

Bay Area Earthquake Shelter Needs White Paper

After a moderate or major earthquake in the Bay Area, housing damage will displace residents and force residents to seek shelter. Many jurisdictions are not prepared for the magnitude of shelter seekers not just from within their own jurisdiction but from neighboring jurisdictions. The analysis here is designed to help jurisdictions – and residents – understand what shelter needs might look like after a Bay Area earthquake and plan ahead to meet the region’s shelter needs. The companion paper, *Bay Area Earthquake Residential Building Damage White Paper*, discusses how local policies can reduce displacement, and therefore shelter needs, before the earthquake occurs.

Who will seek shelter?

For the purposes of this study, the numbers of people who seek shelter are not the same as the number of people who are displaced from their homes. Shelter-seekers are those who will seek publicly or privately-provided sheltering, including beds, meals, and basic services. Many people who are displaced will leave their homes but not seek shelter in the sense we are using it here – they will stay in a hotel, stay with a neighbor or relative, or temporarily leave the region. Anticipating whether or not a resident will seek shelter depends on a number of demographic characteristics, as explained below.

The shelter numbers in this analysis were estimated using FEMA’s Hazus multi-hazard loss estimation methodology and software, with modified model parameters based on prior research. Hazus is a Geographic Information Systems (GIS)-based computer model that utilizes an algorithm combining hazard areas, anticipated damage, and population characteristics to determine how many residents are likely to seek shelter. The adjusted model uses a number of assumptions determined by behavior in past earthquakes. Some of these assumptions are¹:

- 100% of residents in both single family and multifamily homes that are completely damaged will be displaced and need shelter. In homes that are extensively damaged but not completely damaged, more residents of multifamily homes will seek shelter than single family homes. Some residents will also seek shelter if their home is moderately damaged, even if their home is technically habitable; this could be due to fear about extent of damage or additional damage from aftershocks, or due to utility outage.
- Ethnicity is assumed to influence whether residents will seek shelter. Hispanic and Black households are assumed to be more likely to seek shelter. White, Asian, and Native American households are assumed less likely to seek shelter.
- Income is the largest determinate in shelter-seeking behavior. Lower income households are five times more likely to seek shelter than higher income households.

¹ Seligson, Hope (May 9, 2017). Technical Memo #3 – Hazus Earthquake Scenario Housing-Related Impact Estimates, Methodology, & Results, Prepared for the Association of Bay Area Governments

It should be noted that the Hazus shelter model parameters, including the refined parameters utilized in the current analyses, are based on available historic earthquake data. Because these historic events have generally been of Magnitude less than 7 (e.g., M6.9 Loma Prieta and M6.7 Northridge earthquakes), it is possible that the shelter estimates do not adequately reflect the broader regional impacts expected in larger scenarios. Accordingly, the short-term shelter estimates presented here could be considered lower-bound estimates.

How many people will seek shelter?

In the earthquake scenario with the greatest anticipated regional impact, a magnitude 7.8 on the San Andreas Fault (similar to the 1906 earthquake), approximately 51,600 people throughout the Bay Area will seek shelter. Approximately a third of these residents (16,500) will be in San Francisco. Santa Clara County and San Mateo County will also have large numbers of residents seeking shelter (12,700 and 11,000, respectively). These concentrations are to be expected as these counties lie closest to the San Andreas Fault. Alameda County will have about 7,500 shelter seekers and the remaining counties will each have 1,500 or fewer. However, while these numbers sound large, they represent relatively small percentages of the total county population: 0.7% of the overall region’s population; in San Francisco 2% of the population; Santa Clara County 0.7%; San Mateo County 1.5%; Alameda, Contra Costa, Marin, Napa, Solano, and Sonoma Counties less than 1%. For shelter numbers for all counties, see Figure 1.

As mentioned above, not everyone who is displaced will seek shelter. In the San Andreas scenario, regionally only 10.8% of residents who are displaced will seek shelter. This number will be highest in Napa County (12.5%) and lowest in San Mateo County (9.9%). Approximately the same percentage of people who are displaced from their homes will seek shelter whether they were displaced from single family, multifamily, or mobile homes, though nearly four times more people in the region who end up in shelters will be coming from multifamily buildings than from single family buildings and manufactured homes combined. For a breakdown of shelter numbers by displaced household type, see

| | Marin | Sonoma | Napa | Solano | Contra Costa | Alameda | Santa Clara | San Mateo | San Francisco | Total |
|---|-------|--------|------|--------|--------------|---------|-------------|-----------|---------------|--------|
| Short-term shelter – Multi-Family origin | 1,100 | 500 | 100 | 200 | 900 | 6,000 | 9,800 | 7,000 | 14,300 | 27,300 |
| Short-term shelter – Single Family origin | 400 | 200 | 0 | 0 | 200 | 1,300 | 2,100 | 3,700 | 2,200 | 7,700 |
| Short-term shelter – Manufactured Home origin | 100 | 200 | 0 | 0 | 100 | 200 | 800 | 300 | 0 | 1,000 |

Figure 2.

Short-term Shelter Loads - San Andreas M 7.8

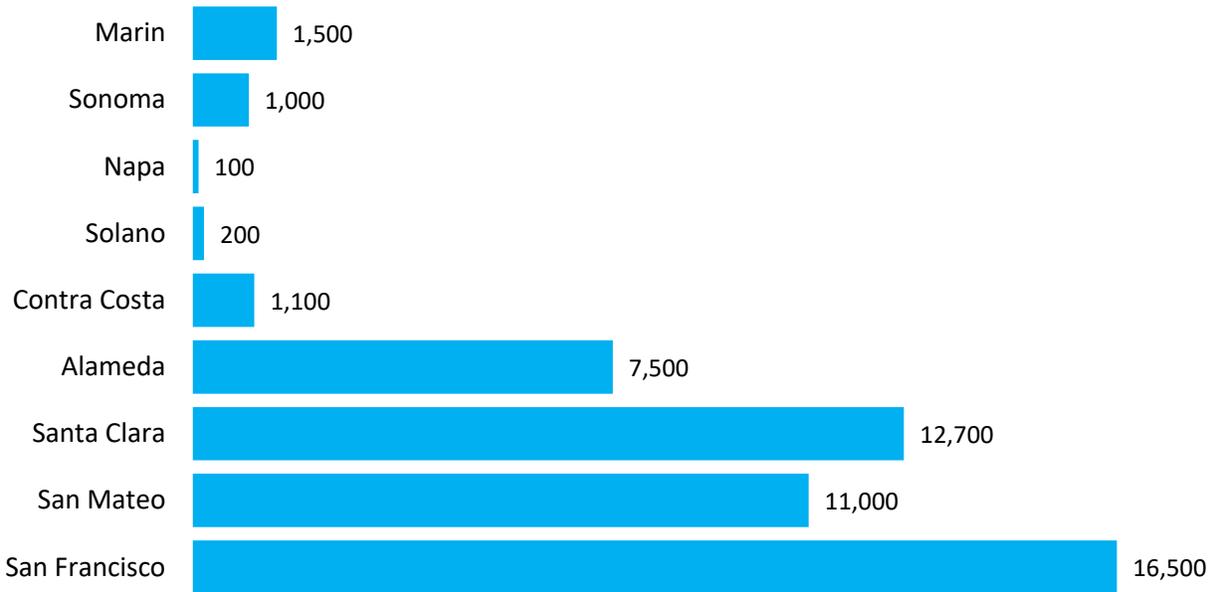
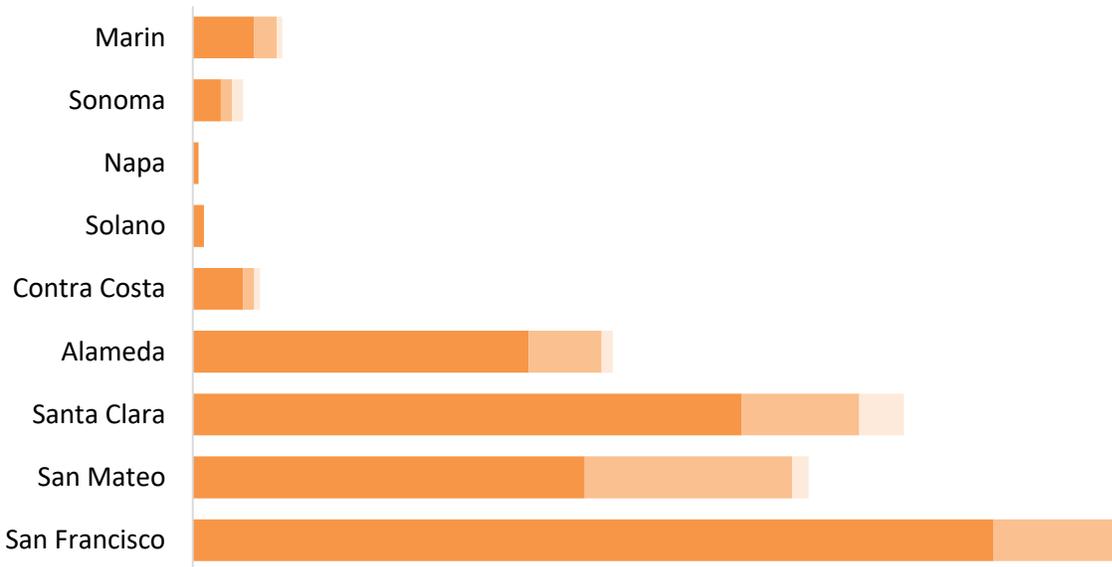


Figure 1: Short-term shelter loads (number of people) for a M7.8 earthquake on all northern segments of the San Andreas Fault

Short-Term Shelter Loads by Housing Type - San Andreas (All Northern Segments) M7.8



| | Marin | Sonoma | Napa | Solano | Contra Costa | Alameda | Santa Clara | San Mateo | San Francisco | Total |
|--|-------|--------|------|--------|--------------|---------|-------------|-----------|---------------|--------|
| Short-term shelter – Multi-Family origin | 1,100 | 500 | 100 | 200 | 900 | 6,000 | 9,800 | 7,000 | 14,300 | 27,300 |

| | | | | | | | | | | |
|---|-----|-----|---|---|-----|-------|-------|-------|-------|-------|
| Short-term shelter – Single Family origin | 400 | 200 | 0 | 0 | 200 | 1,300 | 2,100 | 3,700 | 2,200 | 7,700 |
| Short-term shelter – Manufactured Home origin | 100 | 200 | 0 | 0 | 100 | 200 | 800 | 300 | 0 | 1,000 |

Figure 2: Short-Term shelter loads (number of people) by housing type for a M7.8 earthquake on all northern segments of the San Andreas Fault

In a large scenario on an East Bay fault, a magnitude 7.0 earthquake on the North and South segments of the Hayward Fault, the overall shelter numbers will be lower, and distributed differently across the region. In this scenario, the total number of residents seeking shelter would be 42,000 (0.6% of the region’s population). 23,100 of those would be in Alameda County (1.5% of the population); 6,500 in Santa Clara County (0.4%); 5,100 in San Francisco County (0.6%); 4,300 in Contra Costa County (0.4%); 1,300 in San Mateo County (0.2%); 800 in Marin County (0.3%), and 500 or less in the remaining counties. For shelter numbers for all counties, see Figure 3.

In the Hayward scenario, regionally 11.6% of residents who are displaced will seek shelter. This number will be highest in Solano County (13.2%) and lowest in Napa County (8.3%). A similar percentage of people who are displaced from their homes will seek shelter whether they were displaced from single family, multifamily, or mobile homes, though, like the San Andreas scenario, 75% of those seeking shelter in the region will be coming from multifamily buildings rather than single family or manufactured homes.

Short-term Shelter Loads - Hayward North + South M7.0

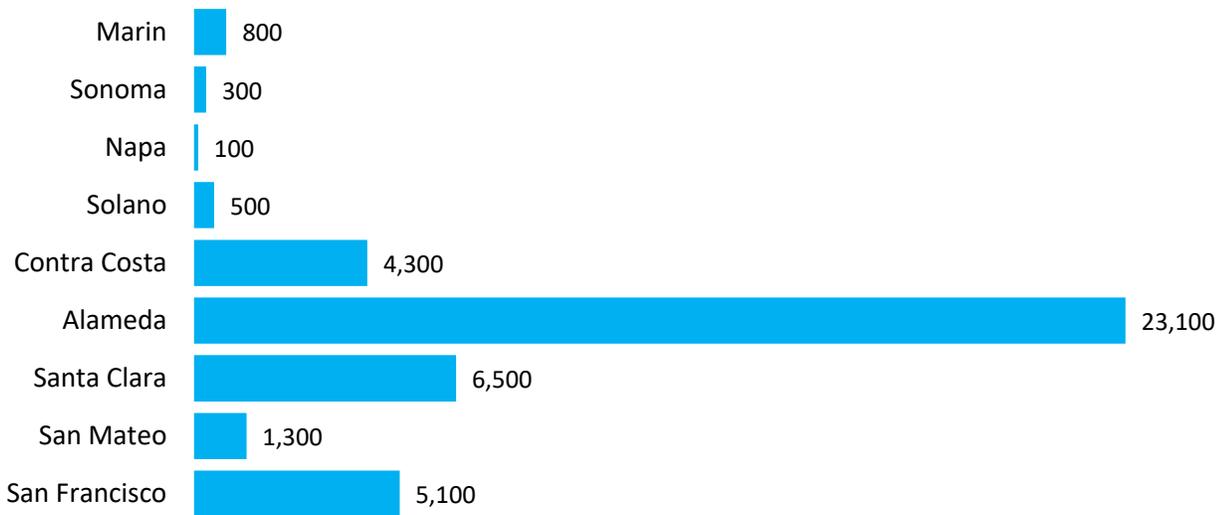


Figure 3: Short-term shelter loads (number of people) for a M7.0 earthquake on the North and South segment of the Hayward Fault

Smaller events, or those occurring outside of the major population centers, will lead to smaller shelter demands. For example, a M6.7 earthquake on the West Napa Fault will cause approximately 5,600 residents to seek shelter, representing less than 0.1% of the region’s population. However, there will still be relatively significant shelter demands in Napa and Solano Counties (1,200 and 1,100 residents seeking shelter, respectively). A M7.4

earthquake on the Maacama fault, though large in magnitude, will only produce approximately 2,300 shelter-seekers due to its location away from major population centers. A comparison of shelter numbers for all 16 earthquake scenarios examined in this study is below in Figure 4.

Short-term Shelter Loads (# People)

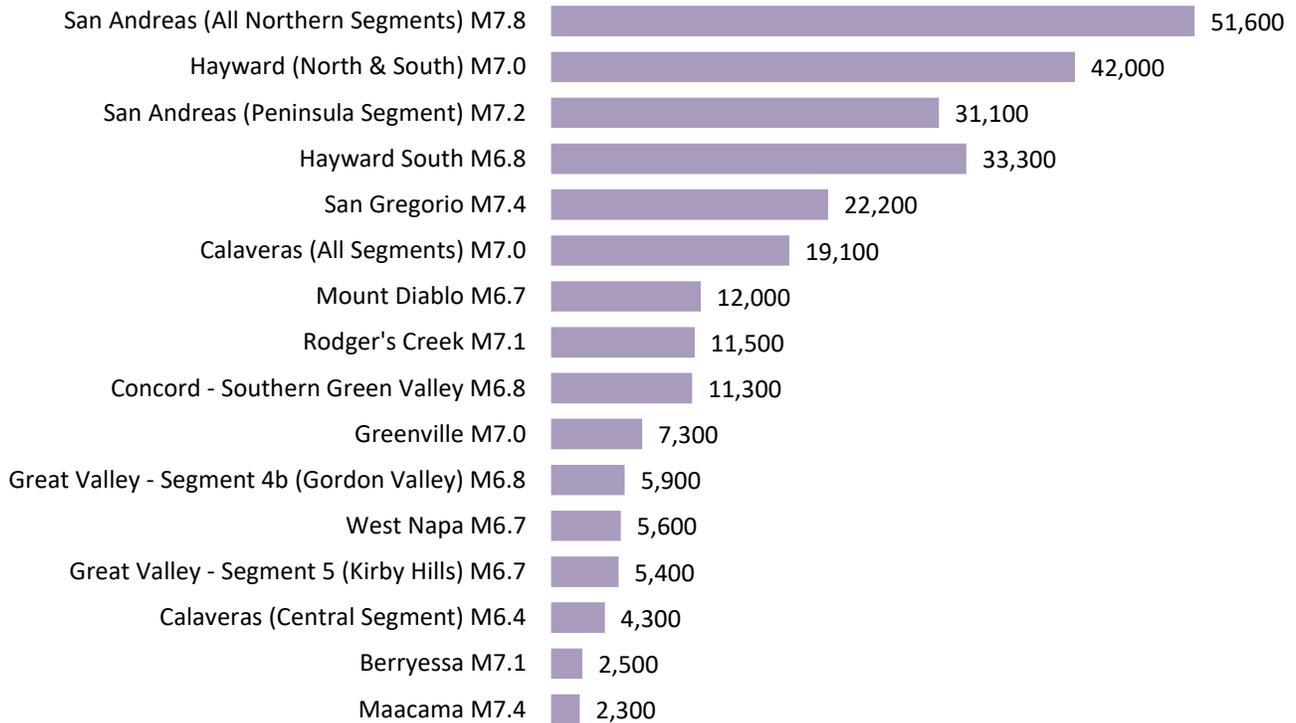


Figure 4: Comparison of short-term shelter loads (number of people) for 16 Bay Area earthquake scenarios

What can cities do?

Cities and counties need to take a few critical points into account when planning for sheltering displaced residents after a major disaster. Some of these suggestions are actions ready to go; others will require more research before they are actionable.

- Understand local demographics to anticipate shelter-seeking behavior.** As discussed above, different social characteristics are assumed to contribute towards the likelihood of residents seeking shelter, damage being equal. Primarily, Black and Hispanic lower-income households are assumed to be the most likely to seek shelter. It may be preferable to site shelters in neighborhoods where these demographics are more prevalent so they are more accessible to those who will be seeking them.
- Plan for how to move residents of higher density neighborhoods to shelter locations.** Higher density neighborhoods will likely have more shelter-seekers, but siting shelters will be more difficult. A few factors contribute to this problem: the two most impactful earthquake scenarios (San Andreas and Hayward) will have the greatest impacts on some of the more densely populated areas of the Bay Area;

San Francisco and the East Bay. Additionally, multifamily housing residents tend to seek shelter more frequently than single family housing residents, so higher density areas with a higher percentage of multifamily residential will have a higher percentage of residents seeking shelter. However, siting shelters in more dense areas that are able to accommodate more people will be a challenge, as shelters typically require larger spaces to accommodate its occupants. Identifying multiple smaller sites in higher density areas may help accommodate shelter demands, particularly if residents are unable to easily move from one neighborhood to another due to road damage or other transportation challenges, or if they do not own a car.

- **Anticipate some shelter demand even in relatively small earthquakes.** Past disasters have shown that some residents seek shelter even if their homes are only minimally or moderately damaged and technically able to be occupied. This may be due to uncertainty about the structural integrity of their home, fear of additional damage due to aftershocks or settling, lack of utilities making sheltering in place more uncomfortable or difficult, or other factors like cold weather or having special needs (disability or medical needs). There are two appropriate approaches to this: educate residents about how to shelter in place successfully, and also plan to shelter residents, even if expected impacts are not high in your area for a given earthquake scenario.
- **Coordinate shelters across neighboring jurisdictions and counties.** In the San Andreas event, over 90% of the region's census tracts are estimated to have at least one resident seeking shelter. Even in the earthquake scenario with the smallest number of residents seeking shelter (Maacama M7.4, 2,300 residents seeking shelter), all counties except San Mateo and Santa Clara are anticipated to have at least a few people seeking shelter. In a moderate event, such as a West Napa M6.7 (the 2014 South Napa earthquake was a M6.0), nearly 60% of the region's census tracts will have at least one resident seeking shelter. The implications of this are that jurisdictions may not be able to count on neighboring jurisdictions to accommodate shelter-seekers from their jurisdiction, and cities may benefit from coordinating during shelter planning. Conversely, in a moderate earthquake, many cities and counties may only need to shelter a small number of residents (for example, fewer than 100 residents are expected to seek shelter in Sonoma county and Napa county in a Calaveras M 7.0 event). In this case, either these shelters could be consolidated, or Napa and Sonoma Counties could make their excess capacity available to neighboring counties who have a larger shelter load. More research is needed to determine the impacts of sheltering residents outside their communities, or willingness to travel to seek shelter. Counties also may play a large role in coordinating and providing shelter sites if jurisdictions don't have enough sites within their boundaries.
- **Anticipate that shelters themselves may be damaged in an earthquake.** Shelter facilities are not exempt from earthquake damage. In the areas of highest damage, select shelter sites that are retrofitted or of newer construction. Even following this best practice, localized damage may mean that there is not enough shelter capacity close by in the areas of most significant damage. In this case, cross-jurisdictional or cross-county coordination is especially important.
- **Plan for changing shelter needs over time.** The numbers in this analysis only represent short-term shelter needs. Over time, these needs will change as residents move into interim housing, repair, rebuild, and move back into their homes, or decide leave the area. Additional research is needed to determine how shelter needs will change over time and for what timeframe cities and counties should

expect to provide shelter. Shelters are designed to be short-term; many residents will not tolerate shelter living for an extended period of time, so consideration of interim or temporary housing is essential to understanding the long-term recovery of housing.

- **You can reduce shelter demand through residential retrofit policies and building codes.** More retrofits of older homes will result in less housing damage in an earthquake. Even if older residential buildings are only retrofitted to the point of life safety, this has the potential to significantly reduce the number of residents seeking shelter as shelter-seeking behavior is dependent upon the degree of damage and even in homes with extensive damage only a percentage of residents of those homes are assumed to seek shelter. For new residential buildings, current building codes do not ensure that homes will be habitable after a disaster, only that loss of life is not expected to occur. Updating building codes for new buildings beyond life safety to habitability could also significantly reduce shelter demands. In addition, reducing the damage state of residential buildings reduces time for repair or rebuilding homes, which impacts how long shelters will need to stay open and what kind of demand there will be for interim or temporary housing.