure.

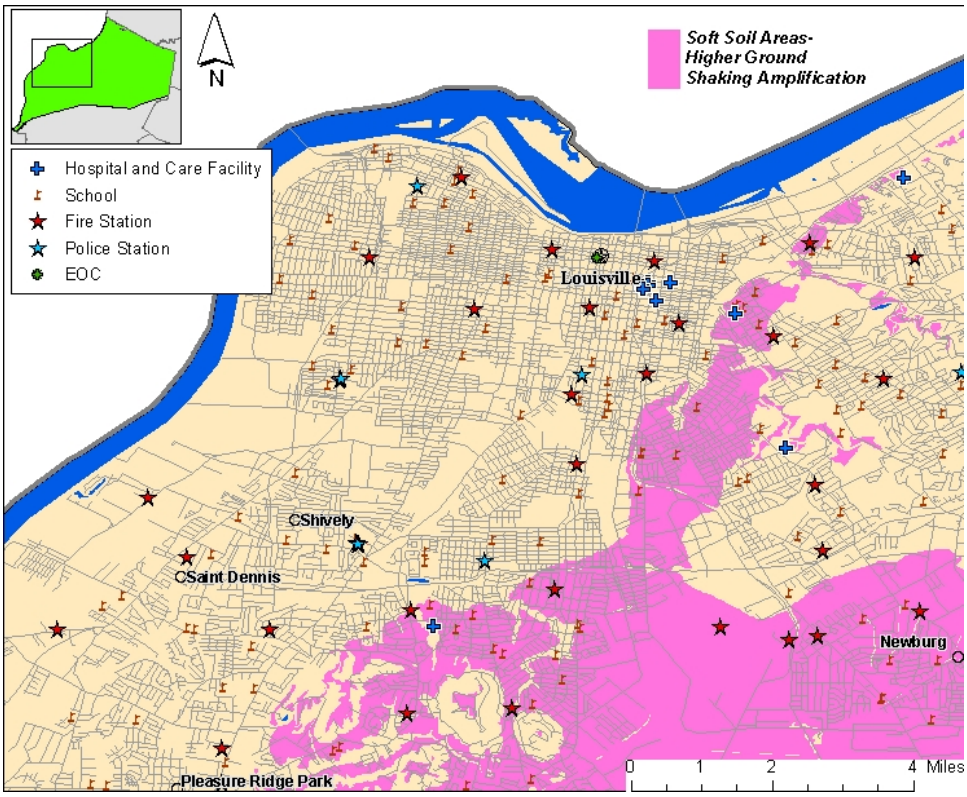


Figure 5-7. Distribution of Transportation Lifeline Systems in Relation to the Earthquake Hazard Based on Soil Liquefaction Potential

Note: The portion of the study region for which refined soil mapping data was obtained is shown in the upper left hand corner. That portion of the study region is then shown in the figure.

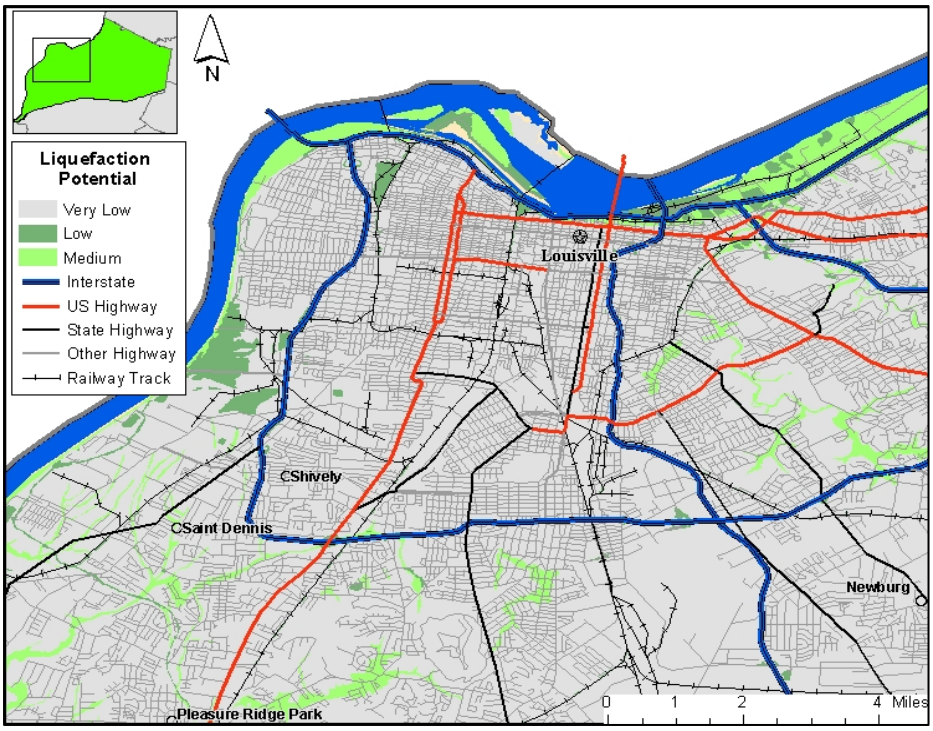
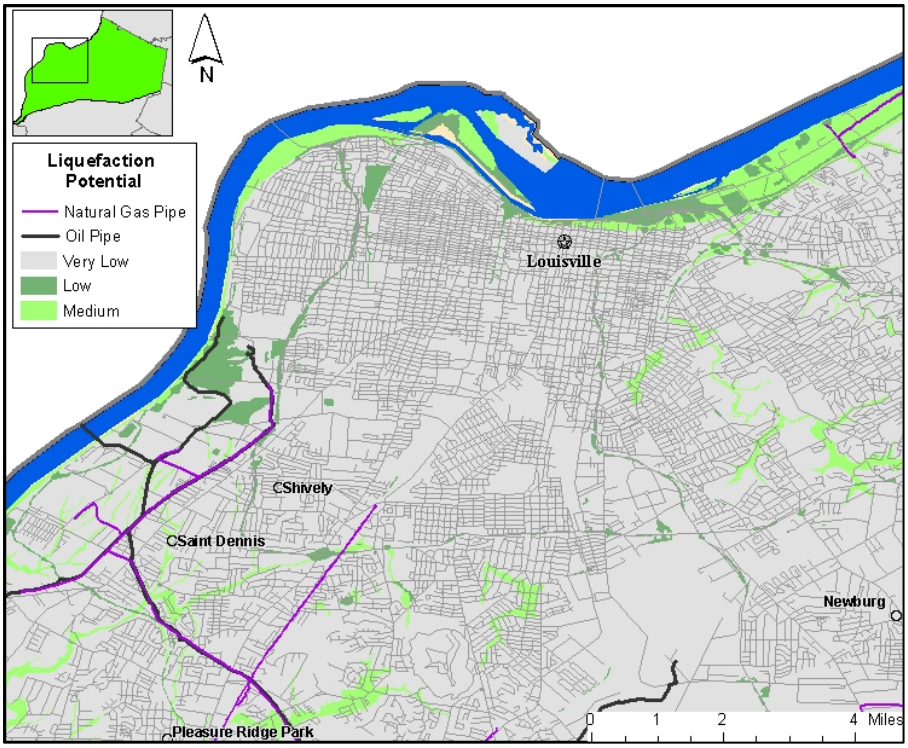


Figure 5-8. Distribution of Utility Lifeline Systems in Relation to the Earthquake Hazard Based on Soil Liquefaction Potential



As additional local hazard data (for example, soil and liquefaction data for the entire study area) become available through ongoing KGS and other efforts, earthquake hazard assumptions and data can be refined for future risk assessment estimates. The analysis conducted in this pilot project provides a foundation for such efforts. Although liquefaction is not assumed for this analysis, its impact would be negligible given the level of shaking expected for the study area. At least moderate shaking is required in order to trigger liquefaction and this level of shaking is highly unlikely based on available USGS data.