Geographic Analysis and Monitoring Program

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

Open-File Report 2008–1211

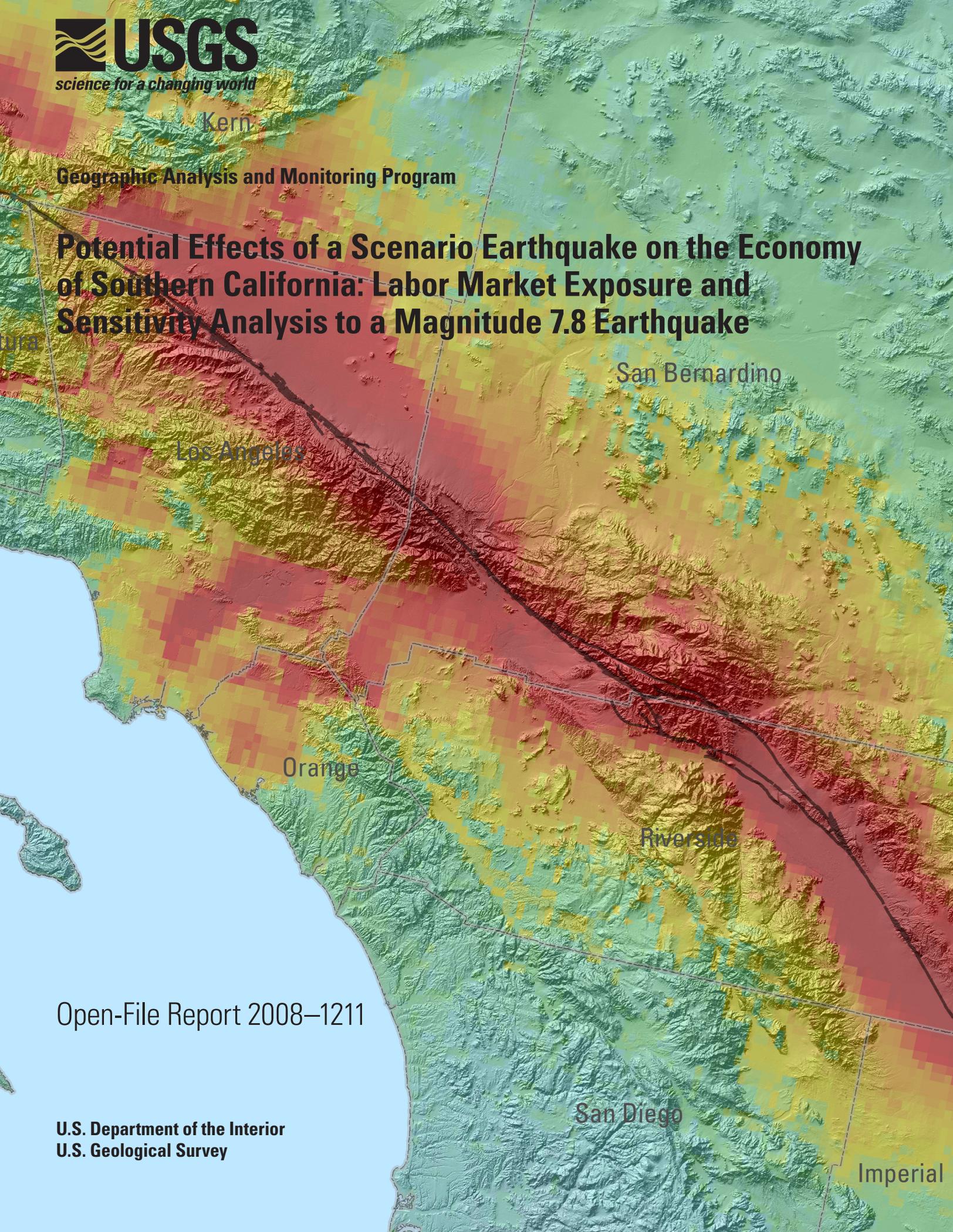**U.S. Department of the Interior**
U.S. Geological Survey

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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U.S. Department of the Interior
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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 economic Super Sectors 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 Super Sector to each Instrumental Intensity level. The analysis concerns the direct effect of the scenario earthquake on economic sectors and provides a baseline for the indirect and interactive analysis of an input-output model of the regional economy.

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 the North American Industry Classification System (U.S. Census Bureau, 2004).

According to the analysis results, nearly 225,000 business establishments, or 44 percent of all establishments, would experience Instrumental Intensities between VII (7) and X (10). This represents more than 4 million employees earning over $45 billion in quarterly payroll. Over 57,000 of these establishments, employing over 1 million employees earning over $10 billion in quarterly payroll, would experience Instrumental Intensities of IX (9) or X (10). Based upon absolute counts and percentages, the Trade, Transportation, and Utilities Super Sector and the Manufacturing Super Sector are estimated to have the greatest exposure and sensitivity respectively. The Information and the Natural Resources and Mining Super Sectors are estimated to be the least impacted. Areas estimated to experience an Instrumental Intensity of X (10) account for approximately 3 percent of the region's labor market.

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 the North American Industry Classification System (NAICS) scheme (U.S. Census Bureau, 2004).

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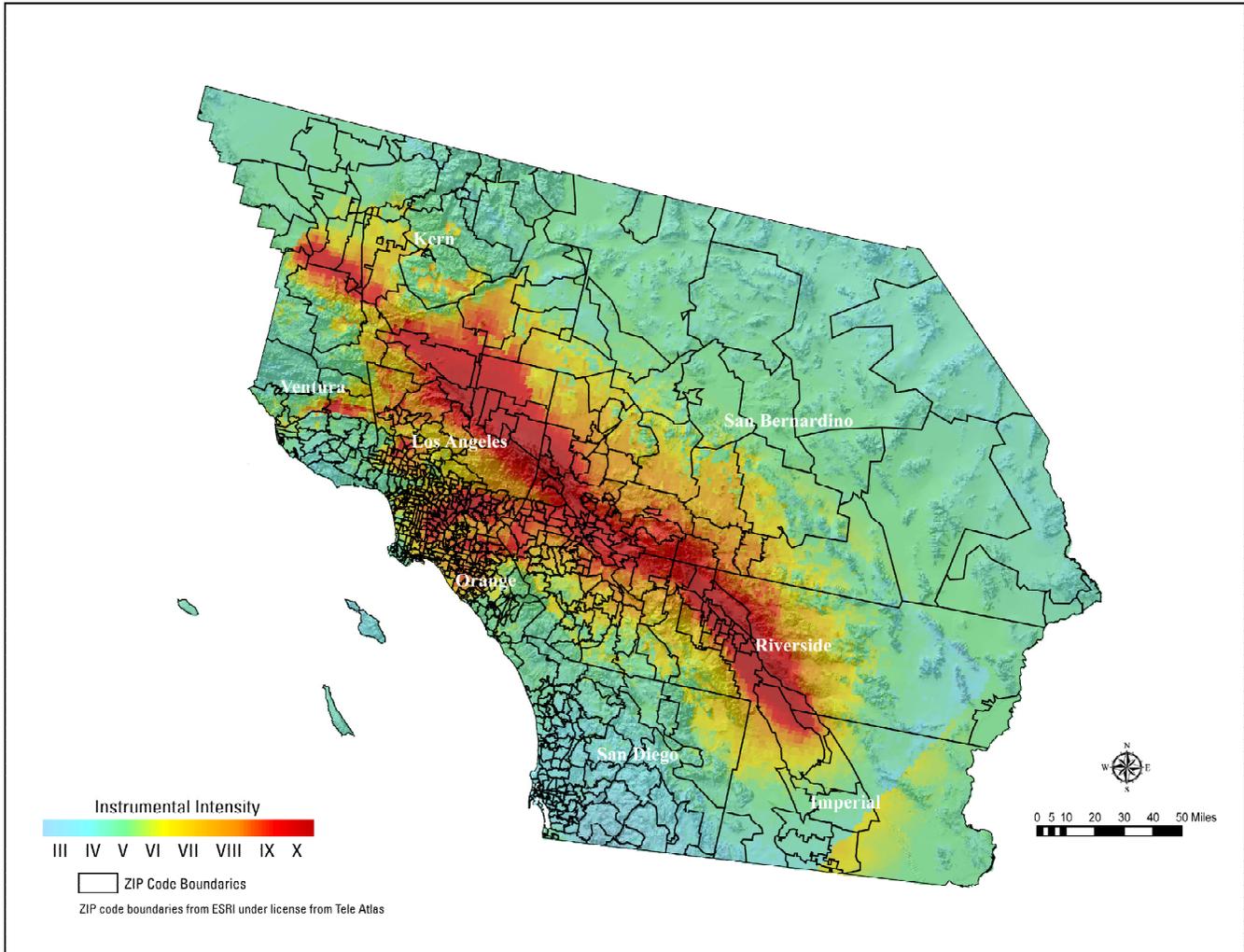
Figure 1.   The ShakeMap of a M7.8 earthquake in Southern California, along with the ZIP code boundaries for mapping labor market data.

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 much more limited. While over 50 percent of the region's data records disaggregated by industry were suppressed, this only accounted for approximately 7 percent of reported employees and quarterly payroll. The suppression rate for the region and for individual counties is summarized below (table 1).

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

County name	Records		Establishments		Employees[1]		Payroll ($ millions)	
	Total	% Suppressed	Total	% Suppressed	Total	% Suppressed	Total	% Suppressed
Imperial	261	48.7%	6,475	0.0%	55,428	6.1%	$440	6.4%
Kern	1,101	52.2%	17,484	0.0%	283,525	6.0%	$2,659	8.1%
Los Angeles	9,106	47.4%	399,115	0.0%	4,244,059	7.1%	$55,435	7.9%
Orange	4,040	55.0%	96,258	0.0%	1,534,382	6.2%	$19,795	5.7%
Riverside	2,439	53.1%	43,766	0.0%	636,540	6.6%	$5,874	7.0%
San Bernardino	2,176	54.2%	46,513	0.0%	666,241	6.1%	$6,434	6.3%
San Diego	3,479	54.3%	93,399	0.0%	1,332,134	4.8%	$15,913	5.0%
Ventura	1,028	54.3%	21,901	0.0%	318,719	7.8%	$3,931	10.8%
TOTAL	**23,630**	**51.5%**	**724,911**	**0.0%**	**9,071,028**	**6.5%**	**$110,481**	**7.0%**

[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.

Additional records that could not be matched to the ZIP code polygon layer 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 proportion of unmapped establishment data was much greater than the proportion of unmapped employment and quarterly payroll data (table 2). However, the vast majority (approximately 94 percent) of the establishments that could not be mapped were identified as "Other Services" that were reported for the Sacramento, Calif., ZIP code 95814, outside the Southern California region.

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

Industry data	Establishments	Employees[1]	Payroll ($ millions)
Total unsuppressed data	724,911	8,485,293	$102,723
Total unmapped data	218,390	371,698	$3,614
Percent unsuppressed data not mapped	30.1%	4.4%	3.5%

[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.

Included below is an example of the different exposure estimates resulting from the alternative calculation methods (fig. 2). Presented are Trade, Transportation, and Utilities business establishments. Overall results indicate that the estimates based on the area weighted average and dominant values were similar. The average difference between the proportion of establishments, employees, and quarterly payroll estimated for a particular Instrumental Intensity by these two methods was approximately 1 percent with a standard deviation of slightly over 1 percent. The maximum difference for any single estimate (that is, for a specific Super Sector and Instrumental Intensity) was 6.9 percent. Due to the similarity of these two estimates, for brevity, the following exposure estimates are reported based on the dominant Instrumental Intensity calculations. Again, since the estimates are directly affected by land area, the ranges between the minimum and maximum Instrumental Intensity estimates tend to be greatest in the larger, sparsely populated ZIP codes. A complete tabular set of exposure and sensitivity estimates based on the different calculation methods are included in appendix 2.

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 EDD industry-level data are reported by NAICS industry sector. For this analysis these sector data were grouped into 11 Super Sectors (table 3). The 11 categories used for this analysis exclude nonclassified data. The EDD data were cross-tabulated by Super Sector and ZIP code. The resulting cross-tabulation was then joined to the land use ZIP code polygon and ZIP code point layers by ZIP code value. The joined Super Sector data were totaled by Instrumental Intensity level to produce Super Sector–level summaries of the number of establishments and employees as well as the amount of quarterly payroll that were estimated to experience each Instrumental Intensity level.

Alternative Estimates of Labor Market Exposure

Trade, Transportation, and Utilities Establishments

	III	IV	V	VI	VII	VIII	IX	X
Maximum	560	15,402	8,403	14,400	16,716	24,681	18,804	9,549
Area Weighted	6,257	16,939	13,441	15,064	22,950	19,837	10,062	3,965
Dominant	6,257	18,304	12,261	14,111	21,965	20,568	10,366	4,683
Minimum	12,066	22,752	15,507	19,344	25,197	8,654	4,190	805

Instrumental Intensity
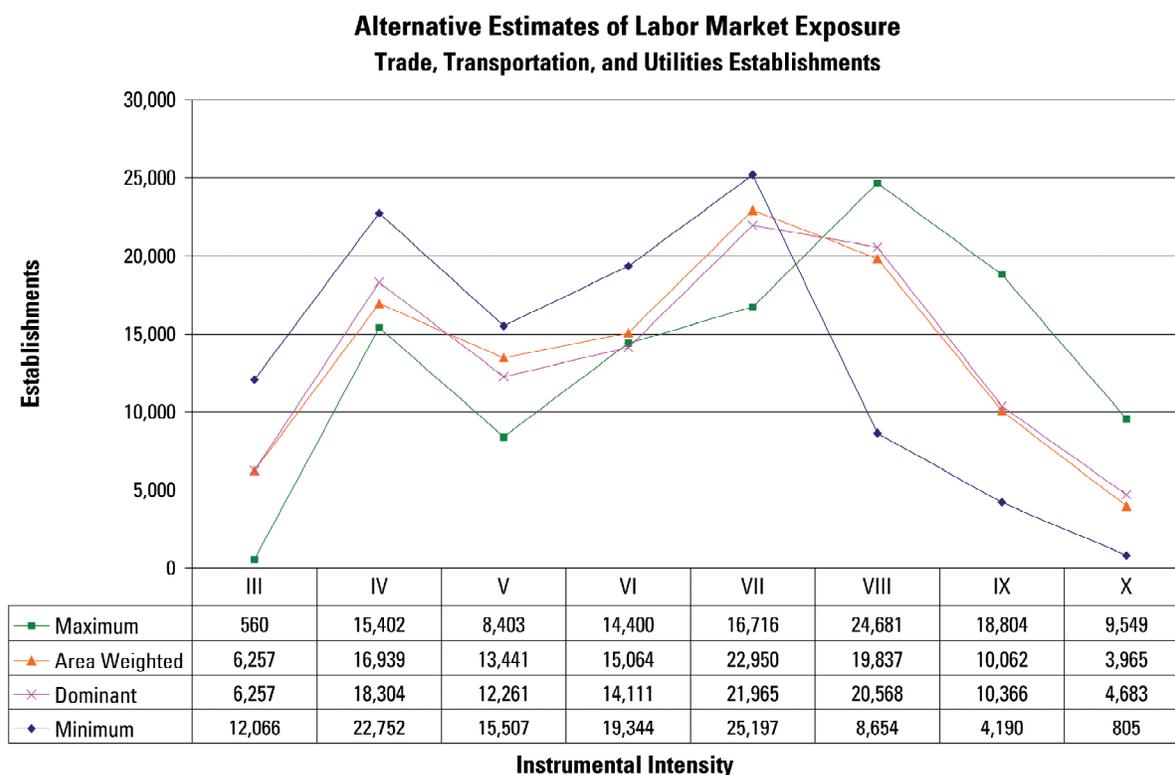
Figure 2. A comparison of the alternative exposure estimates for the Trade, Transportation, and Utilities NAICS Super Sector business establishments. The Area Weighted Instrument Intensity (orange) and Dominant Instrumental Intensity (pink) estimates are similar.

Table 3. The EDD industry data were grouped into 11 Super Sectors. Nonclassified data were not included.

Code	NAICS Super Sector
01	Natural Resources and Mining
02	Construction
03	Manufacturing
04	Trade, Transportation, and Utilities
05	Information
06	Financial Activities
07	Professional and Business Services
08	Education and Health Services
09	Leisure and Hospitality
10	Other Services
11	Government

Estimates of Labor Market Exposure and Sensitivity

Overall, an estimated 44 percent of business establishments (nearly 225,000) would experience an Instrumental Intensity from VII (7) to X (10). This intensity suggests at least some nonstructural damage resulting from the scenario earthquake. These 225,000 establishments account for over 4 million employees earning over $45 billion in quarterly payroll (tables 4–6). Over 57,000 of these establishments and over 11 percent of all establishments (representing over 1 million employees and more than $10 billion in quarterly payroll) are estimated to experience an Instrumental Intensity of IX (9) or X (10). At these levels, heavy to extreme structural damage is not unlikely.

Comparisons of exposure and sensitivity between Super Sectors are complicated by the fact that the direct effect of the same Instrumental Intensity could be different for each Super Sector depending upon their particular vulnerabilities. For example, the infrastructure associated with Trade, Transportation, and Utilities would likely be affected differently than structures associated with Financial Activities. Additionally, some Super Sectors might be inconsistently affected by the methodology used in the analysis to assign Instrumental Intensities to ZIP code polygons depending upon the size of the ZIP code areas in which they tend to be located. The results highlighted below are based on the selection of those Super Sectors with the highest number and highest percentage of establishments estimated to experience Instrumental Intensities of VII (7) or greater without attempting to account for the unique vulnerabilities of each Super Sector.

Over 57,000 establishments in the Trade, Transportation, and Utilities Super Sector are estimated to experience Instrumental Intensities of between VII (7) and X (10). These establishments have over 900,000 employees earning nearly $9 billion in quarterly payroll. Of these establishments, over 15,000 of them, with more than 250,000 employees earning $2.3 billion in quarterly payroll, are estimated to experience Instrumental Intensities of IX (9) or X (10). These latter totals represent approximately 14 to 15 percent of Trade, Transportation, and Utilities establishments, employees, and quarterly payroll. This would indicate it to be the most "exposed" Super Sector in terms of absolute numbers. In terms of percentages, however, the most "sensitive" Super Sector is Manufacturing. Approximately 64 percent of its establishments and employees along with 57 percent of its quarterly payroll are estimated to experience Instrumental Intensities between VII (7) and X (10) while approximately 16 percent of its establishments, 19 percent of its employees, and 15 percent of its quarterly payroll are estimated to experience Instrumental Intensities of IX (9) or X (10). For comparison, the Information Super Sector and the Natural Resources and Mining Super Sector appear to be the least directly affected by the shaking. Given the estimated exposure and sensitivity levels of the Trade, Transportation, and Utilities Super Sector and the Manufacturing Super Sector, their spatial and estimated intensity distributions are shown below (figs. 3–14).

Table 4. A summary of affected business establishments by Super Sector based on the intensity anticipated from the scenario earthquake. Because of rounding, the percentages for each Super Sector may not total 100%.

Employees by Instrumental Intensity

NAICS Super Sector	III Number	III Percent	IV Number	IV Percent	V Number	V Percent	VI Number	VI Percent	VII Number	VII Percent	VIII Number	VIII Percent	IX Number	IX Percent	X Number	X Percent
Natural Resources and Mining	118	2.9%	1,809	43.8%	680	16.5%	347	8.4%	298	7.2%	426	10.3%	256	6.2%	196	4.7%
Construction	3,270	8.2%	8,766	22.0%	4,146	10.4%	4,811	12.1%	6,941	17.4%	6,926	17.4%	3,451	8.6%	1,588	4.0%
Manufacturing	1,178	4.1%	3,895	13.5%	2,499	8.6%	2,918	10.1%	7,006	24.2%	6,692	23.2%	3,252	11.3%	1,457	5.0%
Trade, Transportation, and Utilities	6,257	5.8%	18,304	16.9%	12,261	11.3%	14,111	13.0%	21,965	20.2%	20,568	19.0%	10,366	9.6%	4,683	4.3%
Information	576	4.4%	2,421	18.7%	2,697	20.8%	3,807	29.4%	1,637	12.6%	1,187	9.2%	452	3.5%	179	1.4%
Financial Activities	4,823	8.6%	12,195	21.7%	7,028	12.5%	9,583	17.0%	8,762	15.6%	8,456	15.0%	4,028	7.2%	1,375	2.4%
Professional and Business Services	7,705	8.3%	20,240	21.7%	12,944	13.9%	17,765	19.1%	13,893	14.9%	13,272	14.2%	5,272	5.7%	2,131	2.3%
Education and Health Services	3,648	6.5%	10,973	19.7%	6,943	12.4%	9,765	17.5%	9,735	17.4%	8,286	14.8%	5,057	9.1%	1,423	2.5%
Leisure and Hospitality	3,276	6.6%	9,185	18.5%	7,607	15.3%	9,808	19.7%	7,540	15.2%	7,000	14.1%	4,003	8.0%	1,349	2.7%
Other Services	2,976	6.3%	10,233	21.6%	6,675	14.1%	9,647	20.4%	6,988	14.8%	6,160	13.0%	3,378	7.1%	1,281	2.7%
Government	651	6.8%	1,656	17.2%	853	8.9%	573	5.9%	2,019	21.0%	1,970	20.5%	1,356	14.1%	555	5.8%
TOTAL	**34,478**	**6.8%**	**99,677**	**19.7%**	**64,333**	**12.7%**	**83,135**	**16.4%**	**86,784**	**17.1%**	**80,943**	**16.0%**	**40,871**	**8.1%**	**16,217**	**3.2%**

Table 5.   A summary of the affected number of employees by Super Sector based on the intensity anticipated from the scenario earthquake. Because of rounding, the percentages for each Super Sector may not total 100%.

NAICS Super Sector	Employees by Instrumental Intensity															
	III		IV		V		VI		VII		VIII		IX		X	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Natural Resources and Mining	515	0.5%	56,415	52.1%	18,119	16.7%	10,424	9.6%	2,288	2.1%	4,208	3.9%	7,336	6.8%	8,896	8.2%
Construction	39,990	8.3%	90,779	18.8%	43,170	8.9%	51,947	10.7%	94,426	19.5%	102,824	21.2%	38,500	8.0%	22,400	4.6%
Manufacturing	27,922	3.4%	112,919	13.7%	88,486	10.8%	70,019	8.5%	176,907	21.5%	193,273	23.5%	117,548	14.3%	35,660	4.3%
Trade, Transportation, and Utilities	98,576	6.0%	247,166	15.1%	197,545	12.1%	187,120	11.4%	313,020	19.1%	340,955	20.8%	177,042	10.8%	73,883	4.5%
Information	11,882	5.1%	37,424	16.2%	37,713	16.3%	78,831	34.1%	34,639	15.0%	20,958	9.1%	5,768	2.5%	3,874	1.7%
Financial Activities	42,551	8.2%	86,916	16.7%	59,831	11.5%	111,246	21.4%	92,941	17.8%	88,144	16.9%	29,224	5.6%	9,861	1.9%
Professional and Business Services	96,648	8.1%	208,641	17.4%	152,597	12.7%	228,145	19.0%	207,666	17.3%	208,091	17.3%	68,328	5.7%	30,398	2.5%
Education and Health Services	60,239	7.5%	131,236	16.2%	97,846	12.1%	127,982	15.8%	156,561	19.4%	131,852	16.3%	75,488	9.3%	27,312	3.4%
Leisure and Hospitality	70,456	8.6%	163,629	20.0%	113,691	13.9%	126,112	15.4%	128,286	15.6%	124,200	15.1%	68,206	8.3%	25,521	3.1%
Other Services	20,862	7.8%	46,893	17.6%	32,591	12.2%	46,165	17.3%	48,526	18.2%	41,900	15.7%	21,936	8.2%	7,475	2.8%
Government	92,014	7.6%	176,708	14.5%	154,350	12.7%	60,586	5.0%	403,443	33.2%	171,691	14.1%	110,259	9.1%	46,975	3.9%
TOTAL	**561,655**	**6.9%**	**1,358,726**	**16.7%**	**995,939**	**12.3%**	**1,098,577**	**13.5%**	**1,658,703**	**20.4%**	**1,428,096**	**17.6%**	**719,635**	**8.9%**	**292,255**	**3.6%**

Table 6. A summary of the amount of payroll affected by Super Sector based on the intensity anticipated from the scenario earthquake. Because of rounding, the percentages for each Super Sector may not total 100%.

Quarterly Payroll ($ millions) by Instrumental Intensity

NAICS Super Sector	III		IV		V		VI		VII		VIII		IX		X	
	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent
Natural Resources and Mining	$5	0.6%	$371	52.6%	$127	18.0%	$72	10.2%	$19	2.6%	$30	4.2%	$42	6.0%	$41	5.7%
Construction	$521	8.1%	$1,212	18.9%	$594	9.3%	$669	10.4%	$1,302	20.3%	$1,376	21.5%	$474	7.4%	$259	4.0%
Manufacturing	$390	3.5%	$1,756	15.9%	$1,690	15.3%	$978	8.8%	$2,200	19.9%	$2,355	21.3%	$1,346	12.2%	$361	3.3%
Trade, Transportation, and Utilities	$812	5.1%	$2,403	14.9%	$2,167	13.5%	$1,819	11.3%	$3,096	19.3%	$3,442	21.4%	$1,629	10.1%	$710	4.4%
Information	$189	3.5%	$999	18.4%	$1,028	18.9%	$2,076	38.2%	$693	12.7%	$339	6.2%	$68	1.3%	$41	0.8%
Financial Activities	$639	6.7%	$1,529	16.1%	$1,144	12.0%	$2,855	30.0%	$1,540	16.2%	$1,363	14.3%	$329	3.5%	$115	1.2%
Professional and Business Services	$1,414	8.2%	$3,181	18.4%	$2,701	15.6%	$4,167	24.1%	$2,538	14.7%	$2,336	13.5%	$693	4.0%	$255	1.5%
Education and Health Services	$698	7.3%	$1,588	16.7%	$1,313	13.8%	$1,593	16.7%	$1,818	19.1%	$1,372	14.4%	$848	8.9%	$279	2.9%
Leisure and Hospitality	$386	6.3%	$1,002	16.3%	$1,198	19.5%	$1,583	25.8%	$1,001	16.3%	$537	8.7%	$294	4.8%	$146	2.4%
Other Services	$155	7.7%	$339	16.9%	$256	12.8%	$357	17.8%	$376	18.7%	$316	15.7%	$155	7.7%	$54	2.7%
Government	$1,246	8.3%	$1,922	12.9%	$1,778	11.9%	$737	4.9%	$5,257	35.2%	$2,129	14.2%	$1,324	8.9%	$554	3.7%
TOTAL	**$6,455**	**6.5%**	**$16,302**	**16.4%**	**$13,996**	**14.1%**	**$16,906**	**17.1%**	**$19,840**	**20.0%**	**$15,595**	**15.7%**	**$7,202**	**7.3%**	**$2,815**	**2.8%**
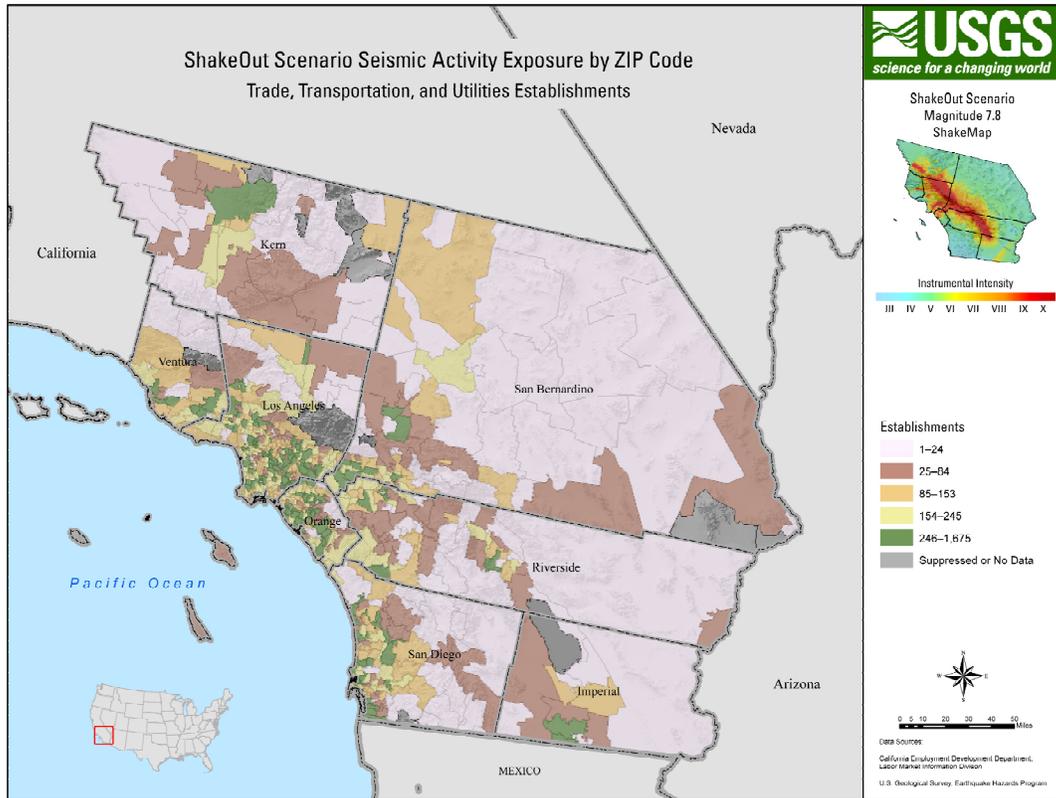
Figure 3.   The spatial distribution of Trade, Transportation, and Utilities establishments. See figure 4 for Exposure and Sensitivity Summary.
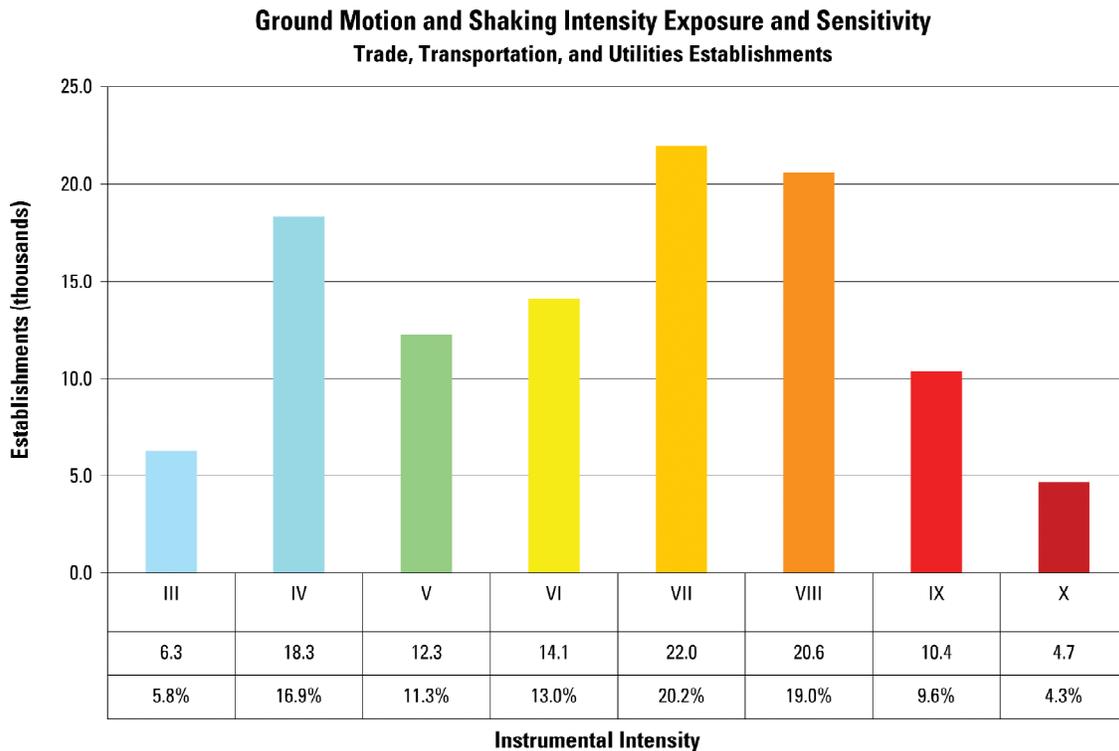
Figure 4.   The estimated intensity distribution of Trade, Transportation, and Utilities establishments. Because of rounding, the percentages for each Instrumental Intensity may not total 100%.
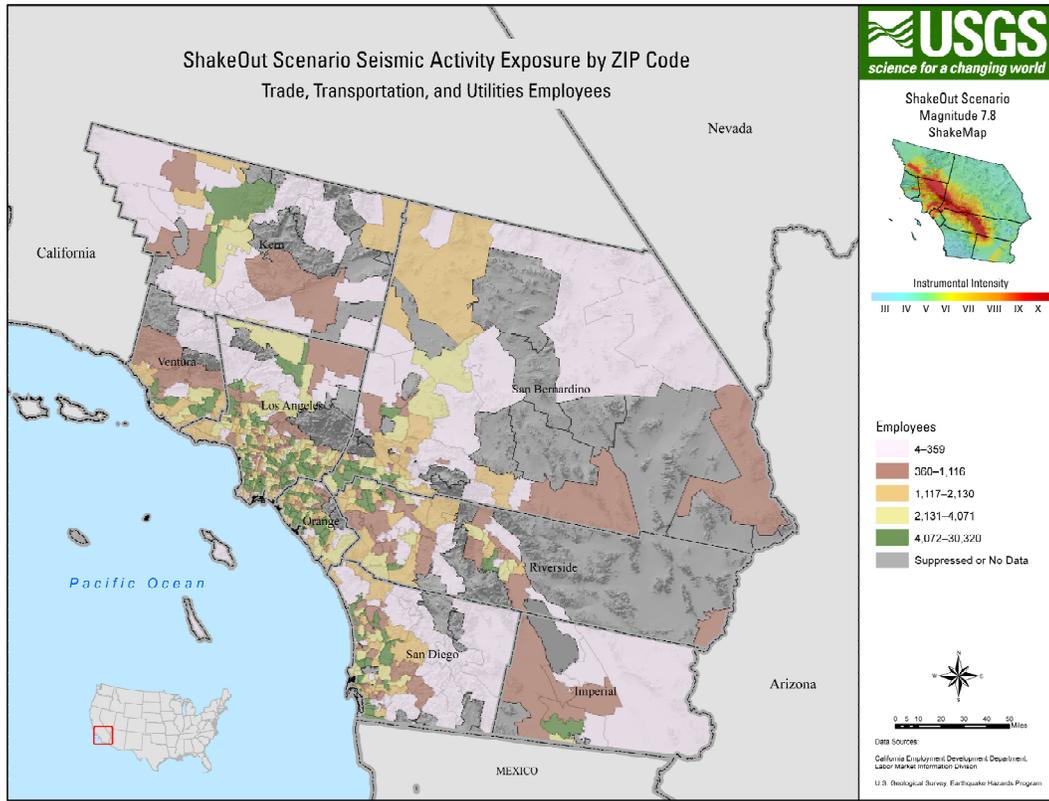
Figure 5. The spatial distribution of Trade, Transportation, and Utilities employees. See figure 6 for Exposure and Sensitivity Summary.

Ground Motion and Shaking Intensity Exposure and Sensitivity
Trade, Transportation, and Utilities Employees

Instrumental Intensity	III	IV	V	VI	VII	VIII	IX	X
	98.6	247.2	197.5	187.1	313.0	341.0	177.0	73.9
	6.0%	15.1%	12.1%	11.4%	19.1%	20.9%	10.8%	4.5%
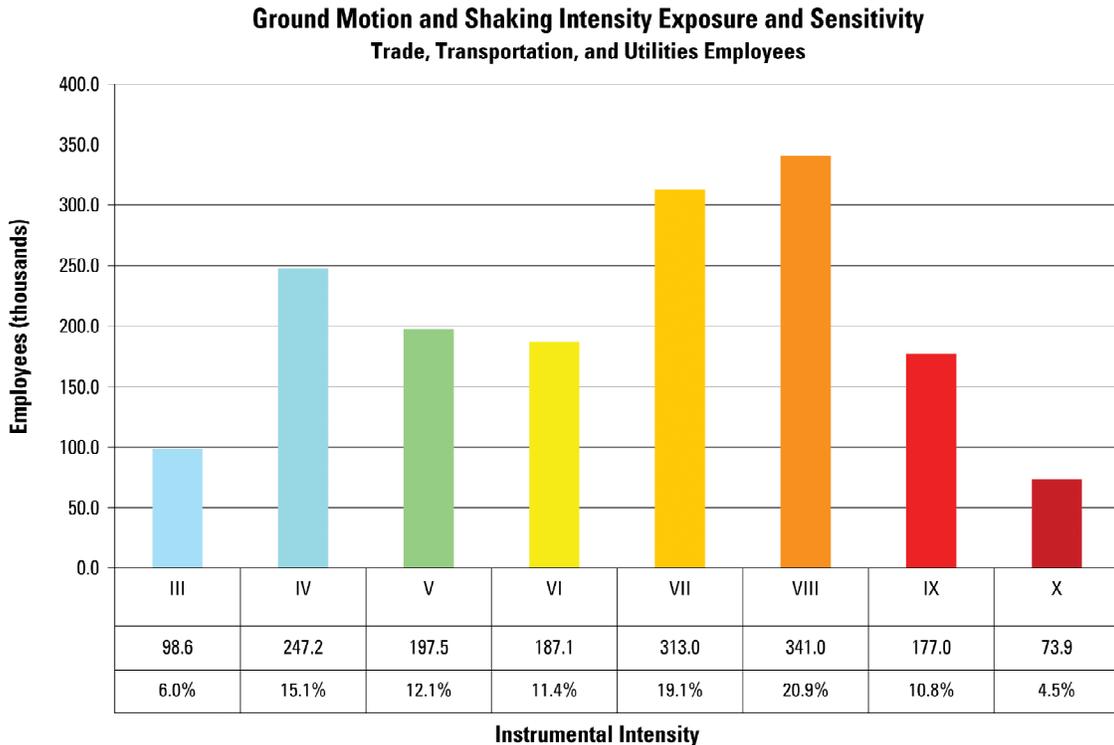
Figure 6. The estimated intensity distribution of Trade, Transportation, and Utilities employees. Because of rounding, the percentages for each Instrumental Intensity may not total 100%.
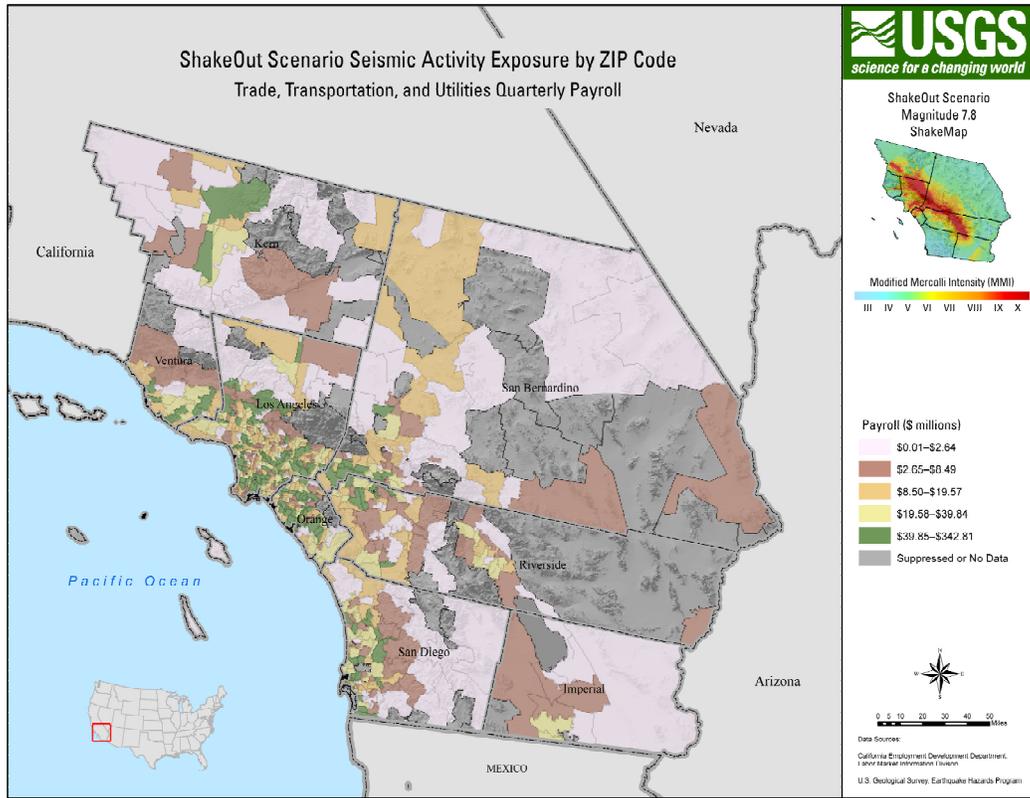
Figure 7. The spatial distribution of Trade, Transportation, and Utilities quarterly payroll. See figure 8 for Exposure and Sensitivity Summary.

Ground Motion and Shaking Intensity Exposure and Sensitivity
Trade, Transportation, and Utilities Quarterly Payroll

Instrumental Intensity	III	IV	V	VI	VII	VIII	IX	X
	$812	$2,403	$2,167	$1,819	$3,096	$3,442	$1,629	$710
	5.1%	14.9%	13.5%	11.3%	19.3%	21.4%	10.1%	4.4%
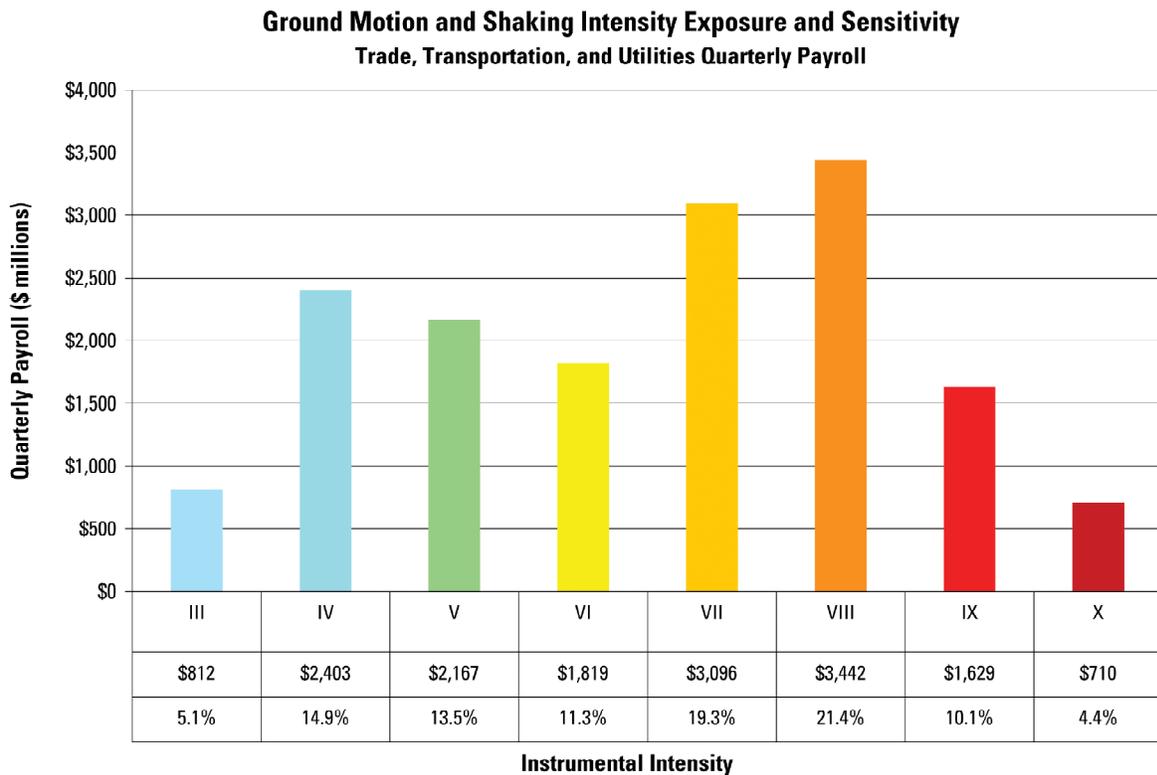
Figure 8. The estimated intensity distribution of Trade, Transportation, and Utilities quarterly payroll. Because of rounding, the percentages for each Instrumental Intensity may not total 100%.
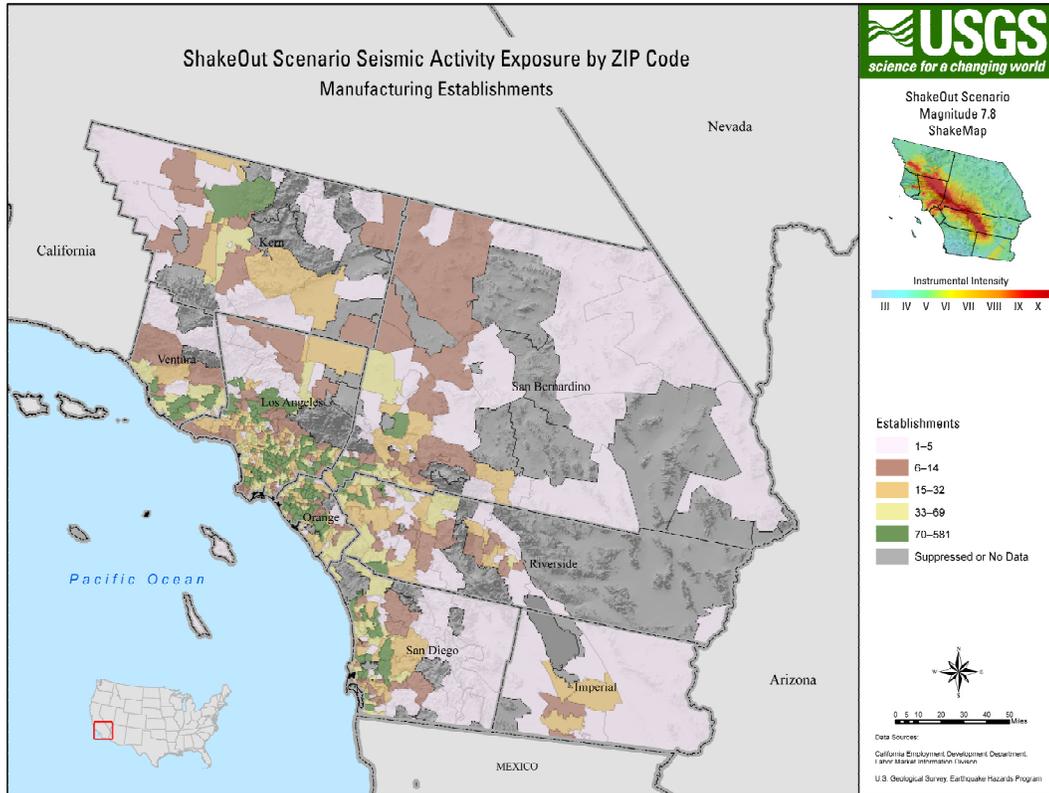
Figure 9. The spatial distribution of Manufacturing establishments. See figure 10 for Exposure and Sensitivity Summary.

Ground Motion and Shaking Intensity Exposure and Sensitivity
Manufacturing Establishments

Instrumental Intensity	III	IV	V	VI	VII	VIII	IX	X
	1.2	3.9	2.5	2.9	7.0	6.7	3.3	1.5
	4.1%	13.5%	8.6%	10.1%	24.2%	23.2%	11.3%	5.0%
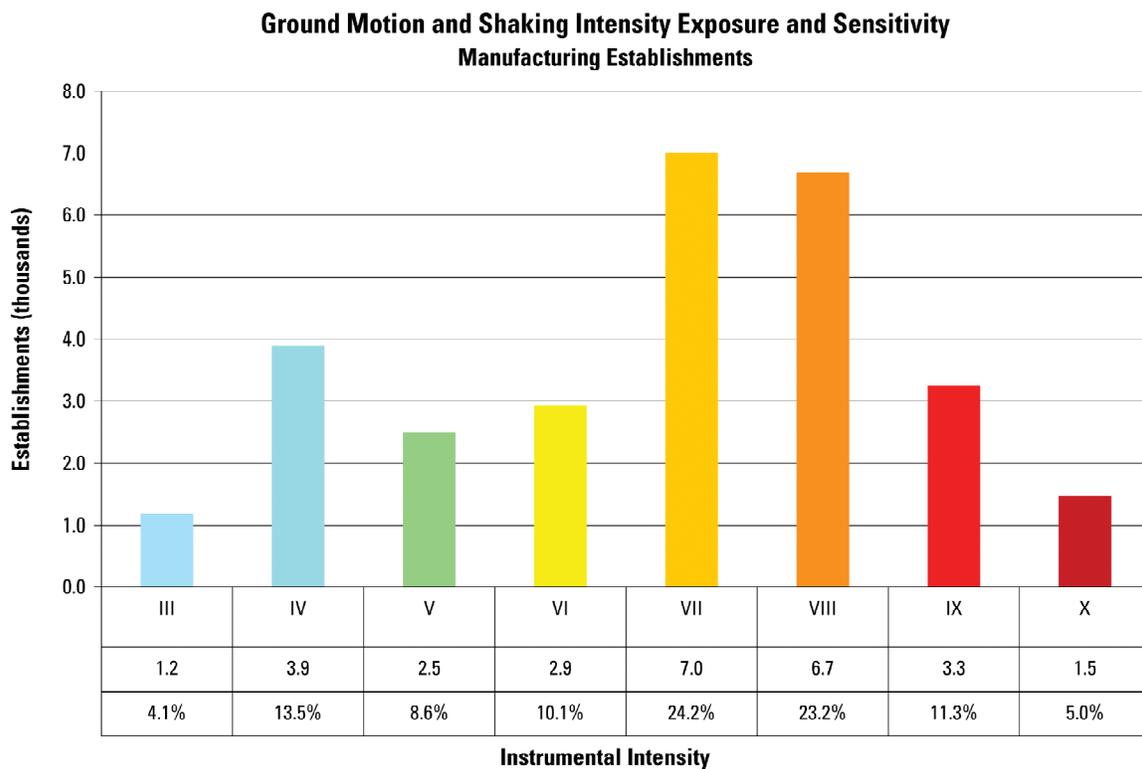
Figure 10. The estimated intensity distribution of Manufacturing establishments. Because of rounding, the percentages for each Instrumental Intensity may not total 100%.
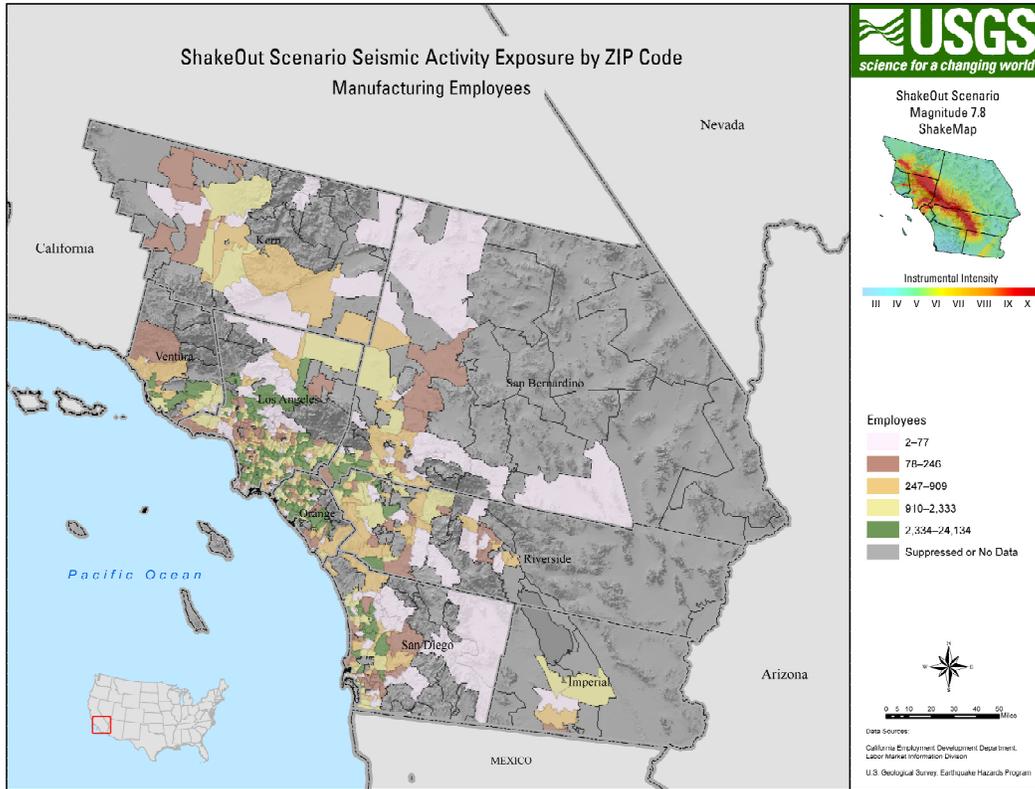
Figure 11.   The spatial distribution of Manufacturing employees. See figure 12 for Exposure and Sensitivity Summary.

Ground Motion and Shaking Intensity Exposure and Sensitivity
Manufacturing Employees

Instrumental Intensity	III	IV	V	VI	VII	VIII	IX	X
	27.9	112.9	88.5	70.0	176.9	193.3	117.5	35.7
	3.4%	13.7%	10.8%	8.5%	21.5%	23.5%	14.3%	4.3%
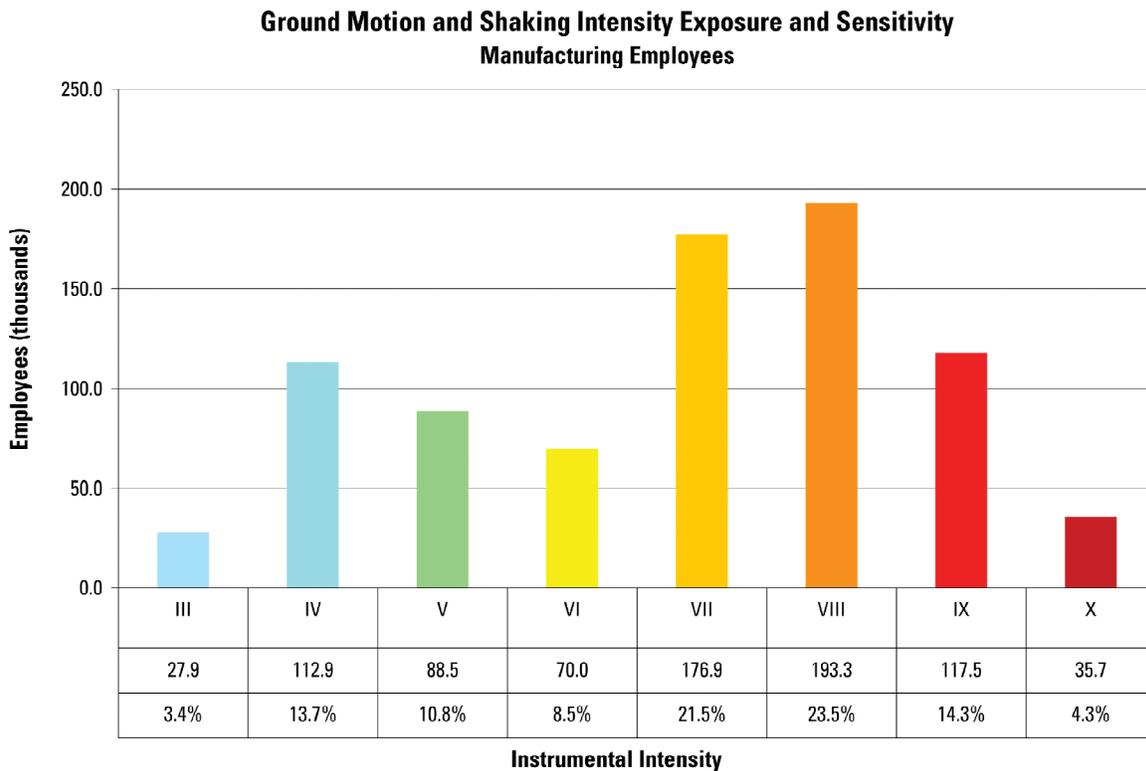
Figure 12.   The estimated intensity distribution of Manufacturing employees. Because of rounding, the percentages for each Instrumental Intensity may not total 100%.
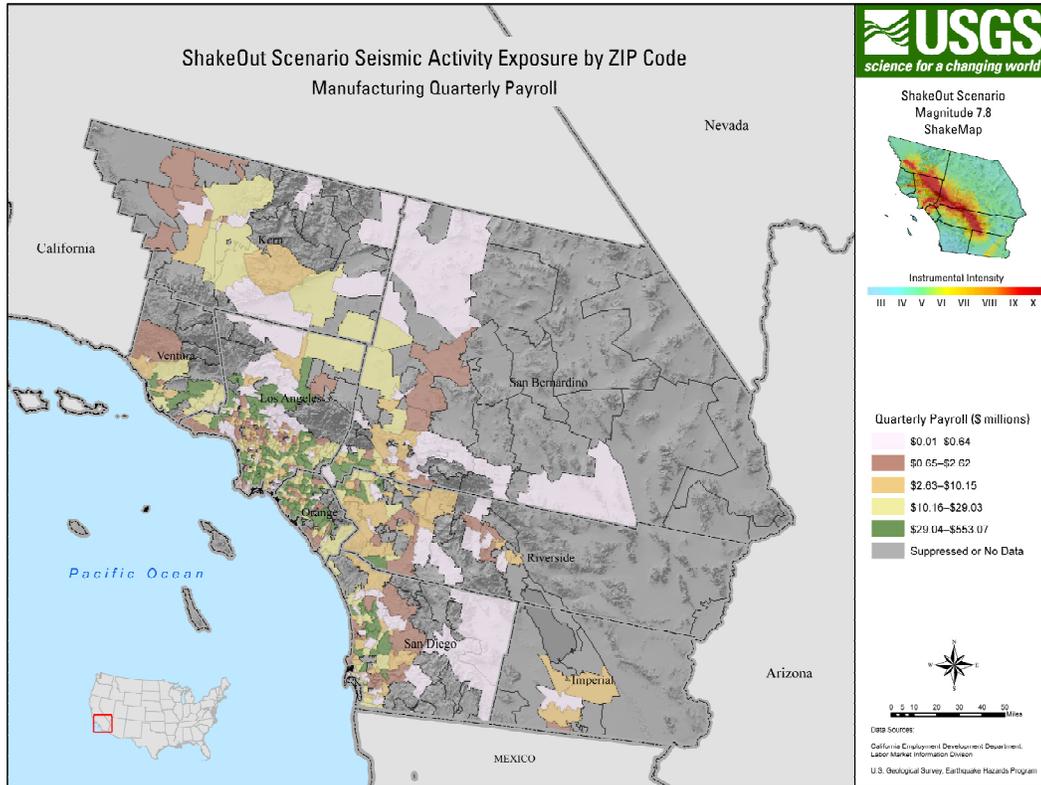
Figure 13.   The spatial distribution of Manufacturing quarterly payroll. See figure 14 for Exposure and Sensitivity Summary.

Ground Motion and Shaking Intensity Exposure and Sensitivity
Manufacturing Quarterly Payroll

Instrumental Intensity	III	IV	V	VI	VII	VIII	IX	X
	$390	$1,756	$1,690	$978	$2,200	$2,355	$1,346	$361
	3.520%	15.851%	15.262%	8.833%	19.863%	21.261%	12.153%	3.256%
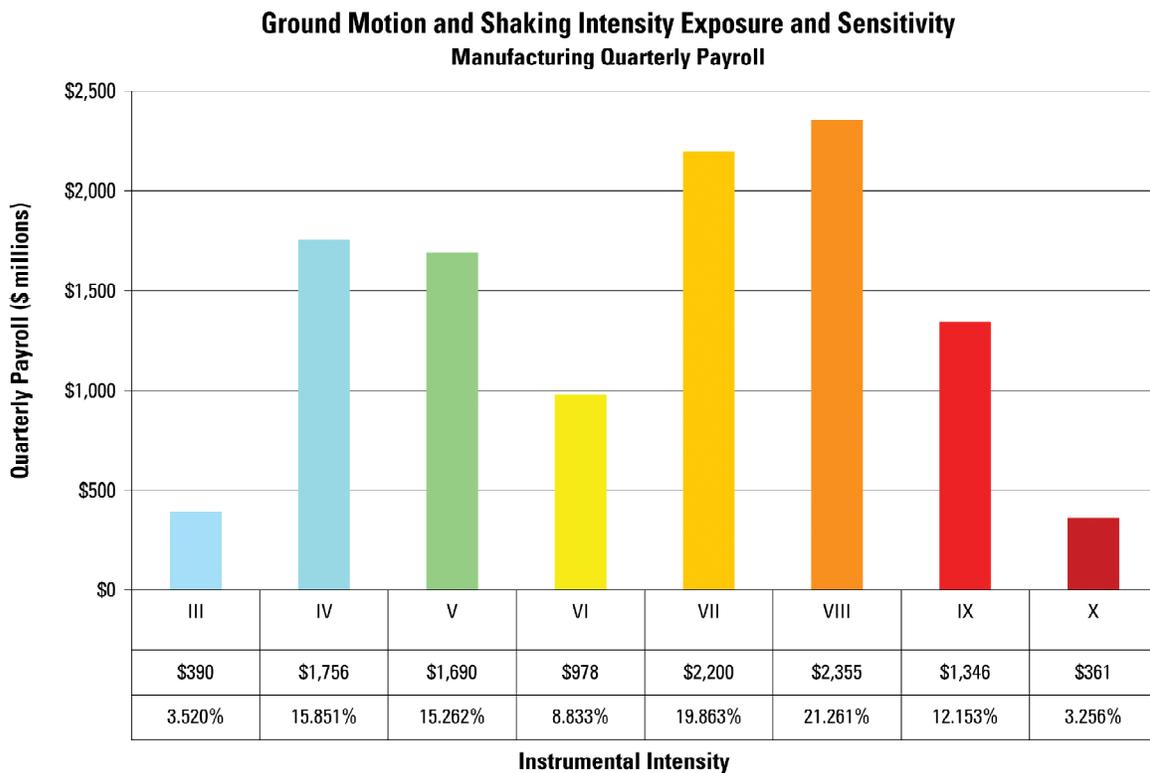
Figure 14.   The estimated intensity distribution of Manufacturing quarterly payroll. Because of rounding, the percentages for each Instrumental Intensity may not total 100%.

The ZIP codes estimated to experience an Instrumental Intensity of X (10) are illustrated below (fig. 15). They are located in four primary areas. Area 1 is centered in the Coachella Valley in Riverside County in communities immediately south and east of the City of Palm Springs. Area 2 includes the cities of San Bernardino and Loma Linda in southwestern San Bernardino County. Area 3 is located in southern Los Angeles County east of the City of Los Angeles. Area 4 extends from Lancaster and Palmdale in northern Los Angeles County into western San Bernardino County. Labor market exposure is greatest in Area 3 near the City of Los Angeles. Here, nearly 9,000 establishments employ over 142,000 workers earning nearly $1.5 billion in quarterly payroll (table 7). Area 4 is the least exposed, having fewer than 1,000 establishments with approximately 13,000 employees and $95 million in quarterly payroll. In total, these four areas contain over 16,000 establishments with over 290,000 employees earning $2.8 billion in quarterly payroll, accounting for approximately 3 percent of the region's labor market.

Level X Dominant Instrumental Intensity ZIP Codes

Area 1: Bryn Mawr, Cathedral City, Coachella, Desert Hot Springs, Indio, La Quinta, Mecca, Palm Desert, Salton City, Thermal, Thousand Palms

Area 2: Loma Linda, San Bernardino

Area 3: Baldwin Park, El Monte, La Puente, Montebello, Monterey Park, Rosemead, South El Monte, Temple City

Area 4: Lancaster, Littlerock, Lytle Creek, Palmdale, Pearblossom, Phelan, Pinon Hills, Wrightwood

Instrumental Intensity   III   IV   V   VI   VII   VIII   IX   X

Figure 15.   Level X dominant Instrumental Intensity ZIP codes. ZIP codes with an estimated Instrumental Intensity of X (10) are shown in red. In the regional map, the entire ZIP code is symbolized according to its dominant Instrumental Intensity. In the area maps, only the non-excluded land use areas are symbolized by dominant Instrumental Intensity while the original ZIP code boundaries are outlined. Point ZIP codes with an Instrumental Intensity of X are symbolized as red points on the area maps. Areas 1 through 4 are each shown at 1:1,000,000 scale.

Table 7. A summary of labor market exposure in ZIP codes estimated to experience an Instrumental Intensity of X.

Name	ZIP	Establishments	Employees[1]	Payroll ($ millions)
		Area 1		
Cathedral City	92234	820	10,419	$85.67
Coachella	92236	275	7,776	$64.73
Desert Hot Springs	92241	60	276	$1.79
Indio	92201	1,008	16,452	$137.12
Indio	92202	33	256	$2.45
Indio	92203	141	2,019	$21.07
La Quinta	92253	665	13,232	$104.48
Mecca	92254	39	1,597	$7.25
Palm Desert	92211	647	9,625	$82.30
Palm Desert	92255	39	187	$1.20
Palm Desert	92261	59	185	$1.63
Salton City	92275	10	89	$0.82
Thermal	92274	143	6,211	$36.16
Thousand Palms	92276	162	2,306	$19.14
Area 1 Total		4,101	70,630	$565.81
		Area 2		
Loma Linda	92350	10	--	--
Loma Linda	92354	281	11,156	$135.24
Loma Linda	92357	2	1,326	$17.05
San Bernardino	92401	387	7,414	$88.38
San Bernardino	92402	21	461	$3.66
San Bernardino	92403	4	--	--
San Bernardino	92408	1,035	29,068	$270.99
San Bernardino	92410	562	16,400	$175.26
San Bernardino	92412	26	157	$1.34
San Bernardino	92418	5	419	$4.96
San Bernardino	92423	14	21	$0.26
Area 2 Total		2,347	66,422	$697.14
		Area 3		
Baldwin Park	91706	1,322	31,927	$348.63
El Monte	91731	994	18,712	$194.97
El Monte	91732	553	6,390	$54.08
El Monte	91734	23	731	$8.71
El Monte	91735	6	--	--
La Puente	91746	836	17,396	$203.45
Montebello	90640	1,283	23,710	$222.79
Monterey Park	91755	319	2,449	$22.47
Rosemead	91770	993	15,006	$189.84
South El Monte	91733	1,768	20,345	$172.87
Temple City	91780	721	5,344	$37.62
Area 3 Total		8,818	142,010	$1,455.43
		Area 4		
Lancaster	93586	4	5	$0.06
Littlerock	93543	81	905	$11.87
Lytle Creek	92358	10	17	$0.17
Palmdale	93551	669	11,190	$75.23
Palmdale	93590	25	84	$0.79
Palmdale	93599	4	13	$0.31
Pearblossom	93553	16	240	$1.61
Phelan	92329	34	349	$2.71
Pinon Hills	92372	37	123	$1.11
Wrightwood	92397	67	266	$1.60
Area 4 Total		947	13,192	$95.46
TOTAL		**16,213**	**292,254**	**$2,813.84**

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

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 geo-coded 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. Neither do the estimates consider the variance among each Super Sector's specific vulnerabilities (for example, damage to roadways or utility lines that might disproportionately impact a particular Super Sector). 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 labor market that serves to characterize and highlight its potential vulnerabilities to the ShakeOut Scenario earthquake.

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Appendix 1. 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.

Appendix 2. Exposure and Sensitivity Estimates by Minimum, Maximum, Area Weighted, and Dominant Instrumental Intensities

Exposure and sensitivity estimates for establishments, employees, and quarterly payroll in both absolute quantities (exposure) and percentages (sensitivity) are presented by NAICS Super Sector using the two-digit codes (01 through 11) outlined in table 3. Because of rounding, the percentages for each Super Sector may not total 100%.

Establishment Exposure by Minimum Instrumental Intensity

Instrumental Intensity	ZIP Codes	EST01	EST02	EST03	EST04	EST05	EST06	EST07	EST08	EST09	EST10	EST11
III	128	442	5,829	2,667	12,066	1,125	8,674	14,160	6,914	5,860	5,822	1,043
IV	279	2,282	10,568	4,805	22,752	4,050	15,659	26,489	13,299	12,534	13,106	2,045
V	165	562	6,000	3,514	15,507	3,275	8,738	15,787	10,009	9,259	8,249	1,157
VI	180	177	5,397	5,356	19,344	2,585	8,780	15,645	9,454	8,998	8,314	1,275
VII	237	408	7,432	8,380	25,197	1,343	9,213	14,064	10,334	8,379	7,686	2,248
VIII	140	128	3,255	2,923	8,654	378	3,660	4,903	3,840	3,157	2,791	1,103
IX	59	69	1,030	1,070	4,190	162	1,284	1,726	1,729	1,323	1,164	672
X	24	62	388	182	805	38	242	448	251	258	206	90
TOTAL	**1,212**	**4,130**	**39,899**	**28,897**	**108,515**	**12,956**	**56,250**	**93,222**	**55,830**	**49,768**	**47,338**	**9,633**

Establishment Sensitivity by Minimum Instrumental Intensity

Instrumental Intensity	ZIP Code %	EST01	EST02	EST03	EST04	EST05	EST06	EST07	EST08	EST09	EST10	EST11
III	10.6%	10.7%	14.6%	9.2%	11.1%	8.7%	15.4%	15.2%	12.4%	11.8%	12.3%	10.8%
IV	23.0%	55.3%	26.5%	16.6%	21.0%	31.3%	27.8%	28.4%	23.8%	25.2%	27.7%	21.2%
V	13.6%	13.6%	15.0%	12.2%	14.3%	25.3%	15.5%	16.9%	17.9%	18.6%	17.4%	12.0%
VI	14.9%	4.3%	13.5%	18.5%	17.8%	20.0%	15.6%	16.8%	16.9%	18.1%	17.6%	13.2%
VII	19.6%	9.9%	18.6%	29.0%	23.2%	10.4%	16.4%	15.1%	18.5%	16.8%	16.2%	23.3%
VIII	11.6%	3.1%	8.2%	10.1%	8.0%	2.9%	6.5%	5.3%	6.9%	6.3%	5.9%	11.5%
IX	4.9%	1.7%	2.6%	3.7%	3.9%	1.3%	2.3%	1.9%	3.1%	2.7%	2.5%	7.0%
X	2.0%	1.5%	1.0%	0.6%	0.7%	0.3%	0.4%	0.5%	0.4%	0.5%	0.4%	0.9%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Establishment Exposure by Maximum Instrumental Intensity

Instrumental Intensity	ZIP Codes	EST01	EST02	EST03	EST04	EST05	EST06	EST07	EST08	EST09	EST10	EST11
III	53	7	511	98	560	34	376	632	288	271	245	348
IV	198	866	7,092	3,455	15,402	1,564	10,717	17,534	8,572	7,243	7,071	1,169
V	127	1,022	4,330	1,560	8,403	923	5,668	9,198	5,220	4,104	4,283	777
VI	175	581	4,572	2,443	14,400	4,119	8,778	16,727	9,693	10,208	10,283	832
VII	216	221	5,078	4,451	16,716	3,353	8,958	16,257	9,623	9,321	8,860	1,017
VIII	210	419	8,116	8,383	24,681	1,607	11,032	17,522	10,749	8,701	7,936	2,297
X	82	267	3,190	2,358	9,549	425	3,649	5,020	4,446	3,622	3,054	1,103
TOTAL	**1,212**	**4,130**	**39,899**	**28,897**	**108,515**	**12,956**	**56,250**	**93,222**	**55,830**	**49,768**	**47,338**	**9,633**

Establishment Sensitivity by Maximum Instrumental Intensity

Instrumental Intensity	ZIP Code %	EST01	EST02	EST03	EST04	EST05	EST06	EST07	EST08	EST09	EST10	EST11
III	4.4%	0.2%	1.3%	0.3%	0.5%	0.3%	0.7%	0.7%	0.5%	0.5%	0.5%	3.6%
IV	16.3%	21.0%	17.8%	12.0%	14.2%	12.1%	19.1%	18.8%	15.4%	14.6%	14.9%	12.1%
V	10.5%	24.7%	10.9%	5.4%	7.7%	7.1%	10.1%	9.9%	9.3%	8.2%	9.0%	8.1%
VI	14.4%	14.1%	11.5%	8.5%	13.3%	31.8%	15.6%	17.9%	17.4%	20.5%	21.7%	8.6%
VII	17.8%	5.4%	12.7%	15.4%	15.4%	25.9%	15.9%	17.4%	17.2%	18.7%	18.7%	10.6%
VIII	17.3%	10.1%	20.3%	29.0%	22.7%	12.4%	19.6%	18.8%	19.3%	17.5%	16.8%	23.8%
IX	12.5%	18.1%	17.6%	21.3%	17.3%	7.2%	12.6%	11.1%	13.0%	12.7%	11.8%	21.7%
X	6.8%	6.5%	8.0%	8.2%	8.8%	3.3%	6.5%	5.4%	8.0%	7.3%	6.5%	11.5%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Establishment Exposure by Area Weighted Instrumental Intensity

Instrumental Intensity	ZIP Codes	EST01	EST02	EST03	EST04	EST05	EST06	EST07	EST08	EST09	EST10	EST11
III	93	118	3,270	1,178	6,257	576	4,823	7,705	3,648	3,276	2,976	651
IV	223	1,761	8,115	3,728	16,939	1,971	11,025	18,431	9,578	7,926	8,710	1,557
V	145	654	4,836	2,587	13,441	3,417	8,200	14,969	8,396	9,200	8,418	866
VI	183	406	5,009	3,184	15,064	3,661	10,234	18,568	10,352	9,786	9,857	725
VII	235	443	7,367	7,433	22,950	1,709	9,210	14,848	9,719	7,863	7,084	2,182
VIII	192	489	6,770	6,478	19,837	1,063	7,810	11,960	8,174	6,729	6,002	2,211
IX	98	132	3,248	2,988	10,062	403	3,798	4,972	4,689	3,846	3,232	935
X	43	127	1,284	1,321	3,965	156	1,150	1,769	1,274	1,142	1,059	506
TOTAL	1,212	4,130	39,899	28,897	108,515	12,956	56,250	93,222	55,830	49,768	47,338	9,633

Establishment Sensitivity by Area Weighted Instrumental Intensity

Instrumental Intensity	ZIP Code %	EST01	EST02	EST03	EST04	EST05	EST06	EST07	EST08	EST09	EST10	EST11
III	7.7%	2.9%	8.2%	4.1%	5.8%	4.4%	8.6%	8.3%	6.5%	6.6%	6.3%	6.8%
IV	18.4%	42.6%	20.3%	12.9%	15.6%	15.2%	19.6%	19.8%	17.2%	15.9%	18.4%	16.2%
V	12.0%	15.8%	12.1%	9.0%	12.4%	26.4%	14.6%	16.1%	15.0%	18.5%	17.8%	9.0%
VI	15.1%	9.8%	12.6%	11.0%	13.9%	28.3%	18.2%	19.9%	18.5%	19.7%	20.8%	7.5%
VII	19.4%	10.7%	18.5%	25.7%	21.1%	13.2%	16.4%	15.9%	17.4%	15.8%	15.0%	22.7%
VIII	15.8%	11.8%	17.0%	22.4%	18.3%	8.2%	13.9%	12.8%	14.6%	13.5%	12.7%	23.0%
IX	8.1%	3.2%	8.1%	10.3%	9.3%	3.1%	6.8%	5.3%	8.4%	7.7%	6.8%	9.7%
X	3.5%	3.1%	3.2%	4.6%	3.7%	1.2%	2.0%	1.9%	2.3%	2.3%	2.2%	5.3%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Establishment Exposure by Dominant Instrumental Intensity

Instrumental Intensity	ZIP Codes	EST01	EST02	EST03	EST04	EST05	EST06	EST07	EST08	EST09	EST10	EST11
III	93	118	3,270	1,178	6,257	576	4,823	7,705	3,648	3,276	2,976	651
IV	236	1,809	8,766	3,895	18,304	2,421	12,195	20,240	10,973	9,185	10,233	1,656
V	134	680	4,146	2,499	12,261	2,697	7,028	12,944	6,943	7,607	6,675	853
VI	178	347	4,811	2,918	14,111	3,807	9,583	17,765	9,765	9,808	9,647	573
VII	229	298	6,941	7,006	21,965	1,637	8,762	13,893	9,735	7,540	6,988	2,019
VIII	188	426	6,926	6,692	20,568	1,187	8,456	13,272	8,286	7,000	6,160	1,970
IX	107	256	3,451	3,252	10,366	452	4,028	5,272	5,057	4,003	3,378	1,356
X	47	196	1,588	1,457	4,683	179	1,375	2,131	1,423	1,349	1,281	555
TOTAL	1,212	4,130	39,899	28,897	108,515	12,956	56,250	93,222	55,830	49,768	47,338	9,633

Establishment Sensitivity by Dominant Instrumental Intensity

Instrumental Intensity	ZIP Code %	EST01	EST02	EST03	EST04	EST05	EST06	EST07	EST08	EST09	EST10	EST11
III	7.7%	2.9%	8.2%	4.1%	5.8%	4.4%	8.6%	8.3%	6.5%	6.6%	6.3%	6.8%
IV	19.5%	43.8%	22.0%	13.5%	16.9%	18.7%	21.7%	21.7%	19.7%	18.5%	21.6%	17.2%
V	11.1%	16.5%	10.4%	8.6%	11.3%	20.8%	12.5%	13.9%	12.4%	15.3%	14.1%	8.9%
VI	14.7%	8.4%	12.1%	10.1%	13.0%	29.4%	17.0%	19.1%	17.5%	19.7%	20.4%	5.9%
VII	18.9%	7.2%	17.4%	24.2%	20.2%	12.6%	15.6%	14.9%	17.4%	15.2%	14.8%	21.0%
VIII	15.5%	10.3%	17.4%	23.2%	19.0%	9.2%	15.0%	14.2%	14.8%	14.1%	13.0%	20.5%
IX	8.8%	6.2%	8.6%	11.3%	9.6%	3.5%	7.2%	5.7%	9.1%	8.0%	7.1%	14.1%
X	3.9%	4.7%	4.0%	5.0%	4.3%	1.4%	2.4%	2.3%	2.5%	2.7%	2.7%	5.8%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Employee Exposure by Minimum Instrumental Intensity

Instrumental Intensity	ZIP Codes	EMP01	EMP02	EMP03	EMP04	EMP05	EMP06	EMP07	EMP08	EMP09	EMP10	EMP11
III	128	7,012	73,777	77,630	182,679	32,929	72,365	180,317	104,246	125,681	37,117	150,139
IV	279	70,775	110,654	155,323	341,943	39,971	146,503	294,211	156,478	200,229	59,270	220,791
V	165	19,694	78,408	99,177	219,414	56,108	70,683	185,181	150,175	127,948	42,297	129,629
VI	180	860	62,209	132,730	274,421	64,548	101,467	237,636	142,352	136,624	50,971	352,720
VII	237	5,259	97,288	235,944	390,429	27,986	92,024	197,008	153,208	149,004	49,922	191,833
VIII	140	710	42,794	82,411	136,672	5,605	26,303	63,105	64,933	56,372	18,285	94,786
IX	59	509	12,595	34,378	79,248	3,757	9,030	37,778	34,506	21,192	6,961	64,644
X	24	3,382	6,311	5,141	10,501	185	2,339	5,278	2,618	3,051	1,525	11,484
TOTAL	1,212	108,201	484,036	822,734	1,635,307	231,089	520,714	1,200,514	808,516	820,101	266,348	1,216,026

Employee Sensitivity by Minimum Instrumental Intensity

Instrumental Intensity	ZIP Code %	EMP01	EMP02	EMP03	EMP04	EMP05	EMP06	EMP07	EMP08	EMP09	EMP10	EMP11
III	10.6%	6.5%	15.2%	9.4%	11.2%	14.2%	13.9%	15.0%	12.9%	15.3%	13.9%	12.3%
IV	23.0%	65.4%	22.9%	18.9%	20.9%	17.3%	28.1%	24.5%	19.4%	24.4%	22.3%	18.2%
V	13.6%	18.2%	16.2%	12.1%	13.4%	24.3%	13.6%	15.4%	18.6%	15.6%	15.9%	10.7%
VI	14.9%	0.8%	12.9%	16.1%	16.8%	27.9%	19.5%	19.8%	17.6%	16.7%	19.1%	29.0%
VII	19.6%	4.9%	20.1%	28.7%	23.9%	12.1%	17.7%	16.4%	18.9%	18.2%	18.7%	15.8%
VIII	11.6%	0.7%	8.8%	10.0%	8.4%	2.4%	5.1%	5.3%	8.0%	6.9%	6.9%	7.8%
IX	4.9%	0.5%	2.6%	4.2%	4.8%	1.6%	1.7%	3.1%	4.3%	2.6%	2.6%	5.3%
X	2.0%	3.1%	1.3%	0.6%	0.6%	0.1%	0.4%	0.4%	0.3%	0.4%	0.6%	0.9%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Employee Exposure by Maximum Instrumental Intensity

Instrumental Intensity	ZIP Codes	EMP01	EMP02	EMP03	EMP04	EMP05	EMP06	EMP07	EMP08	EMP09	EMP10	EMP11
III	53	0	3,632	1,121	6,905	66	2,684	3,450	2,335	3,269	891	9,411
IV	198	29,373	86,804	103,951	229,865	38,874	88,688	216,016	122,684	150,474	44,217	196,832
V	127	29,991	38,331	41,983	107,547	8,373	37,193	86,096	63,370	73,687	19,978	87,259
VI	175	13,642	48,375	72,630	224,360	66,810	81,731	193,969	123,409	144,029	46,196	135,763
VII	216	1,227	51,513	104,710	214,662	68,259	105,383	214,413	153,865	122,384	46,523	98,341
VIII	210	5,163	113,303	222,511	390,840	24,817	118,346	270,398	159,156	151,339	52,361	434,347
IX	151	18,989	103,649	211,470	313,021	16,397	60,737	150,416	112,428	104,676	36,898	159,598
X	82	9,816	38,429	64,358	148,107	7,493	25,952	65,756	71,269	70,243	19,284	94,475
TOTAL	1,212	108,201	484,036	822,734	1,635,307	231,089	520,714	1,200,514	808,516	820,101	266,348	1,216,026

Employee Sensitivity by Maximum Instrumental Intensity

Instrumental Intensity	ZIP Code %	EMP01	EMP02	EMP03	EMP04	EMP05	EMP06	EMP07	EMP08	EMP09	EMP10	EMP11
III	4.4%	0.0%	0.8%	0.1%	0.4%	0.0%	0.5%	0.3%	0.3%	0.4%	0.3%	0.8%
IV	16.3%	27.1%	17.9%	12.6%	14.1%	16.8%	17.0%	18.0%	15.2%	18.3%	16.6%	16.2%
V	10.5%	27.7%	7.9%	5.1%	6.6%	3.6%	7.1%	7.2%	7.8%	9.0%	7.5%	7.2%
VI	14.4%	12.6%	10.0%	8.8%	13.7%	28.9%	15.7%	16.2%	15.3%	17.6%	17.3%	11.2%
VII	17.8%	1.1%	10.6%	12.7%	13.1%	29.5%	20.2%	17.9%	19.0%	14.9%	17.5%	8.1%
VIII	17.3%	4.8%	23.4%	27.0%	23.9%	10.7%	22.7%	22.5%	19.7%	18.5%	19.7%	35.7%
IX	12.5%	17.5%	21.4%	25.7%	19.1%	7.1%	11.7%	12.5%	13.9%	12.8%	13.9%	13.1%
X	6.8%	9.1%	7.9%	7.8%	9.1%	3.2%	5.0%	5.5%	8.8%	8.6%	7.2%	7.8%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Employee Exposure by Area Weighted Instrumental Intensity

Instrumental Intensity	ZIP Codes	EMP01	EMP02	EMP03	EMP04	EMP05	EMP06	EMP07	EMP08	EMP09	EMP10	EMP11
III	93	515	39,990	27,922	98,576	11,882	42,551	96,648	60,239	70,456	20,862	92,014
IV	223	53,818	86,604	110,901	229,412	34,986	80,731	195,950	117,645	149,283	41,836	168,804
V	145	20,190	50,118	85,941	210,880	39,723	67,638	163,375	112,699	124,314	38,058	152,461
VI	183	9,489	52,568	77,658	203,883	80,725	120,906	252,793	137,262	134,396	47,828	73,339
VII	235	9,783	104,568	196,810	339,183	36,382	100,798	225,847	157,092	139,453	50,071	408,933
VIII	192	7,752	95,073	181,851	320,923	18,656	76,427	174,041	127,301	110,811	40,731	177,147
IX	98	1,349	37,079	112,741	170,259	5,132	23,225	65,758	70,083	72,954	20,433	102,074
X	43	5,305	18,036	28,910	62,191	3,603	8,43-8	26,102	26,195	18,434	6,529	41,254
TOTAL	**1,212**	**108,201**	**484,036**	**822,734**	**1,635,307**	**231,089**	**520,714**	**1,200,514**	**808,516**	**820,101**	**266,348**	**1,216,026**

Employee Sensitivity by Area Weighted Instrumental Intensity

Instrumental Intensity	ZIP Code %	EMP01	EMP02	EMP03	EMP04	EMP05	EMP06	EMP07	EMP08	EMP09	EMP10	EMP11
III	7.7%	0.5%	8.3%	3.4%	6.0%	5.1%	8.2%	8.1%	7.5%	8.6%	7.8%	7.6%
IV	18.4%	49.7%	17.9%	13.5%	14.0%	15.1%	15.5%	16.3%	14.6%	18.2%	15.7%	13.9%
V	12.0%	18.7%	10.4%	10.4%	12.9%	17.2%	13.0%	13.6%	13.9%	15.2%	14.3%	12.5%
VI	15.1%	8.8%	10.9%	9.4%	12.5%	34.9%	23.2%	21.1%	17.0%	16.4%	18.0%	6.0%
VII	19.4%	9.0%	21.6%	23.9%	20.7%	15.7%	19.4%	18.8%	19.4%	17.0%	18.8%	33.6%
VIII	15.8%	7.2%	19.6%	22.1%	19.6%	8.1%	14.7%	14.5%	15.7%	13.5%	15.3%	14.6%
IX	8.1%	1.2%	7.7%	13.7%	10.4%	2.2%	4.5%	5.5%	8.7%	8.9%	7.7%	8.4%
X	3.5%	4.9%	3.7%	3.5%	3.8%	1.6%	1.6%	2.2%	3.2%	2.2%	2.5%	3.4%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Employee Exposure by Dominant Instrumental Intensity

Instrumental Intensity	ZIP Codes	EMP01	EMP02	EMP03	EMP04	EMP05	EMP06	EMP07	EMP08	EMP09	EMP10	EMP11
III	93	515	39,990	27,922	98,576	11,882	42,551	96,648	60,239	70,456	20,862	92,014
IV	236	56,415	90,779	112,919	247,166	37,424	86,916	208,641	131,236	163,629	46,893	176,708
V	134	18,119	43,170	88,486	197,545	37,713	59,831	152,597	97,846	113,691	32,591	154,350
VI	178	10,424	51,947	70,019	187,120	78,831	111,246	228,145	127,982	126,112	46,165	60,586
VII	229	2,288	94,426	176,907	313,020	34,639	92,941	207,666	156,561	128,286	48,526	403,443
VIII	188	4,208	102,824	193,273	340,955	20,958	88,144	208,091	131,852	124,200	41,900	171,691
IX	107	7,336	38,500	117,548	177,042	5,768	29,224	68,328	75,488	68,206	21,936	110,259
X	47	8,896	22,400	35,660	73,883	3,874	9,861	30,398	27,312	25,521	7,475	46,975
TOTAL	**1,212**	**108,201**	**484,036**	**822,734**	**1,635,307**	**231,089**	**520,714**	**1,200,514**	**808,516**	**820,101**	**266,348**	**1,216,026**

Employee Sensitivity by Dominant Instrumental Intensity

Instrumental Intensity	ZIP Code %	EMP01	EMP02	EMP03	EMP04	EMP05	EMP06	EMP07	EMP08	EMP09	EMP10	EMP11
III	7.7%	0.5%	8.3%	3.4%	6.0%	5.1%	8.2%	8.1%	7.5%	8.6%	7.8%	7.6%
IV	19.5%	52.1%	18.8%	13.7%	15.1%	16.2%	16.7%	17.4%	16.2%	20.0%	17.6%	14.5%
V	11.1%	16.7%	8.9%	10.8%	12.1%	16.3%	11.5%	12.7%	12.1%	13.9%	12.2%	12.7%
VI	14.7%	9.6%	10.7%	8.5%	11.4%	34.1%	21.4%	19.0%	15.8%	15.4%	17.3%	5.0%
VII	18.9%	2.1%	19.5%	21.5%	19.1%	15.0%	17.8%	17.3%	19.4%	15.6%	18.2%	33.2%
VIII	15.5%	3.9%	21.2%	23.5%	20.8%	9.1%	16.9%	17.3%	16.3%	15.1%	15.7%	14.1%
IX	8.8%	6.8%	8.0%	14.3%	10.8%	2.5%	5.6%	5.7%	9.3%	8.3%	8.2%	9.1%
X	3.9%	8.2%	4.6%	4.3%	4.5%	1.7%	1.9%	2.5%	3.4%	3.1%	2.8%	3.9%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Quarterly Payroll ($ millions) Exposure by Minimum Instrumental Intensity

Instrumental Intensity	ZIP Codes	PAY01	PAY02	PAY03	PAY04	PAY05	PAY06	PAY07	PAY08	PAY09	PAY10	PAY11
III	128	$40	$995	$1,269	$1,643	$754	$1,115	$2,860	$1,226	$648	$266	$1,903
IV	279	$468	$1,485	$2,616	$3,585	$1,159	$3,109	$4,764	$1,912	$1,578	$458	$2,389
V	165	$132	$1,057	$1,398	$2,250	$1,432	$1,297	$2,750	$2,028	$1,640	$327	$1,477
VI	180	$7	$858	$1,746	$2,798	$1,443	$2,191	$3,798	$1,553	$1,224	$395	$4,731
VII	237	$33	$1,253	$2,719	$3,742	$531	$1,334	$2,127	$1,697	$715	$377	$2,349
VIII	140	$4	$533	$881	$1,196	$69	$336	$610	$698	$244	$128	$1,167
IX	59	$5	$157	$391	$768	$43	$113	$329	$372	$85	$47	$798
X	24	$16	$70	$54	$98	$2	$20	$45	$22	$13	$11	$135
TOTAL	**1,212**	**$705**	**$6,408**	**$11,074**	**$16,080**	**$5,433**	**$9,515**	**$17,283**	**$9,508**	**$6,147**	**$2,009**	**$14,949**

Quarterly Payroll Sensitivity by Minimum Instrumental Intensity

Instrumental Intensity	ZIP Code %	PAY01	PAY02	PAY03	PAY04	PAY05	PAY06	PAY07	PAY08	PAY09	PAY10	PAY11
III	10.6%	5.7%	15.5%	11.5%	10.2%	13.9%	11.7%	16.5%	12.9%	10.5%	13.2%	12.7%
IV	23.0%	66.4%	23.2%	23.6%	22.3%	21.3%	32.7%	27.6%	20.1%	25.7%	22.8%	16.0%
V	13.6%	18.7%	16.5%	12.6%	14.0%	26.4%	13.6%	15.9%	21.3%	26.7%	16.3%	9.9%
VI	14.9%	1.0%	13.4%	15.8%	17.4%	26.6%	23.0%	22.0%	16.3%	19.9%	19.7%	31.6%
VII	19.6%	4.7%	19.6%	24.6%	23.3%	9.8%	14.0%	12.3%	17.8%	11.6%	18.8%	15.7%
VIII	11.6%	0.6%	8.3%	8.0%	7.4%	1.3%	3.5%	3.5%	7.3%	4.0%	6.4%	7.8%
IX	4.9%	0.7%	2.5%	3.5%	4.8%	0.8%	1.2%	1.9%	3.9%	1.4%	2.3%	5.3%
X	2.0%	2.3%	1.1%	0.5%	0.6%	0.0%	0.2%	0.3%	0.2%	0.2%	0.5%	0.9%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Quarterly Payroll ($ millions) Exposure by Maximum Instrumental Intensity

Instrumental Intensity	ZIP Codes	PAY01	PAY02	PAY03	PAY04	PAY05	PAY06	PAY07	PAY08	PAY09	PAY10	PAY11
III	53	$0	$40	$16	$43	$1	$44	$36	$20	$11	$5	$108
IV	198	$142	$1,175	$1,652	$2,132	$883	$1,462	$3,366	$1,426	$793	$322	$2,342
V	127	$203	$482	$769	$997	$167	$617	$1,094	$767	$385	$145	$1,000
VI	175	$132	$681	$1,297	$2,283	$1,890	$1,726	$3,779	$1,695	$1,997	$365	$1,543
VII	216	$12	$640	$1,370	$2,212	$1,775	$2,250	$3,579	$1,891	$1,451	$365	$1,303
VIII	210	$41	$1,569	$2,732	$4,009	$424	$2,315	$3,312	$1,742	$733	$394	$5,633
IX	151	$129	$1,369	$2,480	$3,089	$211	$797	$1,503	$1,191	$416	$267	$1,855
X	82	$48	$451	$758	$1,311	$82	$304	$616	$777	$362	$145	$1,162
TOTAL	**1,212**	**$707**	**$6,407**	**$11,074**	**$16,076**	**$5,433**	**$9,515**	**$17,285**	**$9,509**	**$6,148**	**$2,008**	**$14,946**

Quarterly Payroll Sensitivity by Maximum Instrumental Intensity

Instrumental Intensity	ZIP Code %	PAY01	PAY02	PAY03	PAY04	PAY05	PAY06	PAY07	PAY08	PAY09	PAY10	PAY11
III	4.4%	0.0%	0.6%	0.1%	0.3%	0.0%	0.5%	0.2%	0.2%	0.2%	0.2%	0.7%
IV	16.3%	20.1%	18.3%	14.9%	13.3%	16.3%	15.4%	19.5%	15.0%	12.9%	16.0%	15.7%
V	10.5%	28.7%	7.5%	6.9%	6.2%	3.1%	6.5%	6.3%	8.1%	6.3%	7.2%	6.7%
VI	14.4%	18.7%	10.6%	11.7%	14.2%	34.8%	18.1%	21.9%	17.8%	32.5%	18.2%	10.3%
VII	17.8%	1.7%	10.0%	12.4%	13.8%	32.7%	23.6%	20.7%	19.9%	23.6%	18.2%	8.7%
VIII	17.3%	5.8%	24.5%	24.7%	24.9%	7.8%	24.3%	19.2%	18.3%	11.9%	19.6%	37.7%
IX	12.5%	18.2%	21.4%	22.4%	19.2%	3.9%	8.4%	8.7%	12.5%	6.8%	13.3%	12.4%
X	6.8%	6.8%	7.0%	6.8%	8.2%	1.5%	3.2%	3.6%	8.2%	5.9%	7.2%	7.8%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Quarterly Payroll ($ millions) Exposure by Area Weighted Instrumental Intensity

Instrumental Intensity	ZIP Codes	PAY01	PAY02	PAY03	PAY04	PAY05	PAY06	PAY07	PAY08	PAY09	PAY10	PAY11
III	93	$5	$521	$390	$812	$189	$639	$1,414	$698	$386	$155	$1,246
IV	223	$353	$1,164	$1,733	$2,228	$852	$1,404	$2,965	$1,391	$791	$298	$1,823
V	145	$135	$661	$1,648	$2,198	$1,327	$1,292	$2,915	$1,542	$1,487	$294	$1,717
VI	183	$78	$726	$1,094	$2,121	$1,954	$3,080	$4,516	$1,707	$1,537	$378	$933
VII	235	$55	$1,408	$2,507	$3,449	$762	$1,679	$2,864	$1,792	$1,052	$392	$5,302
VIII	192	$44	$1,271	$2,129	$3,123	$250	$1,062	$1,742	$1,333	$455	$302	$2,207
IX	98	$10	$446	$1,289	$1,536	$61	$260	$649	$775	$357	$144	$1,222
X	43	$27	$211	$285	$610	$39	$97	$219	$271	$81	$47	$497
TOTAL	1,212	$707	$6,408	$11,075	$16,077	$5,434	$9,513	$17,284	$9,509	$6,146	$2,010	$14,947

Quarterly Payroll Sensitivity by Area Weighted Instrumental Intensity

Instrumental Intensity	ZIP Code %	PAY01	PAY02	PAY03	PAY04	PAY05	PAY06	PAY07	PAY08	PAY09	PAY10	PAY11
III	7.7%	0.7%	8.1%	3.5%	5.1%	3.5%	6.7%	8.2%	7.3%	6.3%	7.7%	8.3%
IV	18.4%	49.9%	18.2%	15.6%	13.9%	15.7%	14.8%	17.2%	14.6%	12.9%	14.8%	12.2%
V	12.0%	19.1%	10.3%	14.9%	13.7%	24.4%	13.6%	16.9%	16.2%	24.2%	14.6%	11.5%
VI	15.1%	11.0%	11.3%	9.9%	13.2%	36.0%	32.4%	26.1%	18.0%	25.0%	18.8%	6.2%
VII	19.4%	7.8%	22.0%	22.6%	21.5%	14.0%	17.6%	16.6%	18.8%	17.1%	19.5%	35.5%
VIII	15.8%	6.2%	19.8%	19.2%	19.4%	4.6%	11.2%	10.1%	14.0%	7.4%	15.0%	14.8%
IX	8.1%	1.4%	7.0%	11.6%	9.6%	1.1%	2.7%	3.8%	8.2%	5.8%	7.2%	8.2%
X	3.5%	3.8%	3.3%	2.6%	3.8%	0.7%	1.0%	1.3%	2.8%	1.3%	2.3%	3.3%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Quarterly Payroll ($ millions) Exposure by Dominant Instrumental Intensity

Instrumental Intensity	ZIP Codes	PAY01	PAY02	PAY03	PAY04	PAY05	PAY06	PAY07	PAY08	PAY09	PAY10	PAY11
III	93	$5	$521	$390	$812	$189	$639	$1,414	$698	$386	$155	$1,246
IV	236	$371	$1,212	$1,756	$2,403	$999	$1,529	$3,181	$1,588	$1,002	$339	$1,922
V	134	$127	$594	$1,690	$2,167	$1,028	$1,144	$2,701	$1,313	$1,198	$256	$1,778
VI	178	$72	$669	$978	$1,819	$2,076	$2,855	$4,167	$1,593	$1,583	$357	$737
VII	229	$19	$1,302	$2,200	$3,096	$693	$1,540	$2,538	$1,818	$1,001	$376	$5,257
VIII	188	$30	$1,376	$2,355	$3,442	$339	$1,363	$2,336	$1,372	$537	$316	$2,129
IX	107	$42	$474	$1,346	$1,629	$68	$329	$693	$848	$294	$155	$1,324
X	47	$41	$259	$361	$710	$41	$115	$255	$279	$146	$54	$554
TOTAL	1,212	$707	$6,407	$11,076	$16,078	$5,433	$9,514	$17,285	$9,509	$6,147	$2,008	$14,947

Quarterly Payroll Sensitivity by Dominant Instrumental Intensity

Instrumental Intensity	ZIP Code %	PAY01	PAY02	PAY03	PAY04	PAY05	PAY06	PAY07	PAY08	PAY09	PAY10	PAY11
III	7.7%	0.7%	8.1%	3.5%	5.1%	3.5%	6.7%	8.2%	7.3%	6.3%	7.7%	8.3%
IV	19.5%	52.5%	18.9%	15.9%	14.9%	18.4%	16.1%	18.4%	16.7%	16.3%	16.9%	12.9%
V	11.1%	18.0%	9.3%	15.3%	13.5%	18.9%	12.0%	15.6%	13.8%	19.5%	12.7%	11.9%
VI	14.7%	10.2%	10.4%	8.8%	11.3%	38.2%	30.0%	24.1%	16.8%	25.8%	17.8%	4.9%
VII	18.9%	2.7%	20.3%	19.9%	19.3%	12.8%	16.2%	14.7%	19.1%	16.3%	18.7%	35.2%
VIII	15.5%	4.2%	21.5%	21.3%	21.4%	6.2%	14.3%	13.5%	14.4%	8.7%	15.7%	14.2%
IX	8.8%	5.9%	7.4%	12.2%	10.1%	1.3%	3.5%	4.0%	8.9%	4.8%	7.7%	8.9%
X	3.9%	5.8%	4.0%	3.3%	4.4%	0.8%	1.2%	1.5%	2.9%	2.4%	2.7%	3.7%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**