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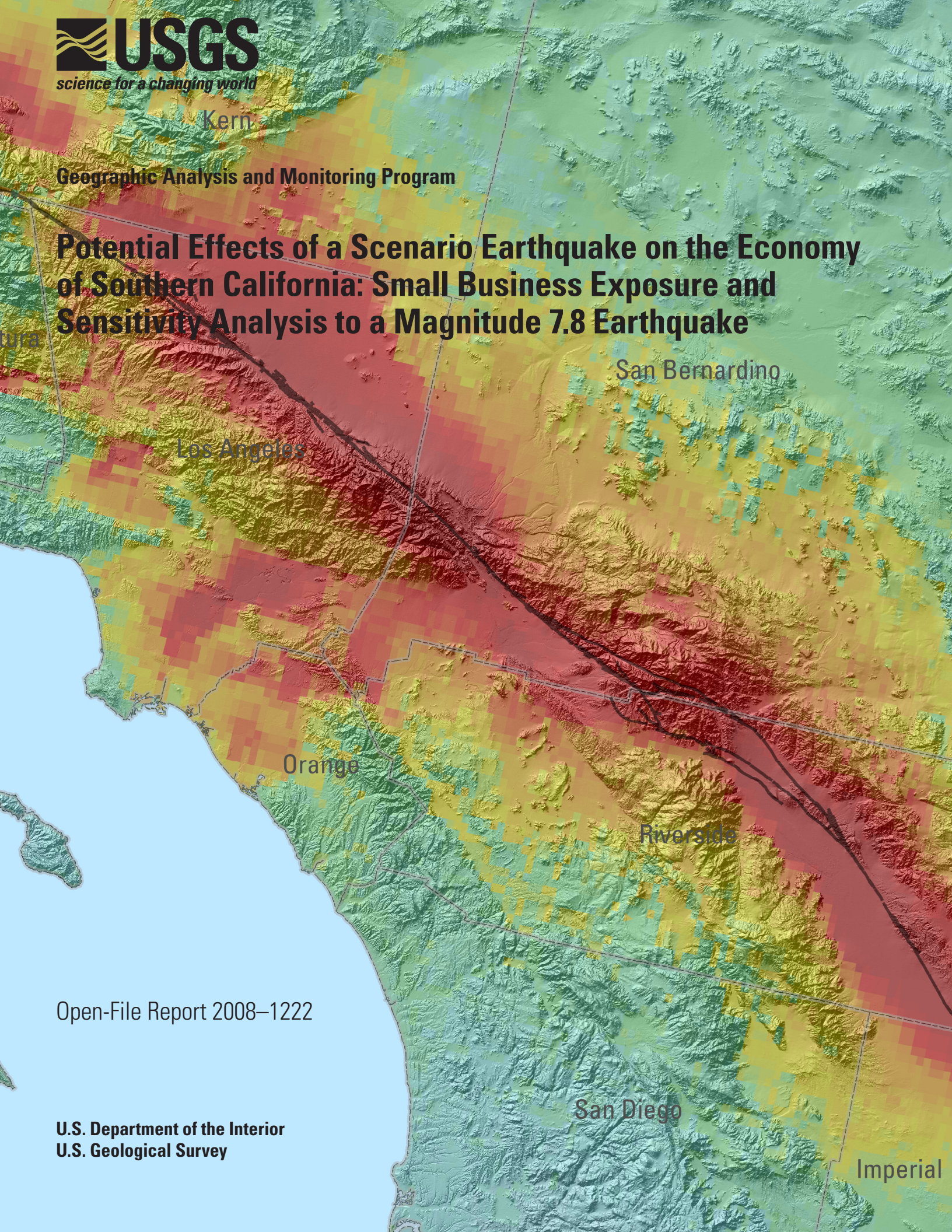
Potential Effects of a Scenario Earthquake on the Economy of Southern California: Small Business Exposure and Sensitivity Analysis to a Magnitude 7.8 Earthquake



Open-File Report 2008–1222

U.S. Department of the Interior
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FRONT COVER—Instrumental Intensity for the simulated magnitude 7.8 ShakeOut Scenario earthquake overlaying a shaded-relief terrain map for a portion of the eight-county Southern California regional study area. Lowest intensities are in blue while highest intensities are in red. A portion of the San Andreas Fault is symbolized in black. California county boundaries are illustrated using a dashed-line symbology and county names are annotated in gray.

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By Benson C. Sherrouse, David J. Hester, and Anne M. Wein

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Contents

Introduction....1
Small Business Definition....1
Data Sources....1
Data Suppression....3
ZIP Code Reconciliation....3
Methodology....4
Estimates of Small Business Exposure and Sensitivity....4
Discussion....10
References....10
Appendix. Modified Mercalli Intensity (MMI) Scale Descriptions....11

Figures

1. The ShakeMap of a M7.8 scenario earthquake in Southern California, along with the ZIP code boundaries for mapping labor market data. 2
2. The spatial distribution of establishments with less than 20 employees.. 7
3. The estimated intensity distribution of establishments with less than 20 employees. 7
4. The spatial distribution of employees at establishments with less than 20 employees. ..8
5. The estimated intensity distribution of small business employees. 8
6. The spatial distribution of quarterly payroll for establishments with less than 20 employees....9
7. The estimated intensity distribution of small business quarterly payroll. 9

Tables

1. A summary of the effects of data suppression on labor market statistics disaggregated by establishment size. 3
2. A summary of data disaggregated by establishment size that could not be matched to Southern California ZIP codes. 3
3. A summary of affected business establishments by number of employees based on the intensity anticipated from the scenario earthquake. 5
4. A summary of the affected number of employees by establishment size based on the intensity anticipated from the scenario earthquake. 5
5. A summary of payroll affected by establishment size based on the intensity anticipated from the scenario earthquake.. 6

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Introduction

The Multi-Hazards Demonstration Project (MHDP) is a collaboration between the U.S. Geological Survey (USGS) and various partners from the public and private sectors and academia, meant to improve Southern California's resiliency to natural hazards (Jones and others, 2007). In support of the MHDP objectives, the ShakeOut Scenario was developed. It describes a magnitude 7.8 (M7.8) earthquake along the southernmost 300 kilometers (200 miles) of the San Andreas Fault, identified by geoscientists as a plausible event that will cause moderate to strong shaking over much of the eight-county (Imperial, Kern, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura) Southern California region (Jones and others, 2008). This report contains an exposure and sensitivity analysis of small businesses in terms of labor and employment statistics. Exposure is measured as the absolute counts of labor market variables anticipated to experience each level of Instrumental Intensity (a proxy measure of damage). Sensitivity is the percentage of the exposure of each business establishment size category to each Instrumental Intensity level. The analysis concerns the direct effect of the earthquake on small businesses.

The analysis is inspired by the Bureau of Labor Statistics (BLS) report (Holden and others, 2007) that analyzed the labor market losses (exposure) of a M6.9 earthquake on the Hayward fault by overlaying geocoded labor market data on Instrumental Intensity values. The method used here is influenced by the ZIP-code-level data provided by the California Employment Development Department (CA EDD), which requires the assignment of Instrumental Intensities to ZIP codes. The ZIP-code-level labor market data (State of California, 2006) includes the number of business establishments, employees, and quarterly payroll categorized by business establishment size.

Small Business Definition

The CA EDD business establishment size data were reported by number of employees. For the purpose of this analysis, it is assumed that small businesses are likely to be disproportionately affected by or less able to recover from the simulated M7.8 earthquake. While this is our operating assumption, it should also be kept in mind that while small businesses may have more limited financial resources, by nature of their size, they may also be capable of greater agility and adaptability in their business recovery operations following a major earthquake.

The threshold value to define a small business can vary depending upon the source and the purpose of the definition. It can be based on the number of employees or the amount revenue and vary by industry, geography, or other factors. Business establishment size standards, as defined by the Small Business Administration (SBA), for employment sectors in the North American Industry Classification System (U.S. Small Business Administration, 2008) were initially considered for this analysis. However, adoption of these standards would have led to such a high proportion of the business establishment data being classified as small, it would have rendered the distinction for the purpose of this analysis nearly meaningless. Instead, a threshold value of less than 20 employees was selected following previous research on the impacts on businesses of the 1994 Northridge Earthquake (Tierney, 1997).

Data Sources

The labor market data were obtained from the CA EDD. The ZIP-code-level statistics from the Quarterly Census of Employment and Wages for the fourth quarter of 2006 were provided (State of California, 2006). Labor market metrics quantified for the end of the quarter included the number of business establishments, number of employees, and the amount of payroll by business establishment size.

The Instrumental Intensity values were taken from a ShakeMap (fig. 1) generated by the U.S. Geological Survey's Earthquake Hazards Program for the ShakeOut Scenario (unpublished). It was obtained in an Environmental Systems Research Institute (ESRI) shapefile format. These data provide spatial and quantitative information regarding the ground motion and shaking intensity of the scenario earthquake. The Instrumental Intensities are derived from empirically modeled ground motions and are an attempt to mimic Community Internet Intensity Maps (CIIM). The CIIM, in turn, are a

means to develop estimates of Modified Mercalli Intensities (MMI) soon following an earthquake event (U.S. Geological Survey, 2006). The MMI scale uses values ranging from I (1) to XII (12) to qualitatively describe earthquake effects. A description of the MMI scale is included in the appendix (Association of Bay Area Governments, 2003). The MMI maps normally take months after such an event to be prepared, and although CIIM cannot be considered identical to MMI, they are meant to provide a useful first approximation of MMI (U.S. Geological Survey, 2006). There are a number of factors—such as infrastructure distribution and resiliency, geologic materials, and ground failure effects—that create differences between CIIM estimates and MMI. Because of these differences among Instrumental Intensities, CIIM, and MMI, the analysis uses the MMI scale values and descriptions to categorize and characterize the relative exposure and sensitivity of the labor market only, not to predict the effects of the earthquake as described by the actual MMI values determined subsequent to the event.

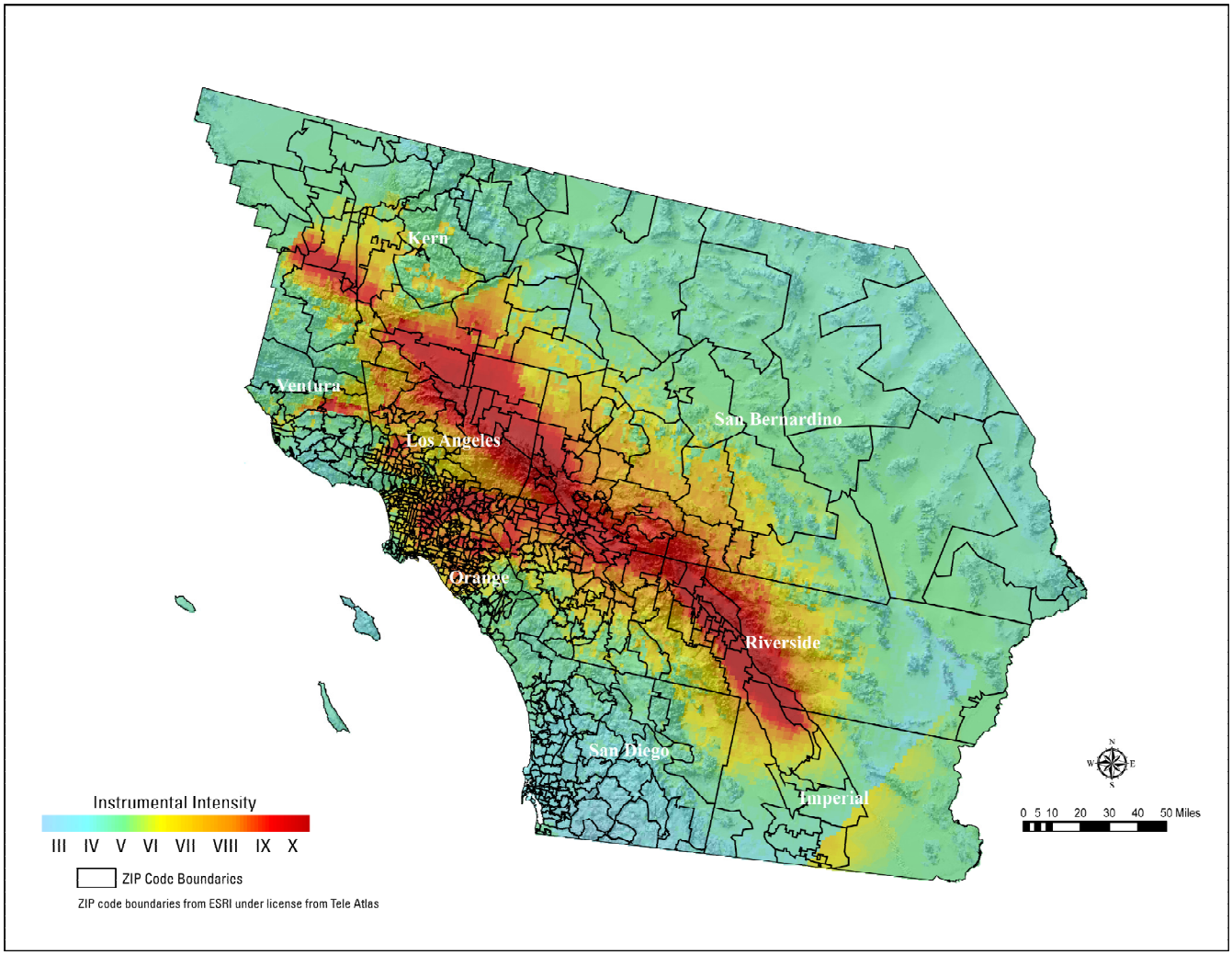

Figure 1. The ShakeMap of a M7.8 scenario earthquake in Southern California, along with the ZIP code boundaries for mapping labor market data.

Data Suppression

For confidentiality purposes, the EDD suppresses employee and quarterly payroll data for ZIP codes with only a few or single establishments of a particular industry. The actual number of establishments, however, is not suppressed in these cases. While this data suppression impacts a large proportion of the total data records, the effect on the number of employees and amount of quarterly payroll excluded from analysis due to the suppression is more limited. While over 50 percent of the region's data records disaggregated by business size were suppressed, this accounted for approximately 14 percent of reported employees and quarterly payroll. The suppression rate for the region and individual counties is summarized below (table 1).

Table 1. A summary of the effects of data suppression on labor market statistics disaggregated by establishment size.

County name	Records		Establishments		Employees[1]		Payroll ($ millions)	
	Total	% Suppressed	Total	% Suppressed	Total	% Suppressed	Total	% Suppressed
Imperial	167	57.5%	6,475	0.0%	55,428	18.3%	$440	18.5%
Kern	613	56.8%	17,484	0.0%	283,525	22.3%	$2,659	22.8%
Los Angeles	5,071	54.3%	399,115	0.0%	4,244,059	14.6%	$55,435	15.1%
Orange	2,459	62.7%	96,258	0.0%	1,534,382	13.7%	$19,795	13.5%
Riverside	1,432	60.1%	43,766	0.0%	636,540	17.5%	$5,874	18.2%
San Bernardino	1,306	60.8%	46,513	0.0%	666,241	15.1%	$6,434	15.8%
San Diego	2,013	59.8%	93,399	0.0%	1,332,134	11.8%	$15,913	10.8%
Ventura	620	65.8%	21,901	0.0%	318,719	17.2%	$3,931	22.4%
TOTAL	**13,681**	**58.5%**	**724,911**	**0.0%**	**9,071,028**	**14.6%**	**$110,481**	**14.9%**

[1]Total at the end of 4th quarter 2006.

ZIP Code Reconciliation

The ZIP code polygon layer used to map the labor market data was obtained from the ESRI Data & Maps DVD (2006). Many of the labor market data records, however, were reported for ZIP codes that do not exist as areas but as points, such as individual buildings and post office boxes. In order to spatially assign the data for these records, it was necessary to reference the ZIP code point layer also included on the DVD.

Records that could not be matched to the ZIP code polygon or point layers resulted from one of two causes. One subset of unmatched records reported data for ZIP codes lying outside the eight-county region. The other unmatched record subset reported data for ZIP codes that could not be identified either within or outside the region. This is likely due to either erroneous ZIP codes being reported to the EDD or possibly to new ZIP codes established after the ZIP code polygon and point layers were created. The effect of these unmatched records on the mapping of the labor market variables are summarized below (table 2).

Table 2. A summary of data disaggregated by establishment size that could not be matched to Southern California ZIP codes.

Industry data	Establishments	Employees[1]	Payroll ($ millions)
Total unsuppressed data	724,911	7,746,511	$94,063
Total unmapped data	214,065	308,277	$2,634
Pct unsuppressed data not mapped	29.5%	4.0%	2.8%

[1]Total at the end of 4th quarter 2006.

Methodology

Since both the size of ZIP code areas and the distribution of the labor market data within them can vary greatly, it was desirable to refine the probable location of the EDD labor market variables within each ZIP code polygon. This was accomplished with land use shapefiles obtained from the Southern California Association of Governments (2005), the San Diego Association of Governments (2007), and the County of Kern (2007). Areas designated as public lands, open space, vacant land, and water were spatially excluded from each ZIP code. While the spatial and categorical detail varied among the three land use data sources, the overall effect of these exclusions was to eliminate approximately 82 percent of the region's total land area from consideration for the spatial allocation of the EDD data. Since the amount of excluded land is a function of each ZIP code's land area, the largest decreases in land area were experienced by the largest and most sparsely populated ZIP codes. The result was a ZIP code layer with polygons defined by the non-excluded land uses. It will be referred to as the land use ZIP code layer.

The ShakeMap shapefile was dissolved according to Instrumental Intensity values ranging from 3 (III) to 10 (X) across the study area. The resulting dissolved layer was then spatially joined to the land use ZIP code layer. Since it was still quite possible for a single ZIP code polygon to intersect areas of more than one Instrumental Intensity, both the minimum and maximum Instrumental Intensities were selected as the basis of the spatial join. The final result of the spatial join was a land use ZIP code polygon layer with a minimum and maximum Instrumental Intensity attributed to each ZIP code. In this manner, business establishment exposure and sensitivity to seismic activity could be estimated as "at least" or "up to" the Instrumental Intensities associated with each ZIP code.

These ranged estimates, however, do not account for the amount of area occupied by multiple Instrumental Intensities within the same ZIP code. To further refine the exposure and sensitivity estimates at the land use ZIP code level, two alternative spatially derived techniques were used to calculate a single Instrumental Intensity value for each of those ZIP codes intersecting multiple Instrumental Intensities. One of these calculations was an area weighted average of Instrumental Intensities. In this calculation, each Instrumental Intensity occurring within a land use ZIP code polygon was weighted based on the percentage of the total area it covered. The resulting weighted values of each Instrumental Intensity were totaled, and this final total was rounded to the nearest Instrumental Intensity value and attributed to the associated land use ZIP code polygon. The other calculation simply identified the dominant Instrumental Intensity within each land use ZIP code polygon (that is, the value covering the highest percentage of area), and that Instrumental Intensity was assigned to the land use ZIP code polygon. Even with the spatial refinement provided by the land use data, these methods still assume that economic activity is evenly distributed throughout the remaining area of the ZIP code polygon.

Allocating Instrumental Intensities to point ZIP codes was a much more straightforward process since each point was located within a single Instrumental Intensity area. The ZIP code point layer was spatially joined to the dissolved Instrumental Intensity layer to produce a ZIP code point layer with a single Instrumental Intensity assigned to each ZIP code point.

The aggregated establishment size data were cross-tabulated by size and ZIP code and joined to the ZIP code polygon and point layers. Establishment size data were then summarized by Instrumental Intensity values.

Estimates of Small Business Exposure and Sensitivity

Small businesses compose a large majority (approximately 85 percent) of establishments in the region though their share of total employees and quarterly payroll is closer to 25 percent. Over 185,000 (approximately 43 percent) of these small businesses are estimated to experience an Instrumental Intensity from VII (7) to X (10). Nearly 840,000 employees earning over $8.6 billion in quarterly payroll work for these establishments (tables 3–5). More than 46,000 of these establishments (nearly 11 percent of all small businesses), accounting for over 216,000 employees and nearly $2 billion in quarterly payroll, are estimated to experience an Instrumental Intensity of IX (9) or X (10). The spatial and estimated intensity distributions of small businesses are shown below (figs. 2–7).

Table 3. A summary of affected business establishments by number of employees based on the intensity anticipated from the scenario earthquake. Small businesses are indicated in yellow. Because of rounding, the percentages for each size category may not total 100%.

Establishments by Size and Instrumental Intensity

	III		IV		V		VI		VII		VIII		IX		X	
Employees	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
0–4	19,608	6.8%	59,586	20.7%	38,508	13.4%	51,987	18.0%	47,535	16.5%	41,750	14.5%	20,985	7.3%	8,220	2.9%
5–9	5,803	6.9%	15,942	19.0%	10,052	12.0%	12,423	14.8%	14,949	17.8%	14,536	17.3%	7,397	8.8%	2,985	3.5%
10–19	4,051	6.9%	11,018	18.9%	6,855	11.8%	8,268	14.2%	10,363	17.8%	10,474	18.0%	5,157	8.8%	2,121	3.6%
20–49	2,985	6.7%	7,849	17.5%	5,292	11.8%	6,212	13.8%	8,136	18.1%	8,359	18.6%	4,362	9.7%	1,672	3.7%
50–99	1,094	6.2%	3,042	17.3%	2,092	11.9%	2,418	13.8%	3,232	18.4%	3,310	18.8%	1,706	9.7%	686	3.9%
100–249	655	6.8%	1,671	17.3%	1,090	11.3%	1,336	13.8%	1,815	18.8%	1,796	18.6%	922	9.5%	380	3.9%
250–499	186	7.6%	369	15.1%	282	11.5%	316	12.9%	469	19.1%	486	19.8%	243	9.9%	99	4.0%
500–999	52	5.8%	146	16.4%	116	13.0%	122	13.7%	188	21.1%	162	18.2%	67	7.5%	39	4.4%
1,000 or more	47	9.6%	68	13.8%	64	13.0%	61	12.4%	112	22.8%	82	16.7%	40	8.1%	17	3.5%
Under 20	29,462	6.8%	86,546	20.1%	55,415	12.9%	72,678	16.9%	72,847	16.9%	66,760	15.5%	33,539	7.8%	13,326	3.1%
TOTAL	**34,481**	**6.8%**	**99,691**	**19.7%**	**64,351**	**12.7%**	**83,143**	**16.4%**	**86,799**	**17.1%**	**80,955**	**16.0%**	**40,879**	**8.1%**	**16,219**	**3.2%**

Table 4. A summary of the affected number of employees by establishment size based on the intensity anticipated from the scenario earthquake. Small businesses are indicated in yellow. Because of rounding, the percentages for each size category may not total 100%.

Employees by Establishments Size and Instrumental Intensity

	III		IV		V		VI		VII		VIII		IX		X	
Employees	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
0–4	30,743	6.7%	91,614	20.0%	58,520	12.8%	78,481	17.1%	78,653	17.1%	70,665	15.4%	35,882	7.8%	14,128	3.1%
5–9	38,042	6.9%	104,683	19.0%	65,988	12.0%	81,214	14.7%	97,674	17.7%	95,236	17.3%	48,414	8.8%	19,541	3.5%
10–19	54,010	6.9%	147,162	18.8%	92,006	11.7%	111,383	14.2%	139,438	17.8%	141,507	18.1%	69,708	8.9%	28,372	3.6%
20–49	88,676	6.6%	233,441	17.3%	160,449	11.9%	186,130	13.8%	245,305	18.2%	252,577	18.7%	131,868	9.8%	50,437	3.7%
50–99	74,565	6.3%	204,670	17.3%	141,482	12.0%	161,405	13.7%	215,975	18.3%	222,237	18.8%	115,875	9.8%	46,120	3.9%
100–249	96,611	6.9%	235,203	16.8%	155,816	11.2%	194,062	13.9%	262,445	18.8%	261,854	18.8%	133,938	9.6%	56,496	4.0%
250–499	57,395	8.1%	103,394	14.6%	81,370	11.5%	88,289	12.5%	135,453	19.2%	146,336	20.7%	67,560	9.6%	26,902	3.8%
500–999	18,586	5.1%	54,663	14.9%	56,166	15.3%	53,486	14.6%	77,331	21.1%	76,417	20.8%	16,691	4.6%	13,334	3.6%
1,000 or more	69,366	10.8%	79,570	12.4%	54,057	8.4%	48,551	7.5%	283,351	44.0%	79,178	12.3%	26,193	4.1%	3,934	0.6%
Under 20	122,795	6.8%	343,459	19.2%	216,514	12.1%	271,078	15.1%	315,765	17.6%	307,408	17,1%	154,004	8.6%	62,041	3.5%
TOTAL	**527,994**	**7.1%**	**1,254,400**	**16.9%**	**865,854**	**11.6%**	**1,003,001**	**13.5%**	**1,535,625**	**20.6%**	**1,346,007**	**18.1%**	**646,129**	**8.7%**	**259,264**	**3.5%**

Table 5. A summary of payroll affected by establishment size based on the intensity anticipated from the scenario earthquake. Small businesses are indicated in yellow. Because of rounding, the percentages for each size category may not total 100%.

Quarterly Payroll ($ millions) by Establishment Size and Instrumental Intensity

	III		IV		V		VI		VII		VIII		IX		X	
Employees	**Amount**	**Percent**	**Amount**	**Percent**	**Amount**	**Percent**	**Amount**	**Percent**	**Amount**	**Percent**	**Amount**	**Percent**	**Amount**	**Percent**	**Amount**	**Percent**
0–4	$433	4.9%	$1,794	20.3%	$1,719	19.5%	$2,406	27.3%	$1,028	11.6%	$902	10.2%	$402	4.6%	$143	1.6%
5–9	$406	6.7%	$1,160	19.3%	$916	15.2%	$1,060	17.6%	$967	16.1%	$926	15.4%	$427	7.1%	$162	2.7%
10–19	$541	6.5%	$1,567	18.9%	$1,093	13.2%	$1,395	16.9%	$1,420	17.1%	$1,404	17.0%	$623	7.5%	$237	2.9%
20–49	$939	6.4%	$2,514	17.2%	$1,959	13.4%	$2,318	15.9%	$2,637	18.0%	$2,590	17.7%	$1,209	8.3%	$454	3.1%
50–99	$786	5.9%	$2,214	16.6%	$1,740	13.1%	$2,153	16.1%	$2,409	18.1%	$2,424	18.2%	$1,150	8.6%	$456	3.4%
100–249	$1,098	6.8%	$2,695	16.7%	$1,922	11.9%	$2,736	17.0%	$2,927	18.1%	$2,832	17.6%	$1,361	8.4%	$562	3.5%
250–499	$729	8.2%	$1,226	13.8%	$1,016	11.4%	$1,552	17.5%	$1,722	19.4%	$1,703	19.2%	$703	7.9%	$239	2.7%
500–999	$250	4.3%	$881	15.0%	$857	14.6%	$1,325	22.6%	$1,310	22.3%	$891	15.2%	$183	3.1%	$174	3.0%
1,000 or more	$936	9.9%	$1,230	13.0%	$1,251	13.2%	$772	8.2%	$3,977	42.1%	$979	10.4%	$278	2.9%	$29	0.3%
Under 20	$1,380	6.0%	$4,521	19.5%	$3,728	16.1%	$4,861	21.0%	$3,415	14.8%	$3,232	14.0%	$1,452	6.3%	$542	2.3%
TOTAL	**$6,118**	**6.7%**	**$15,281**	**16.7%**	**$12,473**	**13.6%**	**$15,717**	**17.2%**	**$18,397**	**20.1%**	**$14,651**	**16.0%**	**$6,336**	**6.9%**	**$2,456**	**2.7%**

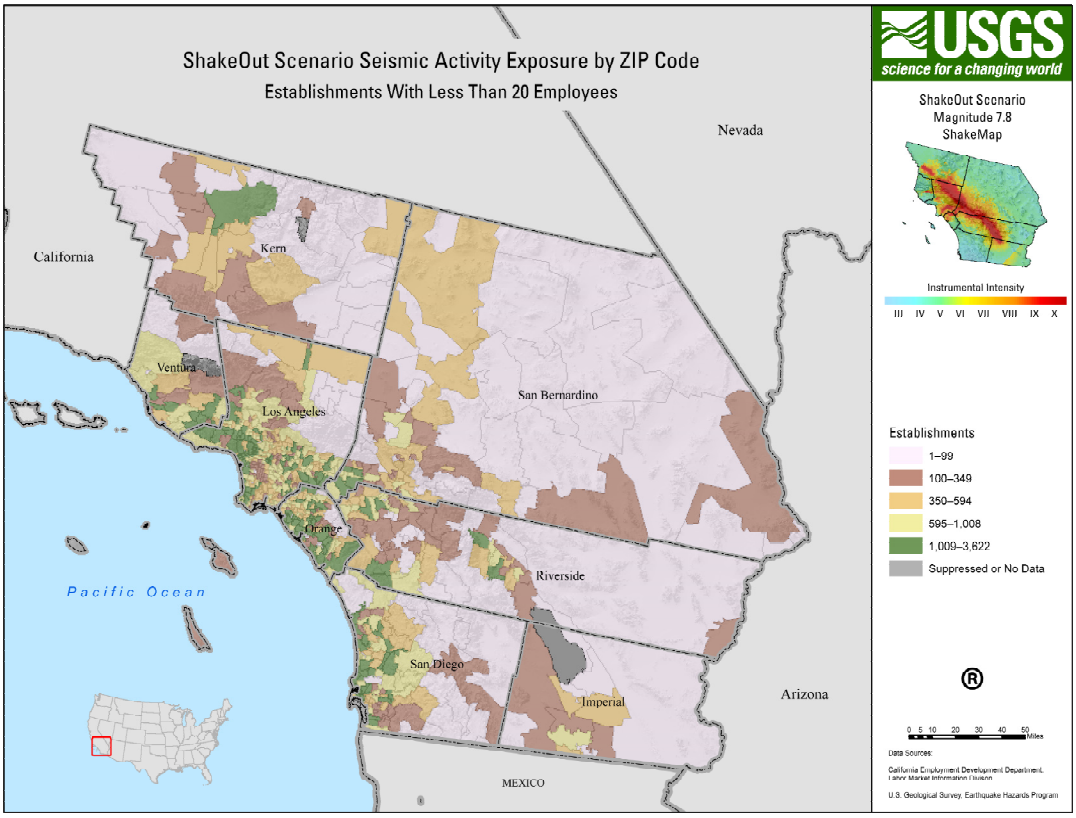

Figure 2. The spatial distribution of establishments with less than 20 employees. See figure 3 for Exposure and Sensitivity Summary.

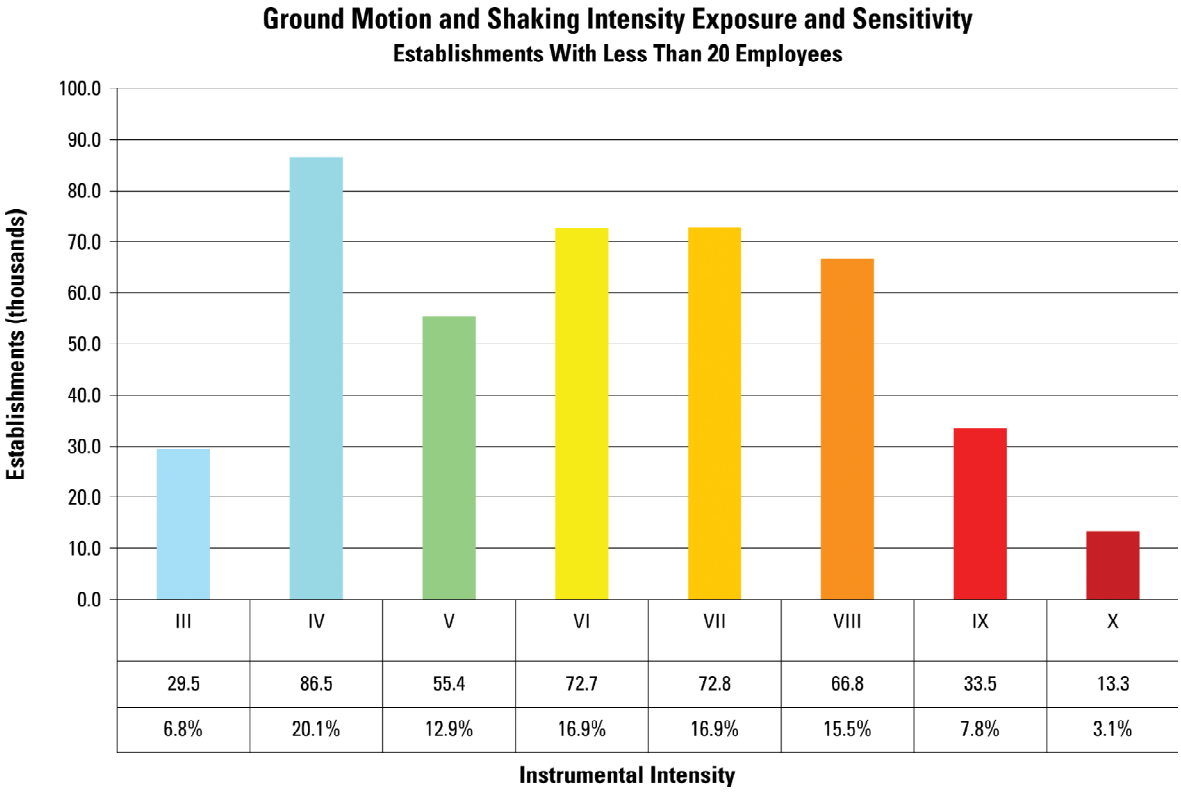

Figure 3. The estimated intensity distribution of establishments with less than 20 employees.

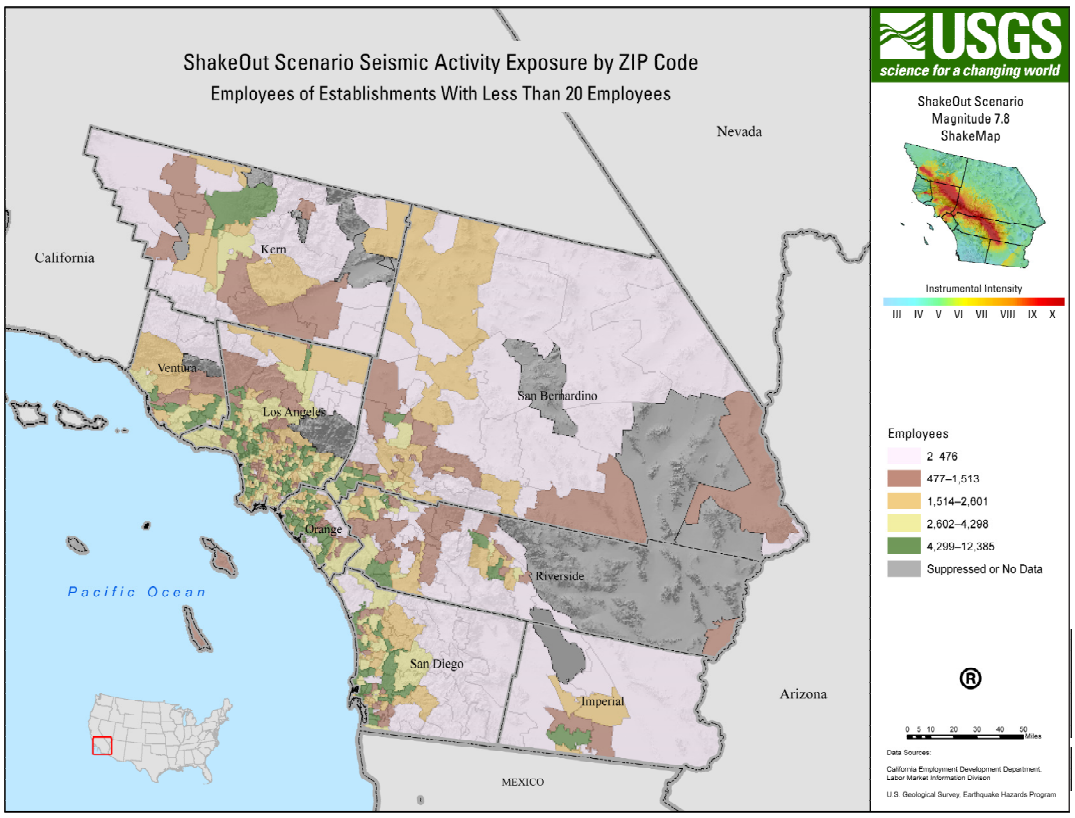

Figure 4. The spatial distribution of employees at establishments with less than 20 employees. See figure 5 for Exposure and Sensitivity Summary.

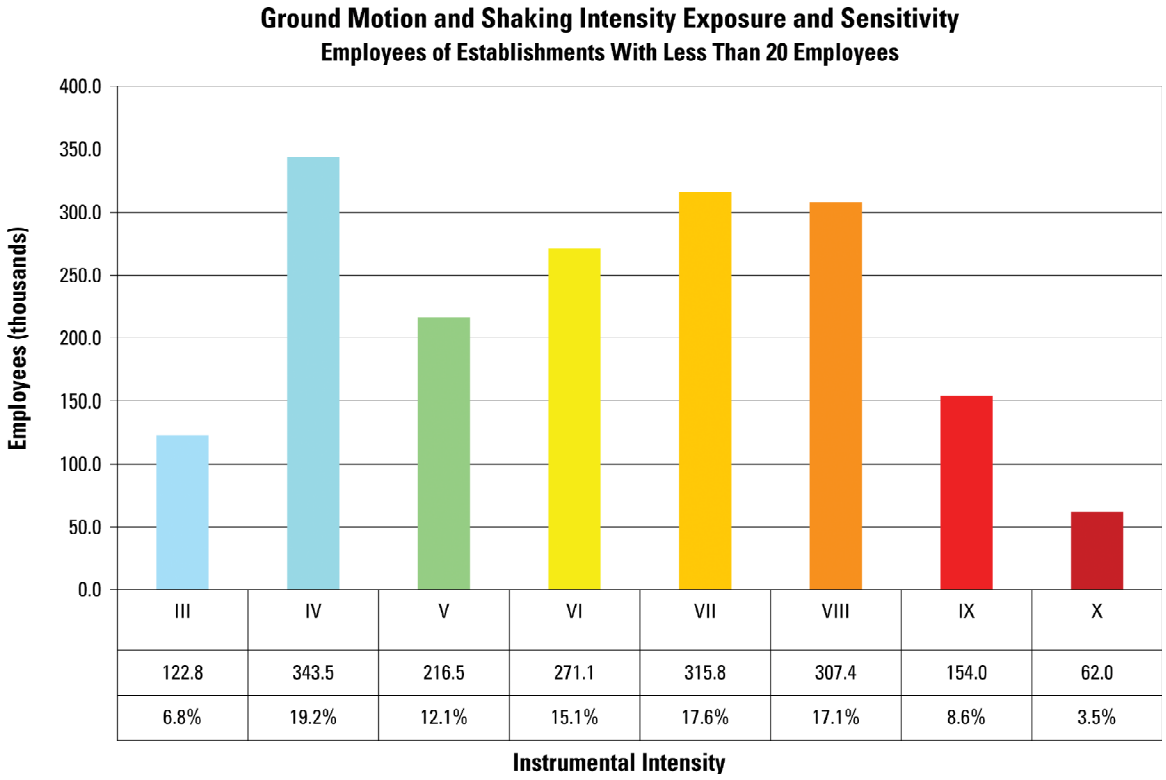

Figure 5. The estimated intensity distribution of small business employees.

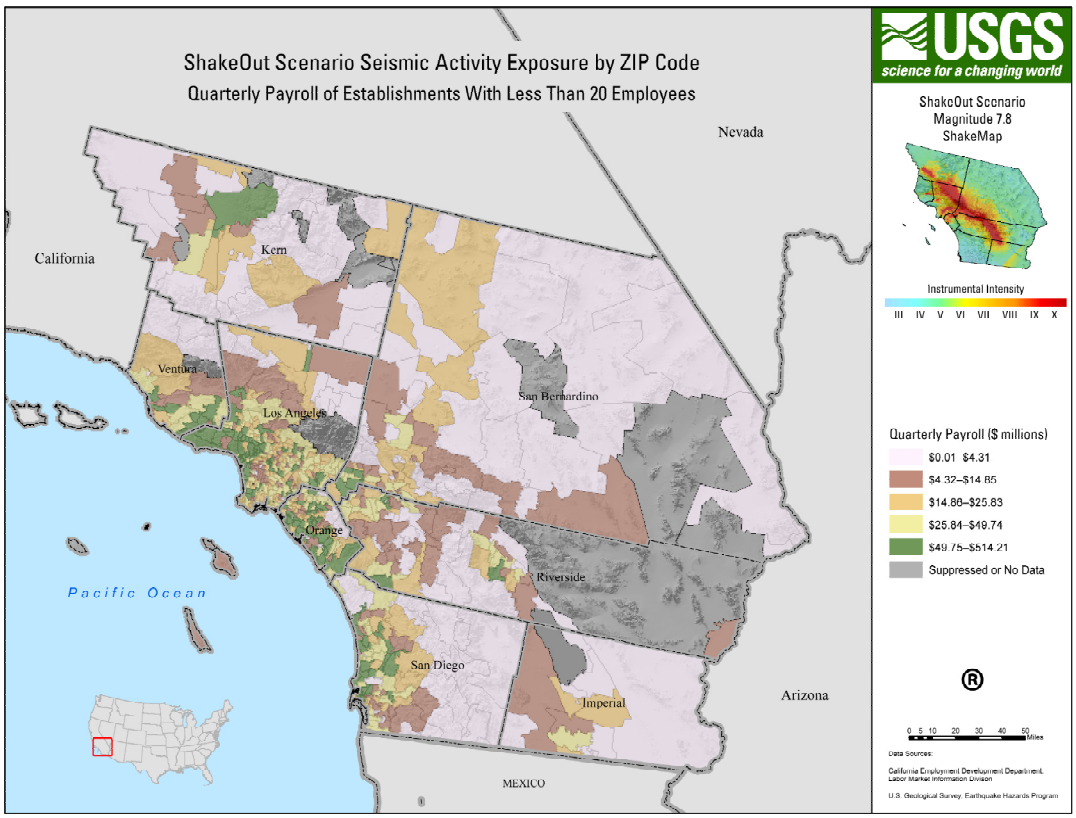

Figure 6. The spatial distribution of quarterly payroll for establishments with less than 20 employees. See figure 7 for Exposure and Sensitivity Summary.

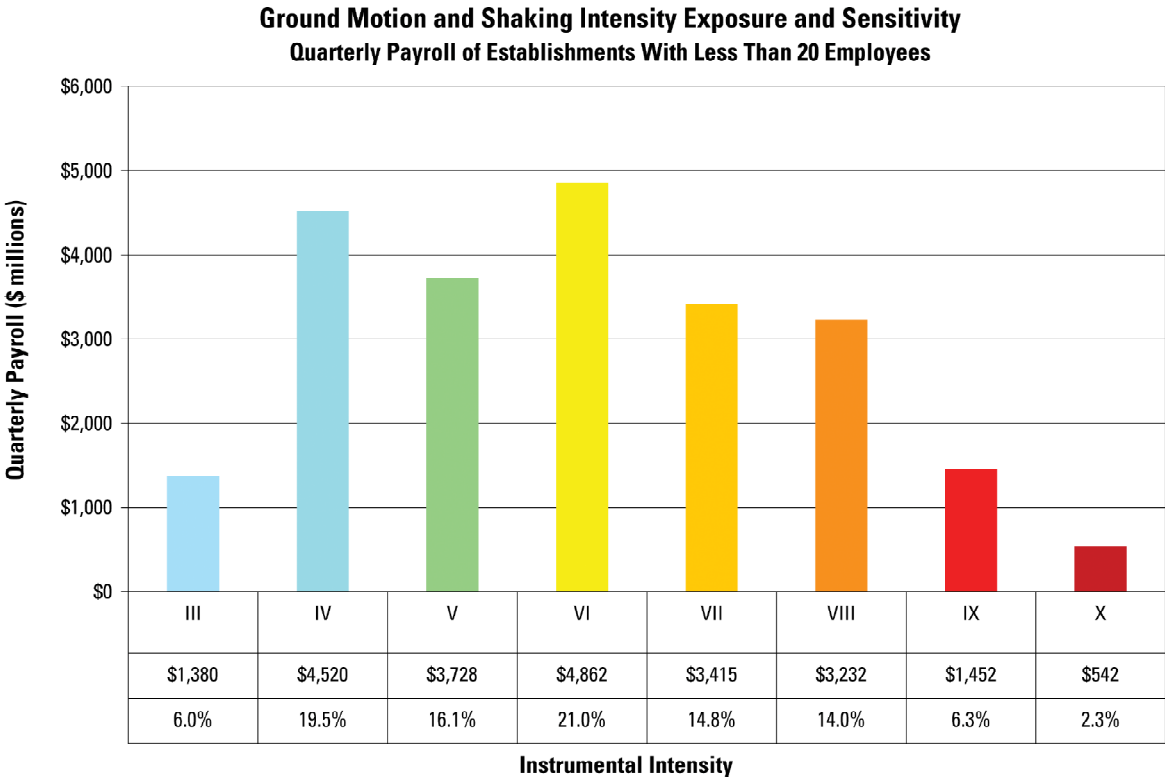

Figure 7. The estimated intensity distribution of small business quarterly payroll.

Discussion

This analysis was motivated, in part, by a September 2007 report released by the Bureau of Labor Statistics (BLS) entitled *Labor Market Risks of a Magnitude 6.9 Earthquake in Alameda County* (Holden and others, 2007). In lieu of geocoded labor market data, the BLS methodology was adapted to produce exposure and sensitivity estimates at a sub-ZIP code level using regional land use data and multiple spatially derived calculation methods to assign specific Instrumental Intensities to each sub-ZIP code area.

The analysis was limited by several factors. While the regional land use data helped to limit the probable location of labor market data within each ZIP code area, the assumption had to be made that these data were uniformly distributed across the remaining sub-ZIP code areas. The exposure and sensitivity estimates do not take into account how individual buildings will withstand actual earthquake intensities, and there is no accounting for impacts on the surrounding infrastructure on which a business establishment depends, whether or not the establishment itself is damaged. Also, the analysis does not consider the economic interactions among businesses, whether they are within the directly impacted region or not.

This analysis might best be thought of as a spatial and quantitative inventory of the region's small businesses that serves to characterize and highlight their potential vulnerabilities to the ShakeOut Scenario earthquake.

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Appendix. Modified Mercalli Intensity (MMI) Scale Descriptions (from Association of Bay Area Governments, 2003)

MMI value	Description of shaking event	Summary of damage description	Full description[1]
I	-	-	Not felt. Marginal and long period effects of large earthquakes.
II	-	-	Felt by persons at rest, on upper floors, or favorably placed.
III	-	-	Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
IV	-	-	Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV, wooden walls and frame creak.
V	Light	Pictures move	Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.
VI	Moderate	Objects fall	Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken (visibly, or heard to rustle).
VII	Strong	Nonstructural damage	Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.
VIII	Very strong	Moderate damage	Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
IX	Violent	Heavy damage	General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations.) Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluvial areas sand and mud ejected, earthquake fountains, sand craters.
X	Very violent	Extreme damage	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
XI	-	-	Rails bent greatly. Underground pipelines completely out of service.
XII	-	-	Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

[1]Richter, 1958.

Masonry A: Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.
Masonry B: Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.
Masonry C: Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.
Masonry D: Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

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