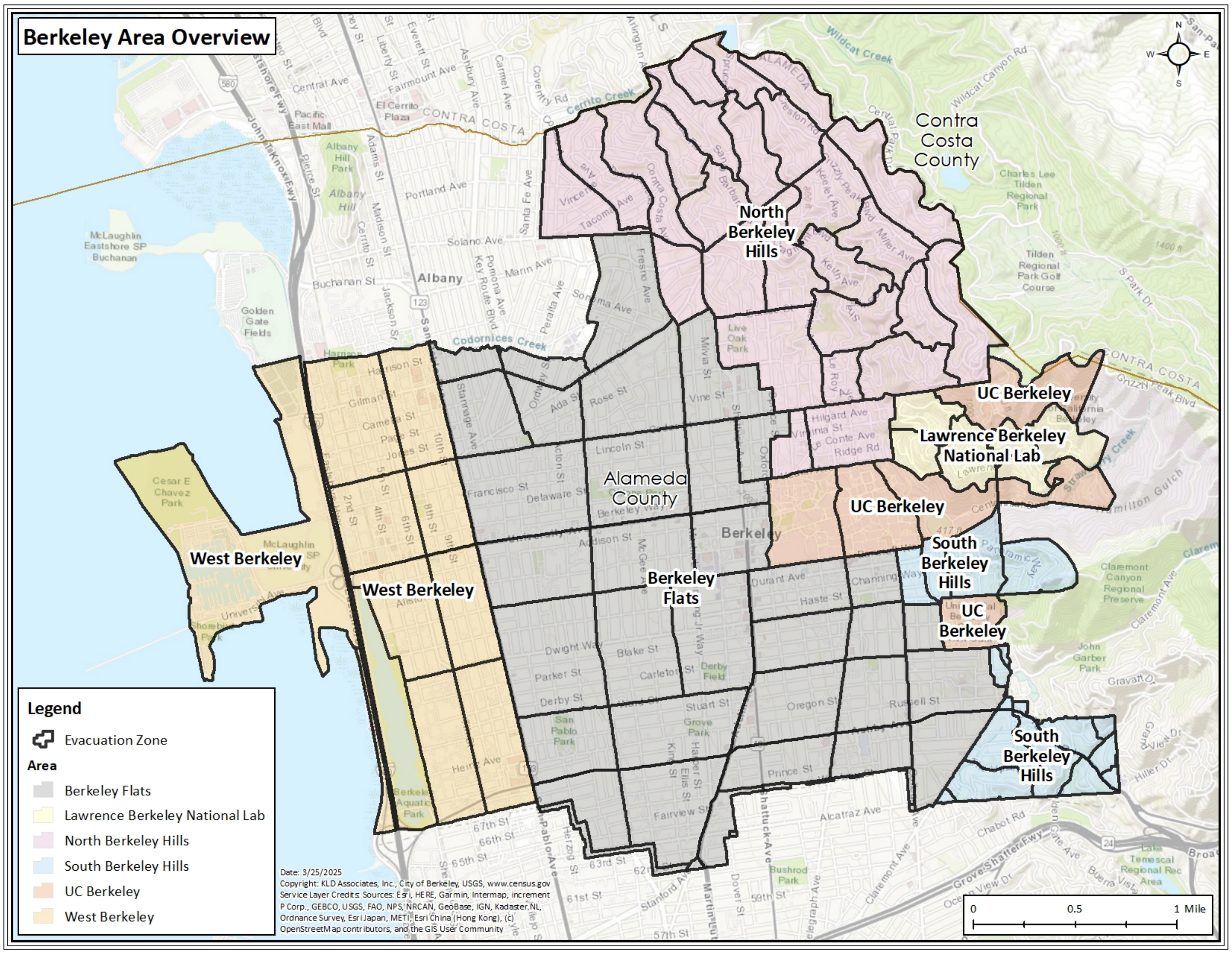
City of Berkeley

Evacuation Time Estimate Study



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EXECUTIVE SUMMARY

A key element of protecting the Berkeley community during wildfires, tsunamis, and other emergencies is safely evacuating people from danger zones. On a typical day, Berkeley's road network balances traffic flow with speed reduction to minimize injuries and/or fatalities. In an emergency, however, it may need to handle the rapid evacuation of tens of thousands of people away from a hazard, including:

- Residents, visitors, employees, and college students evacuating in personal vehicles and via public transit;
- Medical facilities, K-12 schools, preschools and daycares needing transit support;
- Residents without access to a vehicle requiring transit support, including specialized vehicles like wheelchair-accessible vans and ambulances; and
- A small percentage of Berkeley residents, employees, and college students who plan to evacuate on foot or bicycle.

Managing the complex needs of diverse users during emergencies requires a clear understanding of Berkeley's emergency alerting systems, evacuee behavior, transportation needs, and road capacity. To support this, the City has contracted KLD Associates, Inc. to study evacuation dynamics during wildfires, tsunamis, and other emergencies. By analyzing these factors individually and in combination, the study will help guide disaster response, transportation planning, development policy, and household evacuation plans.

This study provides **Evacuation Time Estimates (ETE)** for different conditions—such as time of day, day of week, and season—based on congestion patterns during potential evacuations in Berkeley. **ETE measures the time needed to exit the zones under evacuation order, not to reach a final destination.** The analysis includes evacuation sensitivity studies, which analyze the impact of traffic calming measures, increased housing density, and evacuation tactics to inform emergency planning and decision-making.

City of Berkeley

The City of Berkeley is located on the eastern shore of the San Francisco Bay within Alameda County, California. The eastern edge of Berkeley, bordering Contra Costa County, is defined by the Berkeley Hills, a significant wildland-urban interface, creating a unique interface between urban development and fire-dependent natural ecosystems.

The city is densely populated and occupies an area of about 10.5 square miles.

The city houses approximately 117,000 residents. The city is divided into 106 Evacuation Zones[1]. Figure 6-1 shows a map of the Evacuation Zones which were considered for this study.

[1] https://protect.genasys.com/

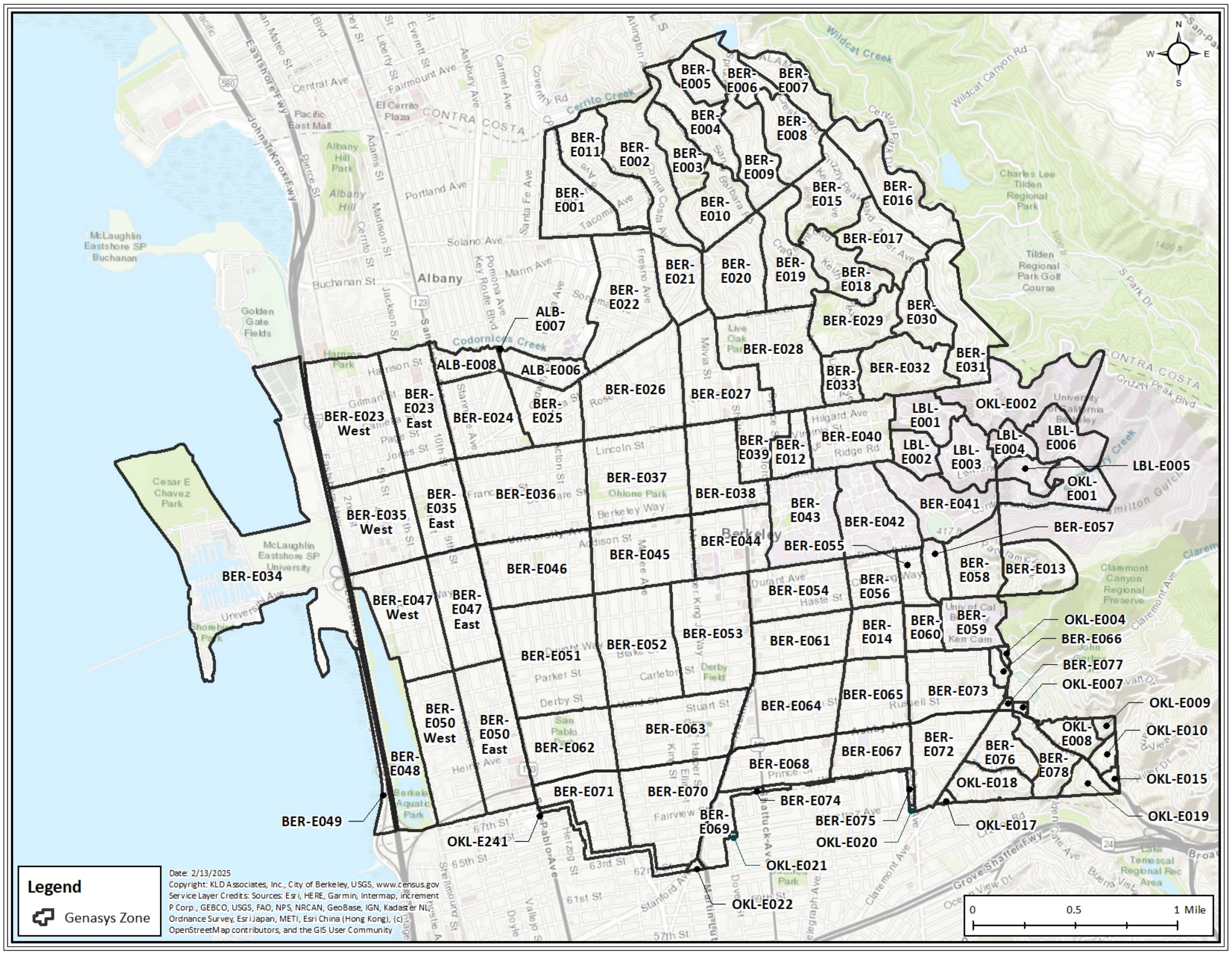


Figure 6-1. Evacuation Zones Boundaries

Berkeley's road network is characterized by predominantly north-south routes and limited east-west connectivity. In addition to the approximately 90,000 vehicles that may need to evacuate the city, Berkeley's position in the heart of the Bay Area means that another 47,000 additional vehicles passing through Berkeley as external traffic could also be traversing Berkeley roadways while evacuation was underway. All of these factors could contribute to difficulties in evacuating during an emergency.

Evacuation Regions

This study groups Berkeley's Evacuation Zones (displayed in Figure 6-1) into 14 different Evacuation Regions. Each Region is included in this study to inform a specific planning question from the City of Berkeley.

Evacuation Regions and Study Questions

See Appendix E for maps visualizing these Regions.

Region		Planning Question
R01	**Citywide Evacuation**	Transportation planning: What patterns of traffic congestion could occur when Berkeley's roadway network is overtaxed?
R02	**Fire - 1923 - All**	Hazard analysis: How long will it take to evacuate people during a current-day repeat of the 1923 Berkeley Fire?
R03	**Fire - 1923 - Phase a (0 minutes)**	Hazard analysis: Will phasing evacuation improve evacuation times for a repeat of the 1923 Berkeley Fire?
R03	**Fire - 1923 - Phase b (0 + 90 minutes)**	
R03	**Fire - 1923 - Phase c (0 + 180 minutes)**	
R04	**Panoramic Hill Fire**	Hazard analysis: How long will it take to evacuate people during a fire affecting Panoramic Hill?
R05	**Fire Zones - Fire Zones 2 & 3 Combined**	Included to analyze administrative changes that could affect development in the Berkeley Hills.
R06	**Tsunami - Phase 3**	Hazard analysis: How long will it take to evacuate people from a tsunami affecting areas west of I-80?
R07	**Tsunami - Max Phase**	Hazard Analysis: How long will it take to evacuate people from a tsunami that crosses I-80?
R08	**Berkeley Flats**	How long will it take to evacuate specific geographic areas of Berkeley?
R09	**North Berkeley Hills**	
R10	**South Berkeley Hills**	
R11	**West Berkeley**	
R12	**UC Berkeley**	
R13	**Lawrence Berkeley National Lab**	
R14	**UC Berkeley + Lawrence Berkeley National Lab**	

Evacuation Time Estimates

The study modeled evacuations associated with wildfire and tsunami, as well as areas that may evacuate together. Evacuation time estimates are influenced by scenario (time of day, day of week, and season) as well as how quickly evacuees prepare to leave and enter the roadway (mobilization time). Key evacuation time estimates include:

- In a current-day repeat of the 1923 Berkeley Fire, known as Berkeley's worst, the time to evacuate people out of the hazard area ranges from 1:35 (hh:mm) to 4:35[2]. Phasing the evacuation – evacuating areas at risk in stages, with the closest to the fire leaving first – results in similar or worse evacuation times, both for the area overall and for the populations closest to the origin of the fire.
- In a fire affecting Panoramic Hill, an area shared with the City of Oakland with one way in and out, the time to evacuate people out of the hazard area ranges from 0:45 to 1:45.
- In a Tsunami Warning affecting areas east of I-80, evacuation times range from 0:55 to 1:45. It should be noted that in the December 5, 2024 Tsunami Warning, as part of a Max Phase evacuation, this area was evacuated approximately 1 hour after the National Tsunami Warning Center issued alerts, and 45 minutes after evacuations of the area began.

Table 7-4 summarizes the ETE values recommended for use in response plans based on the analysis of this report (Section 7). Rows marked "Urgent Mobilization" present ETE expected when evacuees mobilize more quickly than would be predicted from responses to a community survey conducted from August 10 – October 8, 2023 (see "Community Evacuation Behaviors" below and Appendix D for further survey details). Urgent Mobilization times are associated with no-notice evacuations, such as wildfires that ignite in close proximity to the city.

[2] These times include base case 90th and 100th percentile ETE and urgent mobilization ETE.

Table 7-4. Time to Clear the Indicated Area for Response Plans

	Summer	Summer	Summer	Fall	Fall	Fall
	Midweek	Weekend	Midweek Weekend[3]	Midweek	Weekend	Midweek Weekend[4]
Scenario:	**1**	**2**	**3**	**4**	**5**	**6**
Region	**Midday**	**Midday**	**Nighttime**	**Midday**	**Midday**	**Nighttime**
R01 - Citywide Evacuation	5:10*	4:25*	2:30	5:35*	4:00*	2:30
R02 - Fire 1923	2:25	1:50	1:45	4:10*	1:50	1:45
R02 - Fire 1923 Urgent Mobilization	*2:25*	*1:50*	*1:35*	*4:10**	*1:45*	*1:35*
R03 - Fire 1923 Phase a	4:25*	4:30*	1:40	4:30*	4:15*	2:10
R03 - Fire 1923 Phase a Urgent Mobilization	*2:30**	*2:10**	*1:25*	*3:30**	*2:10**	*1:35*
R03 - Fire 1923 Phase b	6:10*	5:55*	2:15	6:15*	6:00*	2:30
R03 - Fire 1923 Phase b Urgent Mobilization	*4:00**	*4:00**	*1:40*	*4:00**	*2:10**	*1:40*
R03 - Fire 1923 Phase c	4:10	4:20	4:30	4:00	4:25	4:35
R03 - Fire 1923 Phase c Urgent Mobilization	*3:35*	*3:45*	*1:40*	*3:50*	*1:30*	*1:40*
R04 - Panoramic Hill Fire	1:40	1:35	1:40	1:45	1:35	1:40
R04 - Panoramic Hill Fire Urgent Mobilization	*1:05*	*0:50*	*0:45*	*1:45*	*0:50*	*0:50*
R05 - Fire Zones 2 & 3 Combined	2:05	1:55	1:45	2:20	1:55	1:45
R06 - Tsunami - Phase 3	1:20	1:20	1:05	1:45	0:55	1:10
R07 - Tsunami - Max Phase	2:15	2:10	1:50	2:15	2:05	1:50
R08 - Berkeley Flats	4:10*	2:35	2:10	4:20*	2:25	2:05
R09 - North Berkeley Hills	2:10	2:00	1:50	2:05	1:50	1:45
R10 - South Berkeley Hills	1:35	1:30	1:35	2:15	1:35	1:35
R11 - West Berkeley	1:40	1:35	1:35	1:45	1:35	1:35
R12 - UC Berkeley	1:05	1:15	1:25	1:20	1:30	1:35
R13 - Lawrence Berkeley National Lab	1:25*	0:45	0:45	2:15*	0:45	0:45
R14 - UC Berkeley + Lawrence Berkeley National Lab	1:30	1:15	1:20	2:15	1:30	1:35

[3] Nighttime scenarios (Scenarios 3 and 6) have approximately the same demand between midweek and weekends.
[4] Nighttime scenarios (Scenarios 3 and 6) have approximately the same demand between midweek and weekends.
* Entries with an asterisk are 100th percentile ETE. All other ETE presented in Table 7-4are the 90th percentile ETE. See Section 7 for details.

Overall evacuation times are faster when Berkeley's population is lower: at night, on weekends, and during summertime, when K-12 schools are not in session and college/university populations are significantly reduced.

For individual evacuees, leaving earlier can result in a faster evacuation trip. Analysis shows that all households who start evacuation trips 30 minutes after receiving an evacuation order will encounter less traffic congestion than they would leaving 60 minutes after the order is issued. For example:

- In a repeat of the 1923 Fire (R02), a 30-minute delay in beginning the evacuation trip also adds another 35 minutes to a vehicle's travel time. This 30-minute delay in leaving, coupled with the additional time on the road, almost doubles an evacuee's overall time from receiving an evacuation order to exiting the evacuated area – from 70 minutes overall to 135 minutes.
- In a Tsunami Warning affecting areas east of Interstate 80, leaving 30 minutes later would add another 45 minutes to a vehicle's travel time. See "Evacuee Experience" writeups in Section 7 for details.

Community Evacuation Behaviors

An online demographic survey was conducted of the people living and working in Berkeley; 1,453 households responded to the survey, which corresponds to a sampling error of ±2.5% at the 95% confidence level based on the 2020 Census household data.

The survey gathered demographic information (average household size, vehicle ownership, etc.), behavioral responses (would evacuees follow evacuation instructions issued by local officials), and time to complete mobilization activities.

Key takeaways include:

- Community members could take as long as 3.5 hours to start their evacuation trip ("mobilize"). Longer mobilization times lead to longer evacuation times overall (Section 7). Populations with the shortest mobilization times are employees and visitors. The population with the longest mobilization times is households with commuters who plan to pick up children from school in an emergency. See Section 5 (Table 5-9) and Appendix D.
- Approximately 22% of households have children who attend school in Berkeley. In an emergency, 88.2% of those households plan to pick up their children or send a trusted guardian to pick up their children at school. This behavior is expected to increase traffic congestion immediately around schools and in evacuating areas more broadly.
- Automobile ownership: The average number of automobiles available per household is 1.55. 73.6% of households would use 1 vehicle for evacuation; 14.6% plan to use 2. Approximately 97% of households of 2 or more people have access to at least one vehicle. 7.5% of all households do not have access to a vehicle. See Appendix D.

- Citywide, 12,870 residents do not have direct access to a vehicle and will require transportation assistance. However, approximately eighty-seven percent (87%) of Berkeley's transit-dependent population will rideshare with a neighbor or friend. This leaves 1,686 (1.4%) of residents citywide who will rely on transportation assistance from the government. (See Table 3-10 and Appendix D.)
- Six percent of households indicated that someone in the household would need help from someone outside the household (caretaker, personal attendant) to prepare to evacuate or to get to a vehicle. Some will also require specialized transportation assistance: Citywide, approximately 1.6% of people will require a wheelchair accessible van, 0.2% require an ambulance and 0.4% require other modes of transportation. The remaining 3.8% do not require a specialized vehicle to evacuate.
- Citywide 2.2% of Berkeley residents, employees, and college students plan to evacuate on foot and 1.4% plan to evacuate on bicycle. (Appendix D)
- During an emergency evacuation, 1% of people would disregard evacuation orders and stay in place. (See Appendix D)
- Emergency officials may notify people outside a hazard area that they are not in danger, and that they are requested to shelter in place (not evacuate). Ninety percent (90%) of households would comply with this request and the remaining 10% would choose to evacuate the area. (See Appendix D)
- Eighty-nine percent (89%) of emergency evacuees plan to evacuate to a friend or relative's home, a hotel, motel, campground, short-term rental (ex. AirBnB/VRBO), or second/seasonal home. Approximately 6% plan to evacuate to an evacuation shelter. See Figure D-12 for complete results.
- Approximately 50% of households have pets. Approximately 38.4% of households have small pets/animals and 11.3% have large pets/animals. Figure D-15 displays these results.

Community Transportation Support Needs

Analysis quantified the transportation resources needed to support evacuation of all Berkeley residents who lack access to a vehicle, residents of special facilities (schools, preschools/day care centers, and colleges/universities), medical facilities providing inpatient care services (including skilled nursing facilities), and transit-dependent visitors and employees. Citywide, these groups collectively require 571 buses, 161 wheelchair vans, and 253 ambulances to evacuate. See Table 8-1 for additional details. However, as discussed in Section 7, a simultaneous evacuation of all of Berkeley is not a realistic scenario. The resource needs associated with a specific large-scale hazard event better inform emergency planning, for example:

- For a repeat of the 1923 Fire (Regions R02 or R03), it is estimated that 262 buses, 48 wheelchair-accessible vans, and 66 ambulances will be needed to evacuate all populations at risk.

- For a Tsunami Warning – Max Phase, it is estimated that 41 buses, 4 wheelchair-accessible vans, and 8 ambulances will be required to evacuate all populations at risk.

These resource needs indicate that for the mass evacuation emergencies studied, the City of Berkeley will be reliant on partners in Berkeley and throughout the region to provide mass transportation assistance to people in Berkeley without access to vehicles. These needs for assistance include both generalized transportation (buses) and specialized vehicles such as wheelchair vans and ambulances.

Evacuation Routes and Signage

In suburban and rural areas, it is critical to designate specific roadways as "Evacuation Routes" and to direct the community to them with signage. In urban environments like Berkeley, this approach can actually reduce evacuation efficiency. City roadway networks generally offer multiple roadways that can serve as evacuation routes and lead evacuees to safety, as compared to suburban and rural systems where there may be only one roadway leading out of a hazard area.

Even Berkeley's highest-capacity roadways, traditionally designated Berkeley's "evacuation routes," are not designed to singlehandedly carry a large volume of vehicles associated with a large-scale evacuation. Rather, evacuation times improve when evacuating vehicles are distributed across all available roadways instead of being directed to roadways with higher (but still inadequate) capacity.

Figure 9-1 highlights Berkeley roadways possessing the greatest capacity for vehicular traffic. These roadways are likely to carry the greatest number of vehicles in an evacuation. However, **these routes are <u>not</u> designated "Evacuation Routes" at the exclusion of other roadways**. **All available roadways should be considered evacuation routes.** See Section 9.

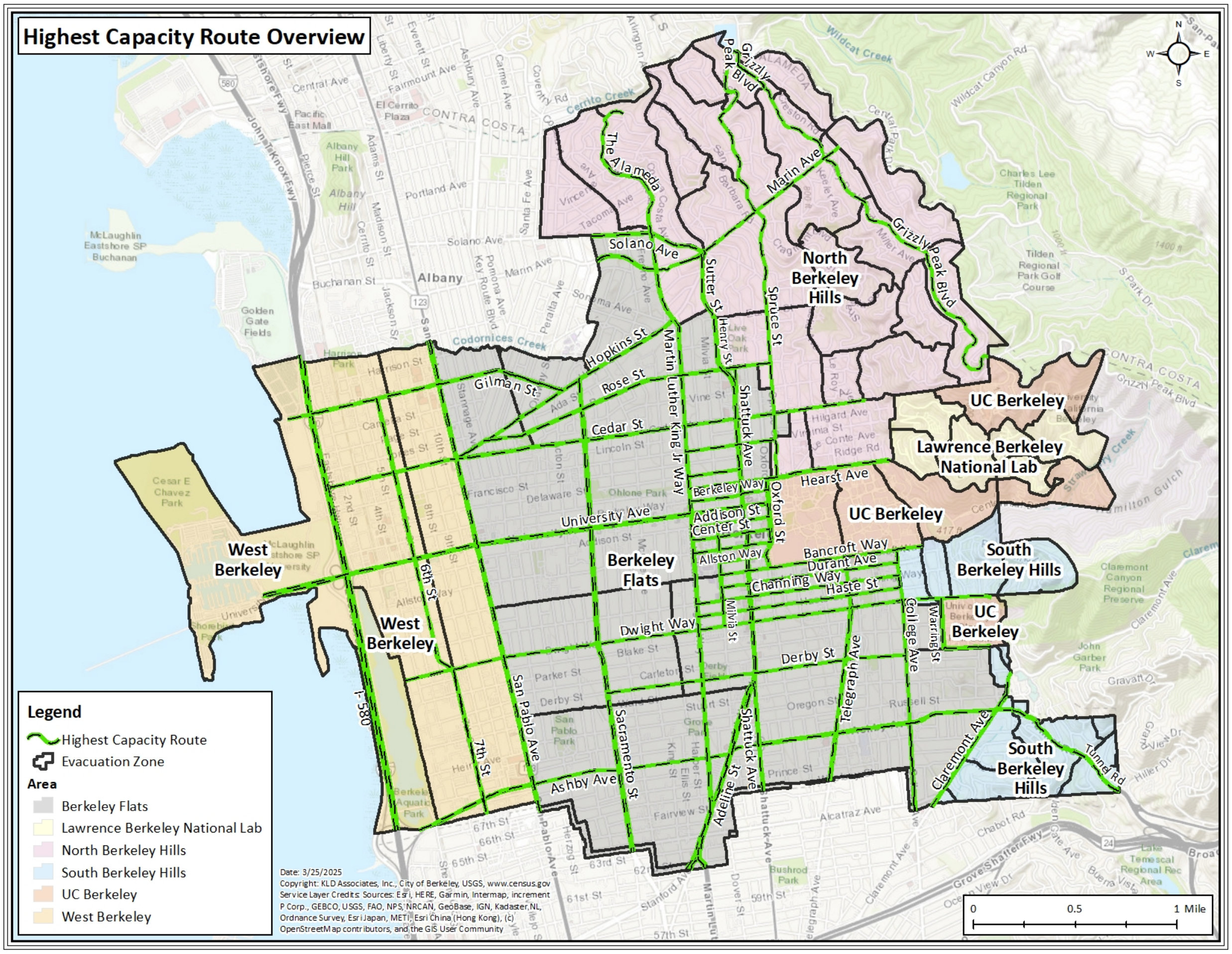


Figure 9-1. Highest Capacity Routes - Overview

Traffic Congestion Patterns

Traffic congestion slows evacuations, and severe congestion is expected to occur in all evacuation cases studied. Congestion is greatest in evacuation scenarios during the day, midweek, during the fall, when Berkeley has the highest vehicular demand.

Some evacuation cases have severe congestion across long stretches of roadway; areas of severe congestion are more limited for other cases.

Figure F-8 shows the patterns of traffic congestion for a 1923 Fire Repeat at 1 hour and 2 hours after the Evacuation Order. Severe congestion is extensive, prolonging the time that evacuees will spend on the roadways and increasing the likelihood that they will be directly impacted by the fire as they try to evacuate.

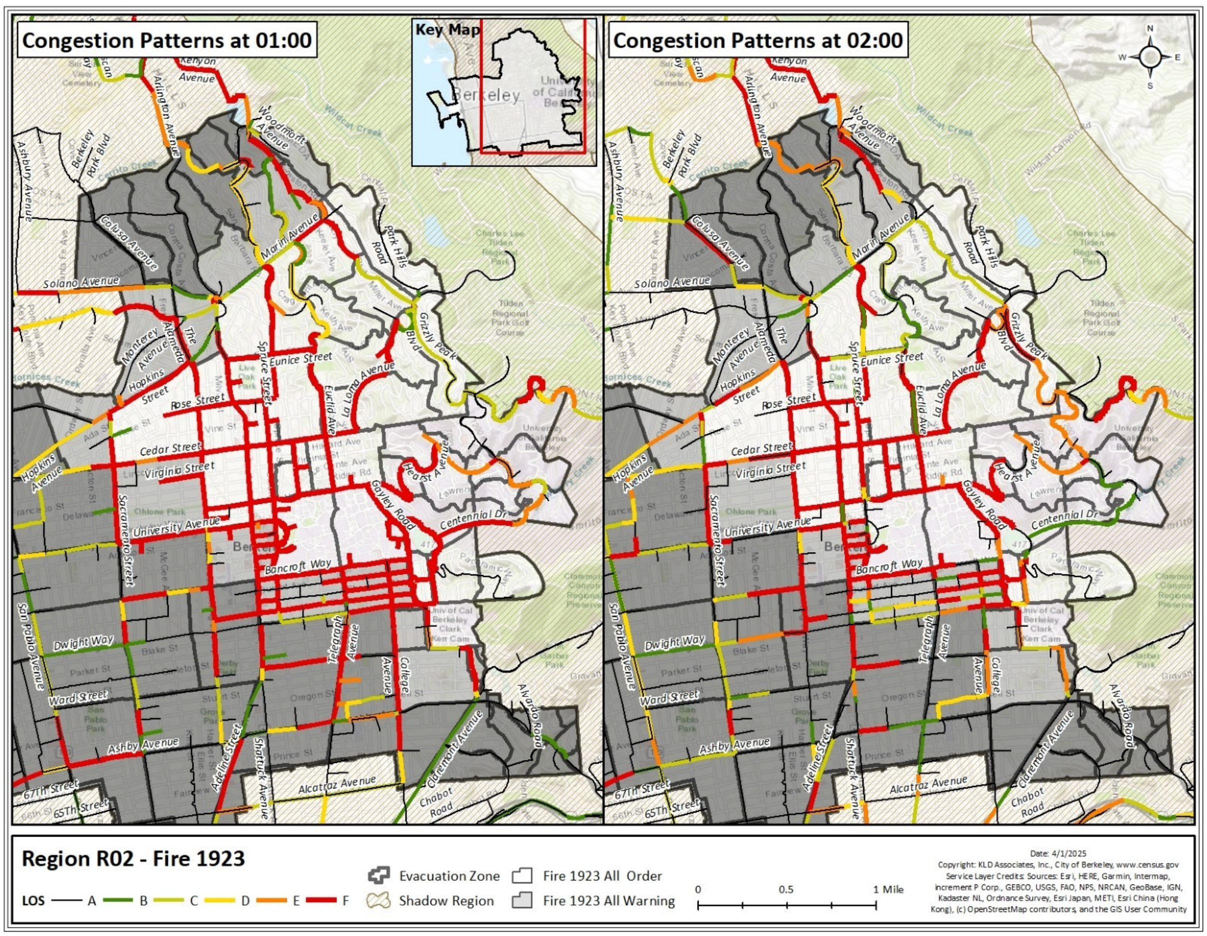


Figure F-8. Region R02 Congestion Patterns 1 Hour and 2 Hours after the Evacuation Order

Figure F-18 displays the patterns of traffic congestion for Tsunami Warning Max Phase at 30 minutes and 1 hour after the Evacuation Order. Evacuees in Region R07 can use I-580, University Ave, Gilman St, Ashby Ave and Seventh/Sixth St to leave the evacuated area. All of these roads experience some level of congestion during the evacuation.

These results indicate that traffic congestion will prolong the time that evacuees will spend on the roadways escaping the tsunami inundation area. Depending on the amount of tsunami warning provided, evacuees could still be evacuating on the roadways at the time of impact.

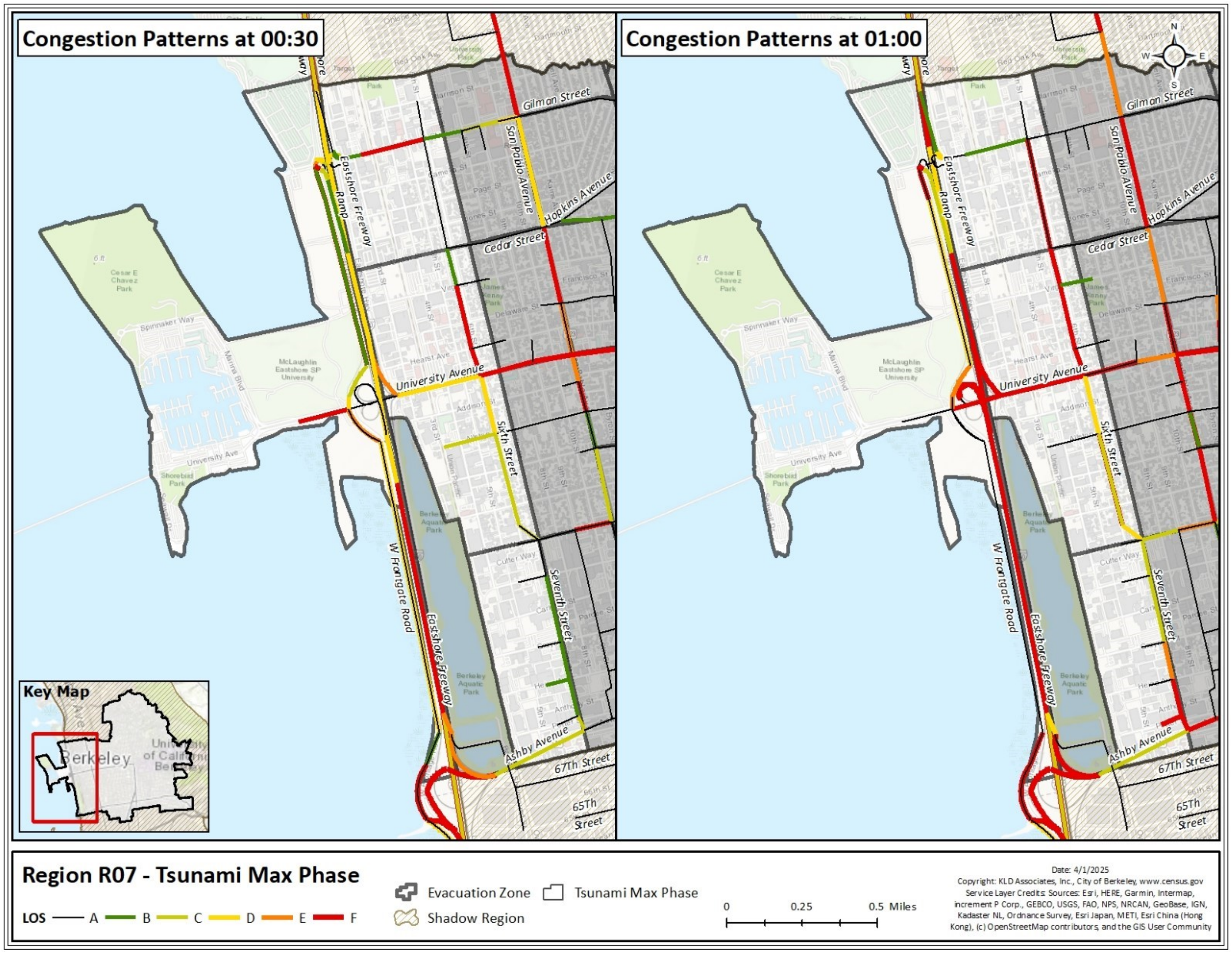


Figure F-18. Region R07 Congestion Patterns 30 Minutes and 1 Hour after the Evacuation Order

Identifying Opportunities to Improve Traffic Flow in Evacuations

Analysis in Appendix F indicates that across multiple evacuation cases, the following areas of Berkeley have patterns of traffic congestion that are likely exacerbated by traffic engineering and/or roadway design that is focused on day-to-day traffic, pedestrian, and cyclist safety:

- South and West of the UC Berkeley Campus
- South and West of Clark Kerr Campus
- North of Ohlone Park
- Lawrence Berkeley National Lab (LBNL)

Appendix G identifies the specific traffic calming devices (TCDs), traffic signals, and other street network characteristics posing challenges to evacuation, with the goal of identifying opportunities to improve traffic flow in evacuations.

Figure G-1 shows the TCDs within the City of Berkeley as of January 14, 2025.

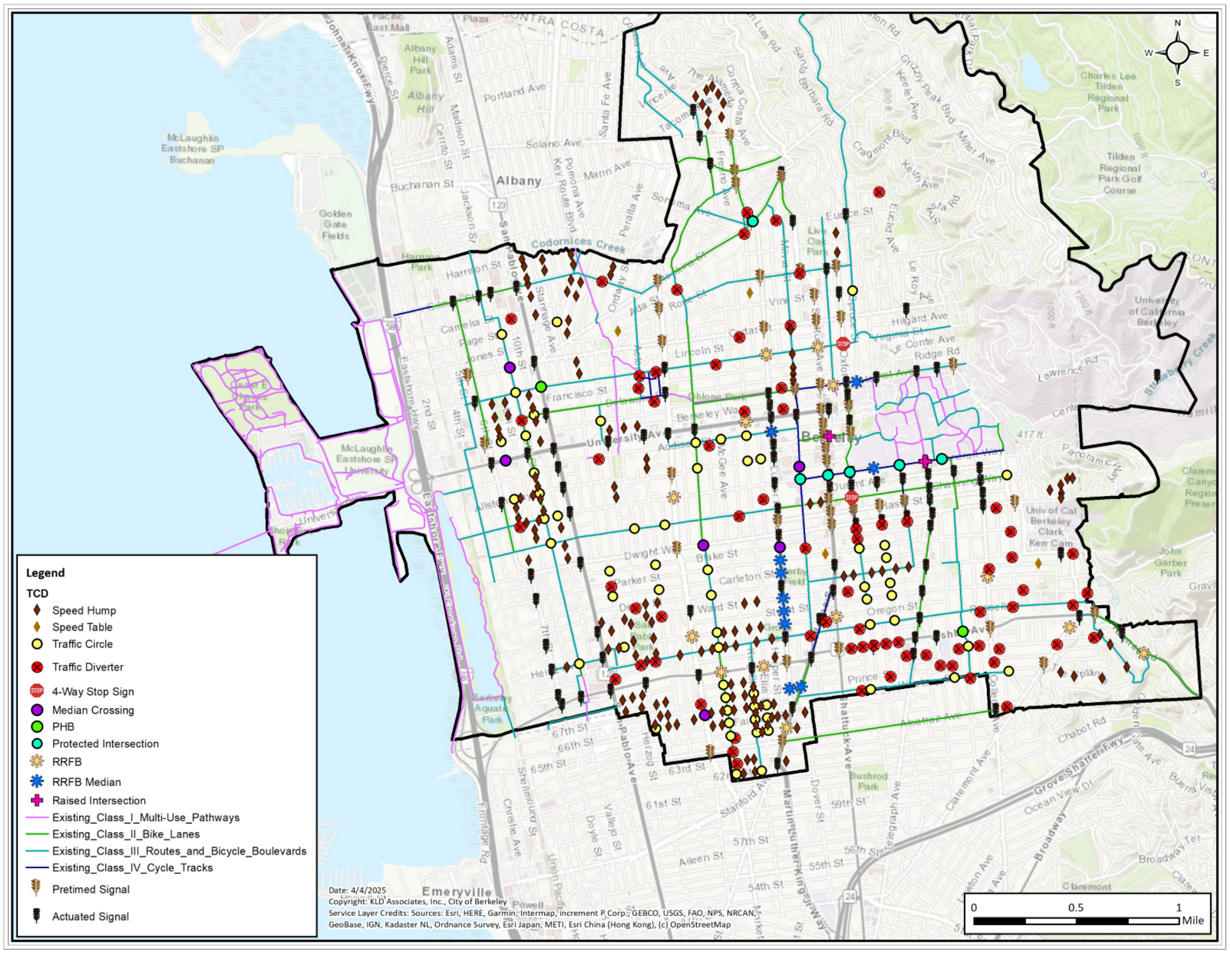


Figure G-1. Traffic Calming Devices, Traffic Signals, and Existing Street Network Characteristics

Street Network Characteristics

The existing characteristics of the road network are noted in Appendix G to provide a comprehensive analysis of the challenges to evacuation traffic flow. Some are assumed to be fixed, such as preexisting facilities and parks; others are noted as traffic design elements that could be improved for evacuation traffic flow.

Traffic Signals

Section 10 identifies improvements to evacuation traffic flow from a widescale transition to actuated/adaptive traffic signals. Appendix G highlights pre-timed signals with notable impacts across various evacuation cases studied, so that they may be considered for prioritization in a shift to actuated/adaptive signals.

Traffic Calming Devices

The impact of Traffic Calming Devices (TCDs) on evacuation illustrates the complexity of the public safety demands on Berkeley's roadway system. In a day-to-day context, traffic calming devices (including diverters, traffic circles, and speed tables) support public safety by reducing vehicle speeds for pedestrian safety, reducing capacity on residential streets, and/or disrupting network connectivity for vehicles. The analysis indicates that the TCDs throughout the city are performing as designed, effectively reducing vehicular speeds and thus reducing the risk of severe injury and/or fatal traffic crashes.

In evacuations, the public safety goal for roadways shifts to expediting traffic flow, both to help evacuees quickly escape, and also to help responders access the hazard area. In a large-scale evacuation, the roadway demands from evacuating vehicles will greatly exceed the capacities of Berkeley's highest capacity roadways (indicated on Figure 9-1). Evacuating drivers will need to decide between waiting in traffic to enter high-capacity roadways or using residential streets (with lower capacities and potentially also TCDs) as they attempt to escape the hazard area.

Because evacuating drivers will use all roadways, they will be slowed by TCDs in two ways – directly, when they encounter them while trying to escape, and indirectly, as drivers trying to avoid TCDs increase congestion on Berkeley's highest capacity routes.

The day-to-day public safety function of TCDs poses significant challenges to evacuation traffic flow. This situation illustrates the dynamic and complex public safety demands on Berkeley's roadway system.

Analyzing Increased Hills Density

The City also used this study to better understand how potential development in the Berkeley Hills could impact evacuation times. Section 10.5 includes detailed analysis addressing multiple development scenarios in the Hillside Overlay, which encompasses the City's Very High Fire Hazard Severity Zone.

These studies considered three different types of development: Accessory dwelling units (ADUs), junior accessory dwelling units (JADUs), and Middle Housing. The analysis examined these development types separately and together. Studies also explored how evacuation times would be affected if ADU/JADU residents living near public transit did not own vehicles and instead relied on public transit in evacuation.

This analysis began with the establishment of a Future Case, assuming projected 2031 population increases in Berkeley.[5] The future case did not include the ADUs/JADUs and/or Middle Housing. Impacts to ETE from ADUs/JADUs and Middle Housing were measured against this Future Case in order to pinpoint evacuation time impacts from these particular development types in the Hillside Overlay.

The study considered four evacuation regions: Region R01 – Citywide Evacuation, Region R02 – 1923 Fire, Region R04 – Panoramic Hill Fire, and Region R05 – Fire Zones 2 & 3 Combined.

The 1923 Fire Repeat (Region R02) and the Panoramic Hills Fire (Region R04) best represent potential hazard scenarios. The 90th percentile ETEs are recommended to be used for evacuation planning purposes (see Section 7). Key findings for 90th percentile ETEs in Regions R02 and R04 include:

<u>Potential Development</u>

- **Maximum ADU/JADU development** increased evacuation times for a 1923 Fire (Region R02) by 102% on average, and for a Panoramic Hill Fire (Region R04) by 52% on average.
- **Likely Middle Housing** development results in increases of up to 8% across the analyzed regions. This increase is smaller than increases from ADU/JADU development because there are considerably fewer parcels likely to develop Middle Housing by 2031 as compared to maximum ADU/JADU development.
- **Combining Maximum ADU/JADU development with Likely Middle Housing** increases evacuation times above the Future Case by 105% on average for a 1923 Fire (Region R02), and about 54% on average for Panoramic Hill Fire (Region R04).

<u>Potential Development with Fewer New Vehicles</u>

- **Maximum ADU/JADU development, but with fewer new vehicles:** Evacuation times still increase when ADU/JADU dwellers living near transit do not own cars. Analysis assumed that residents of ADUs and JADUs living within ½ mile of a transit stop would not own cars and would rely on public transit to evacuate. The 1923 Fire (Region R02) would require an estimated additional 1,051 buses to evacuate these residents. For this case, evacuation times increase by 65% on average, and by 70% on average for Panoramic Hill Fire (Region R04).
- **Adding Middle Housing:** Finally, under this scenario where ADU/JADU dwellers living near transit do not own cars, if likely Middle Housing is added, evacuation times further increase. Middle Housing zoning changes are not expected to influence occupants' vehicle ownership, so Middle Housing dwellers are assumed to evacuate in personal vehicles.

[5] 2031 was selected to align analysis with the 2023-2031 Housing Element Update, which included a projection of likely development that could result from implementation of the "Middle Housing" zoning changes.

When middle housing is added to the scenario where ADU/JADU dwellers living near transit do not own cars, evacuation times increase 68% on average for the 1923 Fire (Region R02) and 69% on average for the Panoramic Hill Fire (Region R04).

Based on the results of the study, it is recommended that the City institute separate, more restrictive ADU/JADU development provisions in the Hillside Overlay. For Middle Housing, it is recommended that the City examine these increases in the context of fire spread scenarios. By overlaying fire spread data with evacuation time estimates, the City can better contextualize potential impacts to public health and safety from Middle Housing zoning changes.

Studies in Section 10.5 illustrate how increasing population density in an area, even when the added people do not own vehicles, can increase emergency evacuation times and create public safety impacts. More broadly, the City should consider impacts to evacuation when implementing zoning changes that could result in an increase in demand on roadways used by wildfire or tsunami evacuees.

Recommendations

The results of this report can inform Berkeley's disaster response planning, transportation and roadway planning, development policies, and the individual evacuation plans of Berkeley households. Section 11 details the following recommendations for consideration by City officials:

1. Emergency Response Strategies
    - 1.1. Overlay evacuation time estimates with hazard-specific data (such as fire spread rates for fire regions, and tsunami arrival times on tsunami warning regions.)
    - 1.2. Develop regional/State planning partnerships to quantify resource shortfalls for transit-dependent evacuees.
    - 1.3. Prioritize specific locations for Traffic Control Points (staffed intersections that help improve traffic flow) during evacuations.
    - 1.4. During evacuations, reduce or eliminate external/pass-through traffic. This can include use of electronic roadside signage, closure of I-80 and CA-24 off-ramps into Berkeley, and/or diversion of through traffic to other routes.
    - 1.5. Encourage schools to develop and communicate site evacuation plans that enable parents and guardians to pick up their children at sites outside the evacuation zone.
2. Extreme Fire Weather Leave Early Policy
    - 2.1. Maintain Berkeley Fire Department Leave Early Policy for extreme fire weather. Focus on households at relatively greater risk due to extended mobilization times and/or on neighborhoods with extended driving times due to severe congestion.
3. Housing Development Policies
    - 3.1. Institute separate, more restrictive ADU/JADU development provisions in the Hillside Overlay.

3.2. Examine ETE increases from Middle Housing zoning changes in the Hillside Overlay in the context of fire spread scenarios.

3.3. Consider impacts to evacuation when implementing zoning changes that could result in an increase in demand on roadways used by wildfire or tsunami evacuees.

4. Community Alerting

4.1. Conduct community education about Berkeley's evacuation zones, the emergency alerting systems that will provide evacuation orders/warnings, and how community members can register for/opt-in to those systems.

4.2. Conduct community education to encourage potential evacuees to monitor evolving conditions and stay in contact with social networks.

4.3. Clearly define areas at risk as well as areas not at risk in public alerts. Include explicit instructions for people outside the hazard area to shelter in place.

5. Improving Household Mobilization and Evacuation Travel Times

5.1. Encourage carpooling.

5.2. Encourage familiarity with primary, secondary, and tertiary evacuation routes.

5.3. Parents should make provisions with schools to pick up children outside the evacuation zone.

5.4. Commuters should plan to remain outside of the evacuation zone and reunite with other household members outside the hazard area, instead of returning to the evacuation zone.

6. Evacuating on Bicycle and Foot

6.1. Encourage community members to explore walking or cycling for household/business tsunami evacuation plans.

7. Traffic Calming Devices

7.1. Existing Infrastructure: Develop a citywide connectivity and evacuation capacity improvement strategy, integrating approaches such as actuated or adaptive signal timing and replacing TCDs with removable/retractable options, and other evolving technologies.

7.2. Future infrastructure: Develop and implement a methodology to evaluate and consider evacuation efficiency and roadway capacity during the planning and implementation phases of future roadway infrastructure development, including TCD installations.

7.3. First Responder response times: Develop and implement a methodology to assess impacts from TCDs to first responder response times in daily traffic environments.

8. Traffic Signal Improvements

8.1. Optimize Signal Timing Plans: Evaluate and implement improved signal timing strategies, including actuated and adaptive systems.

8.2. Install Battery Backup Systems: Upgrade all traffic signal cabinets to include battery backup systems that can operate for a minimum of 6-8 hours.

8.3. Enhance Emergency Vehicle Pre-emption: Evaluate potential improvements to traffic signal system to have the latest pre-emption equipment and capabilities.

8.4. Strengthen Communications Infrastructure: Install a robust fiber-optic network to improve the reliability and speed of traffic signal communications.

8.5. Deploy Smart Traffic Cameras: Install smart traffic cameras at key intersections and corridors to provide real-time detection, monitoring, and traffic data collection.

8.6. Implement Transit Signal Priority (TSP) for public transit vehicles: Upgrade traffic signal system along Berkeley's highest capacity routes.

8.7. Coordinate Regionally: Work closely with surrounding jurisdictions to ensure interoperability and synchronization of traffic signal systems during emergency evacuations.

8.8. Traffic Signal Software for Centralized Control: Assess the need for traffic signal software upgrades to enable full communication with external systems and centralized command through the City's envisioned Traffic Management Center (TMC).

9. Parking Restrictions

9.1. Explore parking restrictions along arterial roadways in the Berkeley Hills utilized by emergency response vehicles for ingress during emergency response.

9.2. Explore temporary parking restrictions implemented on certain roadway segments only during hazardous conditions (e.g., fire weather).

1 INTRODUCTION

This section introduces the study and an overview of the process used to compute Evacuation Time Estimates (ETE) for the City of Berkeley, including preliminary activities of the project.

This study analyzed traffic conditions and evacuation times for a variety of evacuation scenarios in the City of Berkeley. Alternative emergency management strategies that could be used in response to an evacuation of the City of Berkeley were also examined. This study, and the results contained within this report, will further inform the City of Berkeley's emergency planning and protective action decision making.

The Study included the following key analysis components:

1. Methods and Assumptions – Section 2, Study Estimates and Assumptions through Section 6, Evacuation Cases describe the methods used for the evacuation simulation model (DYNEV-II) and the assumptions made for the modeling.
2. Evacuation Time Estimates (ETE) – The estimated total time it takes for the population of an area to evacuate based on the evacuation simulation model. See Section 7, Evacuation Time Estimates for additional information and Section 8, Transit-Dependent Population and special facility ETE calculations.
3. Sensitivity Studies (What-if Scenarios) – Analyzes the sensitivity of the ETE results to changes in several input parameters. See Section 10, Evacuation Sensitivity Studies (What-if Scenarios) for additional information.
4. Recommendations – Recommendations based on the results and analysis of the Study as well as professional knowledge. See Section 11, Recommendations for additional information.

At the time of this Study, there were no available state or federal regulations on evacuation modeling for wildfires. However, the nuclear industry is highly regulated and offers several resources for developing evacuation studies. While the hazard is different, many of the concepts of evacuation (e.g., warning time, imminent threat of danger, outbound movements (away from the hazard), etc.) are applicable. As such, most of the references used in this Study have been published by the US Nuclear Regulatory Commission (NRC) for evacuation planning for nuclear power plants, including:

- Criteria for Development of Evacuation Time Estimate Studies, NUREG/CR-7002, Rev. 1, February 2021.
- Development of Evacuation Time Estimate Studies for Nuclear Power Plants, NUREG/CR-6863, January 2005.
- Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG-0654/FEMA-REP-1, Rev. 1, November 1980.

There are some contrasts between nuclear evacuations and wildfire evacuations in particular. While there may be no visible warnings of an impending nuclear emergency or incoming tsunami, a large wildfire will be visible throughout the region. As a result, it is reasonable to assume many more residents will evacuate before warnings and orders are issued. This study presents more conservative results because it assumes that people will wait to evacuate until an order or warning is issued. The results quantifying the impact of leaving early are contained in Section 10.

The work effort reported herein was supported and guided by local stakeholders who contributed suggestions, critiques, and the local knowledge base required. Table 1-1 presents a summary of stakeholders and interactions.

1.1 Overview of the ETE Process

The following outline presents a brief description of the Study's effort in chronological sequence:

1. Information Gathering:
    a. Defined the scope of work in discussions with representatives from the City of Berkeley.
    b. Attended meetings with local stakeholders to define methodology and data needs.
    c. Conducted a detailed field survey of the roadway system and area traffic conditions within the City of Berkeley and the Shadow Region.[1] Aerial imagery was used to gather roadway information in areas that could not be driven, like Lawrence Berkeley National Laboratory (LBNL).
    d. Obtained demographic data from the 2020 Census. Projected the 2020 Census data to the study year: 2024 (see Section 3.1).
    e. Estimated the number of employees commuting into the City of Berkeley from areas outside the City of Berkeley using data provided by the city and the data obtained from the US Census Longitudinal Employer-Household Dynamics from the OnTheMap Census[2] analysis tool (see Section 3.4).
    f. Conducted a random sample demographic survey of the residents within the City of Berkeley (see Section 5) to gather demographic and mobilization information.
    g. Obtained data (to the extent available) to develop a database of schools, colleges, special facilities, visitors, and transportation resources available.

[1] An evacuation in the Shadow Region occurs when residents voluntarily evacuate from areas beyond the area officially given the Evacuation Order. This phenomenon can intensify traffic congestion and prolong evacuation times for people in the areas of actual risk.
[2] *OnTheMap*, onthemap.ces.census.gov/.

The majority of this data was provided by the city, supplemented with online research.

2. Estimated the Trip Generation Time Distribution representing the time required by various population groups (permanent residents, employees, and visitors) to prepare for the evacuation trip (i.e., to mobilize). These estimates were based on the demographic survey results and notification time estimate/assumptions (see Section 5 and Appendix D).
3. Defined Evacuation Scenarios. These scenarios reflect the variation in demand associated with different seasons, day of week and time of day (see Section 6).
4. Obtained Evacuation Regions from City of Berkeley. "Regions" are groupings of Evacuation Zones[3] for which ETEs are calculated, depending on the location of the hazard and the extent of the area to be evacuated (see Section 6 and Appendix E).
5. Estimated the demand for transit services for persons at special facilities and for transit-dependent persons, see Section 3.
6. Prepared the input streams for the DYNEV-II system which computes ETE for the Focus Areas (see Appendices B and C).
    a. Estimated the evacuation traffic demand, based on the available information derived from the United States (U.S.) Census Bureau data, provided by stakeholders, and from the demographic survey.
    b. Created the link-node representation of the evacuation network (see Section 1.3), which was used as the basis for the computer analysis that calculates the ETE.
    c. Applied the procedures specified in the 2022 Highway Capacity Manual (HCM) to the data acquired during the field survey, to estimate the capacity of all highway segments comprising the evacuation routes.
    d. Calculated the evacuating traffic demand for each Evacuation Region and each Evacuation Scenario.
    e. Specified selected candidate destinations for each "origin" (location of each "source" where evacuation trips are generated over the mobilization time) to support evacuation travel consistent with outbound movement relative to the location of the hazard.
7. Executed the DYNEV-II model to determine optimal evacuation routing and compute ETE for all residents, visitors, and employees with access to personal vehicles. Generated a complete set of ETEs for all Evacuation Regions and Evacuation Scenarios.

[3] https://protect.genasys.com/

8. Documented ETE results (see Section 7).
9. Estimated the resource needs for transit dependents including those for special facilities (schools, medical facilities and nursing homes) to evacuate (see Section 8).
10. Tested what-if scenarios to evaluate alternative evacuation management strategies that could be used in response to different hazard situations to potentially reduce evacuation time and/or to see the impacts to evacuation time due to specific changes to the input parameters (see Section 10).

1.2 Location of the Study Area

The City of Berkeley is located on the eastern shore of the San Francisco Bay within Alameda County, California. It shares municipal boundaries with Oakland and Emeryville to the south, and Albany and Kensington to the north. The eastern edge of Berkeley, bordering Contra Costa County, is defined by the Berkeley Hills, a significant wildland-urban interface. This location places Berkeley within close proximity to major Bay Area population centers, including San Francisco, located across the bay, and Oakland, its immediate neighbor. The city's position also means it is adjacent to substantial wildland areas in the Berkeley Hills, creating a unique interface between urban development and natural ecosystems. Figure 1-1 displays the boundary of the City of Berkeley and the neighboring communities and cities. This map identifies the major roadways and the Shadow Region as well.

1.3 Preliminary Activities

Field Surveys of the Roadway Network

KLD personnel drove the entire roadway system within the city and the Shadow Region. The Shadow Region considered for this study is bounded by I-580, Piedmont Ave and Moraga Ave to the south, State Route 13 and State Route 24 to the southeast, the eastern boundary of Tilden Park to the east, by Moeser Lane, San Pablo Avenue, Potrero Avenue, S 55th Street, and Bayview Avenue to the North, and I-580 and the San Francisco Bay to the West, as shown in Figure 1-1. The characteristics of each section of roadway in the study area were recorded. The characteristics considered are listed in Table 1-2.

Video and audio recording equipment were used to capture a permanent record of the roadway infrastructure. No attempt was made to meticulously measure such attributes as lane width and shoulder width; estimates of these measures based on visual observation and recorded images were considered appropriate for the purpose of estimating the capacity of roadway sections. For example, Exhibit 15-7 in the HCM indicates that a reduction in lane width from 12 feet (the “base” value) to 10 feet can reduce free flow speed (FFS) by 1.1 mile per hour (mph) – not a material difference – for two-lane highways. Exhibit 15-46 in the HCM shows little sensitivity for the estimates of Service Volumes at Level of Service (LOS) E (near capacity), with respect to FFS, for two-lane highways.

The data from the audio and video recordings were used to create detailed geographic information systems (GIS) shapefiles and databases of the roadway characteristics and of the traffic control devices observed during the road survey; this information was referenced while preparing the input stream for the DYNEV II System.

As documented on page 15-6 of the HCM 2022, the capacity of a two-lane highway is 1,700 passenger cars per hour in one direction. A capacity of 2,250 vehicles per hour (vph) per lane is assigned for freeway sections, as per Exhibit 12-37 of the HCM 2022. The road survey identified several segments which are characterized by adverse geometrics (i.e., steep hills and tight curves with no shoulders) on two-lane highways which are reflected in reduced values for both capacity and speed. These estimates are consistent with the service volumes for LOS E presented in HCM Exhibit 15-46. Further discussion of roadway capacity is provided in Section 4.

Traffic signals are either pre-timed (signal timings are fixed over time and do not change with the traffic volume on competing approaches) or are actuated (signal timings vary over time based on the changing traffic volumes on competing approaches). Actuated signals require detectors to provide traffic data used by the signal controller to adjust the signal timings. These detectors are typically magnetic loops in the roadway or video cameras mounted on the signal masts and pointed toward the intersection approaches. If detectors were observed on the approaches to a signalized intersection during the road survey, detailed signal timings were not collected as the timings vary with traffic volume.

If no detectors were observed, the signal control at the intersection was considered pre-timed, and detailed signal timings were provided by the City of Berkeley. These signal timings were input to the DYNEV II system used to compute ETE.

Figure 1-2 presents the link-node analysis network that was constructed to model the evacuation roadway network in the city and the Shadow Region. The directional arrows on the links and the node numbers have been removed from Figure 1-2 to clarify the figure. The observations made during the field survey along with aerial imagery were used to calibrate the analysis network.

Demographic Survey

A demographic survey was performed to gather information needed for the evacuation study. Appendix D presents the survey instrument, the procedures used, and tabulations of data compiled from the survey returns.

This data was utilized to develop estimates of vehicle occupancy to estimate the number of evacuating vehicles during an evacuation and to estimate elements of the mobilization process. This database was also referenced to estimate the number of transit-dependent people, as well as capture attitudinal responses to evacuation.

Computing the Evacuation Time Estimates

The overall study procedure is outlined in Appendix B. Demographic data was obtained from several sources, as detailed later in this report. These data were analyzed and converted into vehicle demand data. The vehicle demand was loaded onto appropriate "source" links of the analysis network using GIS mapping software. The DYNEV II system was then used to compute ETE for all Regions and Scenarios.

Analytical Tools

The DYNEV II System[4] that was employed for this study is comprised of several integrated computer models. One of these is the DYNEV (DYnamic Network EVacuation) macroscopic simulation model[5], a new version of the IDYNEV model that was developed by KLD under contract with the Federal Emergency Management Agency (FEMA).

DYNEV II consists of four sub-models:

- A macroscopic traffic simulation model.
- A Trip Distribution (TD) model that assigns a set of candidate destination (D) nodes for each "origin" (O) located within the analysis network, where evacuation trips are "generated" over time. This establishes a set of O-D tables.
- A Dynamic Traffic Assignment (DTA) model which assigns trips to paths of travel (routes) which satisfy the O-D tables, over time. The TD and DTA models are integrated to form the DTRAD (Dynamic Traffic Assignment and Distribution) model[5].
- A Myopic Traffic Diversion model which diverts traffic to avoid intense, local congestion, if possible.

Another software product developed by KLD, named UNITES (UNIfied Transportation Engineering System) was used to expedite data entry and to automate the production of output tables.

The dynamics of traffic flow over the network are graphically animated using the software product, EVAN (EVacuation ANimator), developed by KLD. EVAN is GIS based and displays statistics such as LOS, vehicles discharged, average speed, and percent of vehicles evacuated, output by the DYNEV II System. The use of a GIS framework enables the user to zoom in on areas of congestion and query road name, town name and other geographic information.

The procedure for applying the DYNEV II System within the framework of developing ETE is outlined in Appendix B. Appendix A is a glossary of terms.

For the reader interested in an evaluation of the original model, I-DYNEV, the following references are suggested:

- NUREG/CR-4873 – Benchmark Study of the I-DYNEV Evacuation Time Estimate Computer Code.

[4] The models of the IDYNEV System were recognized as state of the art by the Atomic Safety & Licensing Board (ASLB) in past hearings. (Sources: Atomic Safety & Licensing Board Hearings on Seabrook and Shoreham; Urbanik). The models have continuously been refined and extended since those hearings and were independently validated by a consultant retained by the NRC. The DYNEV II model incorporates the latest technology in traffic simulation and in dynamic traffic assignment. (Urbanik, T., et. al. Benchmark Study of the I-DYNEV Evacuation Time Estimate Computer Code, NUREG/CR-4873, Nuclear Regulatory Commission, June, 1988.)

[5] https://kldassociates.com/wp-content/uploads/2024/10/DTRAD-DYNEV.pdf

- NUREG/CR-4874 – The Sensitivity of Evacuation Time Estimates to Changes in Input Parameters for the I-DYNEV Computer Code.

The evacuation analysis procedures are based upon the need to:

- Route traffic along paths of travel that will expedite vehicles' travel from their respective points of origin to points outside the evacuated area.
- Restrict movement toward the wildfire to the extent practicable and disperse traffic demand so as to avoid focusing demand on a limited number of roadways.
- Move traffic in directions that are generally outbound relative to the location of the hazard.

DYNEV II provides a detailed description of traffic operations on the evacuation network. This description enables the analyst to identify bottlenecks and to develop countermeasures that are designed to represent the behavioral responses of evacuees. The effects of these countermeasures may then be tested with the model.

Model Limitations

The focus of this study is to estimate times for evacuating vehicular traffic. It does not analyze ingress times, and as a result the interaction between inbound vehicles (such as responders and/or buses) with outbound evacuees is not considered. Additionally, the model is not multimodal and does not analyze evacuation times for cyclists or pedestrians or consider the interaction between drivers, cyclists and/or pedestrians. See Section 11 for Berkeley public safety recommendations related to evacuating on bike or on foot.

Table 1-1. Stakeholder Interaction

City of Berkeley Stakeholders	Nature of Stakeholder Interaction
Fire Department Department of Public Works Planning and Development Department Police Department	• Attended project meetings. • Reviewed demographic survey questions. • Assisted in publicizing the demographic survey. • Assisted in data collection. • Reviewed and discussed all study assumptions. • Identified evacuation regions for study. • Attended bi-weekly meetings, as needed.

Table 1-2. Roadway Characteristics

- Number of lanes
- Lane width
- Shoulder type & width
- Interchange geometries
- Lane channelization & queuing capacity (including turn bays/lanes)
- Geometrics: curves, grades (>4%)
- Posted speed
- Actual free speed
- Abutting land use
- Traffic control and calming devices
- Intersection configuration (including roundabouts where applicable)
- Traffic signal type
- Unusual characteristics: Narrow bridges, sharp curves, poor pavement, inadequate delineations, toll booths, etc.

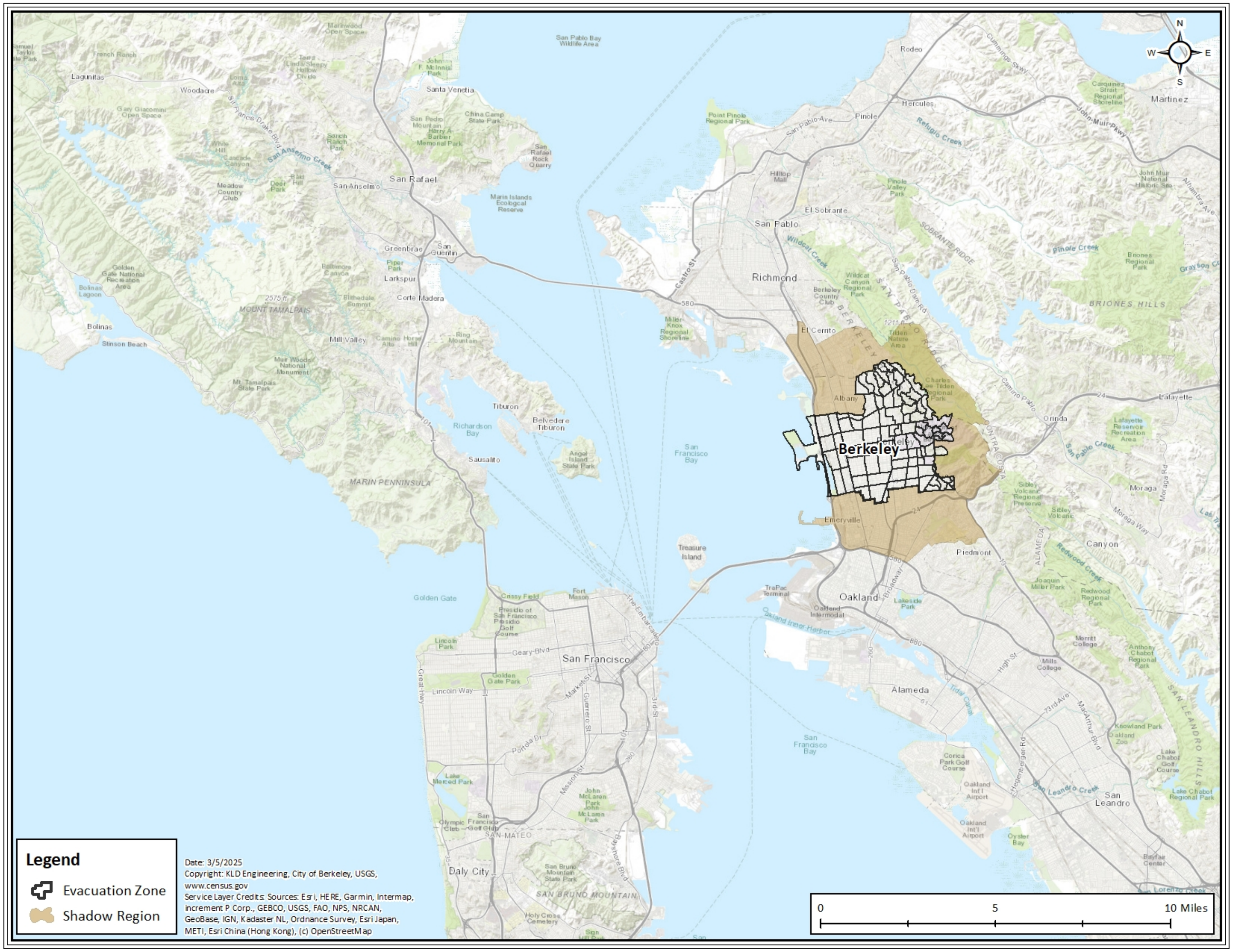


Figure 1-1. Study Area Location

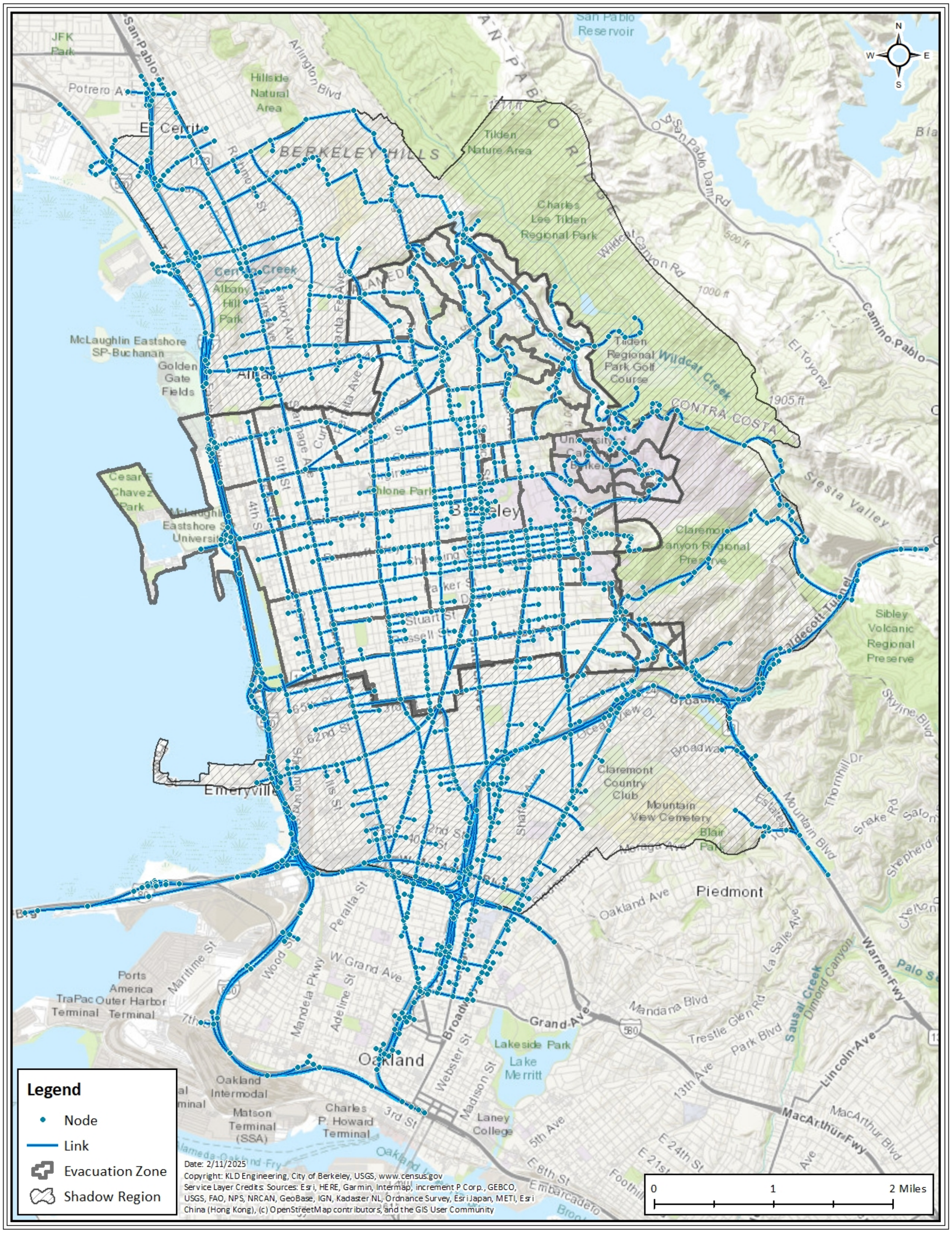


Figure 1-2. Study Area Link-Node Analysis Network

2 STUDY ESTIMATES AND ASSUMPTIONS

This section discusses the data estimates and project assumptions utilized in this study. These assumptions were discussed with representatives from the City of Berkeley. An assumptions memorandum documenting all the project assumptions was reviewed and approved by stakeholders prior to their use in this study.

2.1 Data Estimates

1. The permanent resident population estimates are based on the 2020 U.S. Census population data from the Census Bureau website[1] extrapolated to December 2024 using annual growth rates that are computed from the 2023 Census population estimates. A methodology, referred to as the "area ratio method," will be employed to estimate the population within portions of census blocks that are divided by the evacuation zone boundaries. It is assumed that the population is evenly distributed across a census block in order to employ the area ratio method.
2. Estimates of the number of employees commuting into the study area was provided by the City of Berkeley, supplemented by data from the U.S. Census Longitudinal Employer-Household Dynamics from the OnTheMap Census analysis tool[2].
3. Based on the demographic survey, the majority (64%) of households that have a commuter commute to work/college at least four days a week. Thus, no reduction in commuters was considered for remote work and learning.
4. Population estimates at special facilities (schools and medical facilities) was based on the data received from the City of Berkeley, supplemented by internet searches where data was missing.
5. Population estimates at tourist attractions (hotels, marinas, camps, parks, etc.) were based on parking lot capacities within the City of Berkeley, and the annual number of tourists that visit City of Berkeley. It is assumed that 30% of tourists visit the city via public transit and average vehicle occupancy rate is equal to the average household size (2.37).
6. The variation of tourists in different seasons and day of the week was based on the data provided by the City of Berkeley. The number of tourists within the city during nighttime scenarios (Scenario 3 and 6) was reduced by 60% compared to the daytime.
7. The relationship between permanent resident population and evacuating vehicles was based on the Census[3] and the results of the demographic survey. Values of 2.37 persons

[1] www.census.gov
[2] http://onthemap.ces.census.gov/
[3] https://www.census.gov/quickfacts/fact/table/berkeleycitycalifornia/IPE120223

per household and 1.14 evacuating vehicles per household were used for the permanent resident population.

8. Employee vehicle occupancies were based on the results of the demographic survey. In this study, 1.08 employees per vehicle were used. In addition, it is assumed there are two people per carpool, on average.
9. Roadway capacity estimates were based on field surveys performed in May 2023 and the application of the Highway Capacity Manual 2022.

2.2 Methodological Assumptions

1. The Planning Basis Assumption for the calculation of ETE is a rapidly escalating hazard that requires immediate evacuation, and includes the following:
   a. The order to evacuate is announced coincident with local emergency alerts (AC Alert/IPAWS, Genasys Protect, Outdoor Warning System Sirens, Nixle, social media, local news and similar communication systems).
   b. Mobilization of the general population will commence within 15 minutes after the order to evacuate.
   c. The ETE are measured relative to the order to evacuate being issued by officials.
   d. In a fire context, the “rapidly escalating hazard” scenario being modeled is one where a fire has ignited and is growing in a manner and location that warrants issuance of an evacuation order for all or parts of Berkeley. This study is not analyzing behaviors among evacuees for whom the hazard is actively present (i.e., there is active fire in the neighborhood). This means that mobilization times are not reflective of this type of situation. Additionally, driver behavior in the model does not reflect more unpredictable community behaviors expected when fire is present (violating traffic laws, driving erratically, etc.).
2. The DYNEV II[4] (Dynamic Network Evacuation) macroscopic simulation model was used to compute ETE in this study.
3. Evacuation movements (paths of travel) will be generally outbound relative to the hazard to the extent permitted by the highway network. All major evacuation routes were used in the analysis.
4. Evacuees will drive safely, travel away from the hazard to the extent practicable given the highway network and will obey all traffic control devices and traffic guides. It is noted that drivers under extreme duress may not drive safely, obey traffic control devices, or drive lawfully.
5. One hundred percent (100%) of the people told to evacuate will do so. Although the

[4] The models of the I-DYNEV System were recognized as state of the art by the Atomic Safety & Licensing Board (ASLB) in past hearings. (Sources: Atomic Safety & Licensing Board Hearings on Seabrook and Shoreham; Urbanik). The models have continuously been refined and extended since those hearings and were independently validated by a consultant retained by the NRC. The DYNEV II model incorporates the latest technology in traffic simulation and in dynamic traffic assignment.

demographic survey indicated that 0.8% of people will not leave an area under evacuation order, the ETE is designed to identify the time required to fully evacuate the area.

6. The Evacuation Zones were used to create the study area. Regions are defined by groupings of the Evacuation Zones. Regions to be considered are defined in Table 6-1.
7. Berkeley's evacuation zones establish the underlying geographies for evacuation measurements. For Region R05, evacuation zones do not match boundaries for Fire Zones 2 & 3 exactly. If a significant portion of the evacuation zone was part of Fire Zone 2 or 3, then the entire evacuation zone was included in Fire Zone 2 & 3.
8. The Shadow Region is defined as the area beyond the City of Berkeley and is bounded by I-80 and Grove Shafter Freeway to the south, to the boundary of Tilden Park to the east, Kensington Community to Terrace Drive to Stockton Avenue to Panama Avenue to the North, and the San Francisco Bay to the West.
9. Shadow population characteristics (household size, evacuating vehicles per household, and mobilization time) are assumed to be the same as that of the permanent resident population.
10. This study assumes that 20% of households within the Shadow Region and within the Evacuation Zones not ordered to evacuate, will choose to evacuate, based on the recommendation from Criteria for Development of Evacuation Time Estimate Studies, NUREG/CR-7002, Rev. 1, February 2021. It is noted that due to the limited geographic (North-South) extent of wildfire entry points, it is unlikely that shadow region evacuation will be homogenous. As an example, a wildfire entering Berkeley at Spruce/Wildcat Canyon/Cannon would likely result in 100% evacuation of Kensington and 0% evacuation of Oakland, Emeryville, and Piedmont. Due to the limitations of this study, a uniform 20% was assumed, acknowledging that the geographic areas of shadow evacuation will vary depending on the ignition point of the wildfire.
11. Phased evacuation is a systematic approach to evacuating people. Instead of everyone rushing out at once, the evacuation happens in stages, prioritizing those in immediate danger. This helps prevent overcrowding, making the evacuation process safer and more efficient. A phased evacuation is assumed for Region R03 (see Table 6-1), where residents in specified zones are ordered to evacuate, while residents in other zones receive an evacuation warning and/or are issued no protective order. After some time, zones that were issued a warning, or were given no action, may be issued an order to evacuate, or an evacuation warning, respectively, etc. and so on.
    a. During a phased evacuation, residents are assumed to still follow their regular mobilization curve starting at the time of the first evacuation order (0 minutes/Phase a), 30 minutes after the first evacuation order (Phase b), or 60 minutes after the evacuation order (Phase c).
        i. A voluntary evacuation of 20% is assumed for those within areas that are given no action.

b. Only residents are expected to phase their evacuation. Non-resident population groups (employees, tourists, etc.) are assumed to evacuate immediately if they are in zones that will later be given an evacuation order.

12. It is assumed that 50% of residents will voluntarily evacuate within zones that are given an evacuation warning. For phased evacuation cases, if a zone ultimately reaches an evacuation order, following a phase of no action (20% voluntary evacuation) and an evacuation warning (50% voluntary evacuation), only about 30% of residents remain.
13. Scenarios are outlined in Table 2-1. Fall means that K-12 public schools and colleges are in session. Summer means that K-12 public schools and colleges are in session at summer school enrollment levels (lower than normal enrollment).
14. Employment was assumed to be at its peak during fall scenarios. Employment is reduced slightly (96%) for summer scenarios. This is based on the estimation that 50% of the employees commuting into the evacuation zones will be on vacation for a week during the approximate 12 weeks of summer. It was further estimated that those taking vacations were uniformly dispersed throughout the summer with approximately 4% of employees vacationing each week. It was further estimated that only 10% of the employees work in the nighttime and during the weekends.
15. This study does not assume that roadways are empty at the start of an evacuation. The amount of initialization/fill traffic that is on the roadways in the study area at the start of the evacuation depends on the scenario and the region being evacuated.
16. To account for boundary conditions beyond the study area, this study assumes a 25% reduction in capacity on two-lane roads and multilane highways for roadways that have traffic signals downstream. The 25% reduction in capacity is based on the prevalence of actuated traffic signals in the study area and the fact that the evacuating traffic ("main street") volume will be more significant than the competing traffic ("side street") volume at any downstream signalized intersections, thereby warranting a more significant percentage (75% in this case) of the signal green time. There is no reduction in capacity for freeways due to boundary conditions.
17. Schools often prefer that parents and guardians not pick their children up from an evacuating school. This preference is to help facilitate an orderly evacuation, and the intention is that parents instead pick up their children from a secondary site outside of the evacuating area. Many parents will nevertheless choose to pick their children up from school while the school is evacuating. This influx of vehicles to school sites could impact evacuation flow. The results of the demographic survey indicate some parents will pick up their children from school prior to beginning their evacuation trip (see Assumption 2.a.i in Section 2.4). Based on survey responses, this study uses survey responses and assumes that 18% of households will pick up schoolchildren prior to beginning their evacuation trip.

2.3 Assumption on Mobilization Times

1. Evacuee mobilization times (also called trip generation time) were based on a statistical analysis of data acquired from a random sample demographic survey of the study area residents (documented in Section 5 and Appendix D).
2. The notification time distribution (the time required for evacuees to receive notification of an evacuation) used in the study was estimated using the results of the demographic survey, the data provided by the City of Berkeley and similar studies of this nature.
3. Based on the results of the demographic survey, 41.6% of the households in the evacuation zones have at least 1 commuter; 30.1% of households will await the return of household members before beginning their evacuation trip, based on the demographic survey results. Therefore, about 13% (41.6% x 30.1% = 12.5%) of households will await the return of household members, prior to beginning their evacuation trip. It is noted that these behaviors may not occur for active wildfire situations with ample indication (smoke and embers) of the emergent nature of the threat. In these situations, it is possible that fewer households will wait for all members to return prior to beginning their evacuation trip. Section 10 explores how evacuation time estimates change when evacuees leave more quickly.

2.4 Transit Dependent Assumptions

1. Approximately eighty-seven percent (87%) of the transit-dependent population will rideshare with a neighbor or friend, based on the demographic survey results.
2. Public transportation vehicle needs will be computed for special facilities:
   a. Schools and preschools/day care centers:
      i. Based on the demographic survey, approximately 22% of households have school children and 83% of them would pick them up from the school prior to starting their evacuation trip. The results of the demographic survey were used to estimate the trip generation distribution for this population group, which makes up about 18% (22% x 83% = 18.3%) of households within the evacuation zones.
      ii. If schools are in session, transport (buses) needs were computed based on school enrollments. In addition, the demand at schools will be reduced by 83% to account for parents that will pick up their children prior to evacuating.
      iii. Schoolchildren, if school is in session, are given priority in assigning transit vehicles, if available.
      iv. For those schools wherein buses are used to evacuate students, multiple waves of ETE were computed in the event there is shortfall of bus resources.
      v. It is assumed that infants from infant care centers are picked up by parents.

b. Colleges/Universities
    i. The colleges specifically considered were Berkeley City College and UC Berkeley. At both of these schools, some students have personal vehicles they will use to evacuate and some will rideshare. Although students may walk or cycle, the model conservatively assumes that remaining students without their own car or access to a vehicle will use a bus provided as part of emergency response to evacuate. See Section 3 for additional information.
    ii. Students at small local colleges are likely local residents living within the city or remote learning students living outside of the city.
c. Medical Facilities
    i. Buses, wheelchair transport vehicles and ambulance needs were computed for the evacuation of patients at medical facilities.
    ii. The percent breakdown of ambulatory/wheelchair-using/bedridden patients at medical facilities was assumed to be 45%/30%/25%[5], respectively, for facilities where no data was provided.
d. Numbers of people requiring specialized transportation were based on emPOWER data provided by the City of Berkeley. 348 people within the city are assumed to require specialized transportation assistance to evacuate. 99 people using motorized wheelchairs/scooters will evacuate in 50 wheelchair accessible vans. 249 bedbound people will evacuate in 125 ambulances.
e. The number of people experiencing homelessness was based on the data provided by the City of Berkeley. This population group is transit dependent and is picked up from shelters during an evacuation.
f. Households with 3 or more vehicles were assumed to have no need for transit vehicles.

3. Transit vehicle capacities and maximum speed limits:
    a. Students and children at preschools/day care centers were assumed to be 70 students per bus for elementary schools/preschools/day care centers and 50 students per bus for middle/high schools.
    b. Students at colleges/universities were assumed to be 30 students per bus.
    c. Ambulatory transit-dependent residents were assumed to be 30[6] people per bus.
    d. Employees and visitors, who will not have luggage, etc., are assumed to be 60 passengers per bus[7].
    e. Ambulatory patients at medical facilities were assumed to be 30[6] people per bus.
    f. Wheelchair accessible van was assumed to be 2 passengers per van.

[5] These percentages are based on the breakdown at the facilities at which data was obtained.
[6] The data provided by the City of Berkeley indicates that buses for ambulatory evacuees can accommodate at most 30 passengers with 45 standees. During an evacuation, however, it is likely that resident evacuees will carry personal items such as luggage and pets that will take up some of the available capacity within the bus. Hence, it is conservatively assumed that each bus can carry approximately 30 people.
[7] According to the AC Transit website, buses can accommodate between 40 and 78 passengers. An average of 60 passengers per bus was assumed.

g. Basic Life Support (BLS) (ambulances) was assumed to be 2 persons per vehicle.
h. The maximum bus speed was assumed to be 55 miles per hour in uncongested environments.

4. Transit vehicle[8] mobilization times:
   a. It is understood that the mobilization times for school and transit buses will vary. For the purpose of this study, it is assumed that school and transit buses will arrive at schools, preschools/day care centers and colleges/universities to be evacuated within 90 minutes of the order to evacuate.
   b. Buses for transit-depending evacuees will not be immediately available to pick them up. It is conservatively assumed that these buses will arrive at their designated pick-up routes within 180 minutes of the order to evacuate, which includes considering the notification, arrival and briefing times for the bus drivers.
   c. Vehicles will arrive at medical facilities to be evacuated within 90 minutes of the order to evacuate.

5. Transit vehicle loading times:
   a. School, preschool/day care center and college/university buses will be loaded in 15 minutes.
   b. Buses for transit dependent evacuees will require 1 minute of loading time per passenger[9].
   c. Buses for medical facilities will require 1 minute of loading time per ambulatory passenger.
   d. Wheelchair transport vehicles will require 5 minutes of loading time per passenger.
   e. Ambulances will require 30 minutes per bedridden passenger[10].

6. Tourists that arrive via public transit and rideshare applications, like Uber, will evacuate via the same means that they arrived in the city.

2.5 Access Control Assumptions

1. Vehicles will be traveling through the study area (external-external trips) at the start of a hazard. After the order to evacuate is announced, these pass-through travelers will also evacuate. External traffic vehicles will primarily utilize CA-24, Interstate (I)-580, I-80, and I-880 to pass through the area. It is likely that dynamic and variable message signs will be strategically positioned outside of the hazard area at logical diversion points to attempt to divert traffic away from the hazardous area within the City of Berkeley. As such, it is assumed this pass-through (external) traffic ceases at 2 hours after the order

[8] The City of Berkeley does not own or manage school and/or transit buses
[9] This includes the time for the vehicle to slow down, come to a stop, open the door, the passenger to enter the vehicle, and then for the vehicle to speed up to free flow speed on the roadway.
[10] This includes the time for the bedridden passengers to be brought to the ambulance door, load onto the ambulance, and hook up to the necessary equipment onboard the ambulance.

to evacuate to allow police to mobilize personnel and equipment to block the roadways and to allow time for commuters to return home and unite with family. Average Annual Daily Traffic (AADT) along CA-24 I-580, I-80, and I-880 will be based on the data obtained from California Department of Transportation (Caltrans)[11].

2. External traffic is estimated to be reduced by 60% during nighttime scenarios (Scenario 3 and 6). Nighttime scenarios are considered the time after everyone returns home (commuters and children) and before everyone leaves in the morning for work/school.

Table 2-1. Evacuation Scenario Definitions

Scenarios	Season[12]	Day of Week	Time of Day
1	Summer	Midweek	Midday
2	Summer	Weekend	Midday
3	Summer	Midweek, Weekend	Nighttime
4	Fall	Midweek	Midday
5	Fall	Weekend	Midday
6	Fall	Midweek, Weekend	Nighttime

[11] https://dot.ca.gov/programs/traffic-operations/census

[12] Fall means that school is in session at normal enrollment levels. Summer means that school is in session at summer school enrollment levels (lower than normal enrollment).

3 DEMAND ESTIMATION

This section discusses the estimates of demand, expressed in terms of people and vehicles, which constitute a critical element in developing an evacuation plan. This section also documents the sources of data, as well as the methodology used to extract relevant data from these sources. These estimates consist of three components:

1. An estimate of population within the City of Berkeley, stratified into groups (e.g., residents, employees, visitors, special facilities, etc.).
2. An estimate, for each population group, of average occupancy per evacuating vehicle. This estimate is used to determine the number of evacuating vehicles from the population estimates.
3. An estimate of potential double-counting of vehicles.

Appendix C presents much of the source material for the population estimates. Our primary source of population data, the 2020 Census, is not adequate for directly estimating some visitors.

Throughout the year, vacationers and visitors enter the City of Berkeley. These non-residents may dwell within the city for a short period (e.g., a few days or one or two weeks), or may enter and leave within one day. Estimates of the size of these population components must be obtained, so that the associated number of evacuating vehicles can be ascertained.

The potential for double-counting people and vehicles must be addressed. For example:

- A resident who works and shops within the city could be counted as a resident, again as an employee and once again as a shopper.
- A visitor who spends time at a park and then goes shopping could be counted two times.

Furthermore, the number of vehicles at a location depends on the time of day. For example, parking lots at area parks, which are full at noon, may be almost empty at dawn. Estimating counts of vehicles by simply adding up the capacities of different types of parking facilities will tend to overestimate the number of visitors and can lead to ETE that are too conservative.

Analysis of the population characteristics of the study area indicates the need to identify four distinct groups:

- Permanent residents - people who are year-round residents, including college students who live in Berkeley.
- Visitors - people who reside outside of the city who enter the area for a specific purpose (i.e., recreation) and then leave the area.
- Employees - people who reside outside of the city and commute to work within the city on a daily basis.
- College students who live outside Berkeley – people who reside outside of the city and commute to Berkeley colleges on a daily basis during the school year.

Estimates of the population and number of evacuating vehicles within the city are presented by different subdivisions of the city (Berkeley Flats, North Berkeley Hills, South Berkeley Hills, West

Berkeley, UC Berkeley and Lawrence Berkeley National Lab). These subdivisions are referred to as Areas throughout this report. The grouping of Evacuation Zones[1] that make up each Area are shown in Figure 3-1 and in more detail in Figure 3-2 through Figure 3-6. The evacuation zones were overlaid with the boundary of the City of Berkeley. When the zone extended beyond the City of Berkeley boundary, portions of the City of Oakland were included to reflect the area that would evacuate together. In addition, the eastern portion of Panoramic Hill, which lies completely in the City of Oakland, is included in the study as its own zone because people in this area will need to enter the City of Berkeley to evacuate.

3.1 Permanent Residents

The primary source for estimating permanent population is the latest U.S. Census data. The U.S. Census Bureau conducts a physical census of the permanent resident population in the U.S. every ten years. The latest census began on April 1, 2020, with data from the census being published on September 16, 2021. In the years between the decennial censuses, the Census Bureau works with state and local agencies to provide annual population estimates at the state and local levels. These estimates are done using data on deaths, births and migration. This annual data gathering process and analysis is extensive. As such, population estimates are a year behind – 2024 data are released in 2025[2]. However, the ETE simulations for this study were completed prior to the release of the 2024 data. Thus, this study is based on 2020 Census population data from the Census Bureau website[3] extrapolated to 2024 using annual growth rates computed from the 2023 Census population estimates as outlined in the methodology below.

The Census Bureau QuickFacts website[4] provides annual population estimates for each state, county[5], and municipality[6] in the United States. As discussed above, Census population estimates are a year behind. By the time this study started, the most recent population estimates available for the counties and municipalities are for the time period from April 1, 2020 to July 1, 2023. The population change and annual growth rate for each county and municipality in the study area (the City of Berkeley plus the Shadow Region) are provided in Table 3-1 and Table 3-2, respectively. Figure 3-7 shows the county and municipality boundaries identified by the Census Bureau.

The permanent resident population, as per the 2020 Census, for the city and the Shadow Region was projected to 2024 using the compound growth formula (Equation 1). In the compound growth formula, g is the annual growth rate, and X is the number of years projected forward from Year 2020. The compound growth formula can be solved for g as shown in Equation 2.

Equation 1

$$(Compound\ Growth\ for\ X\ years): Population\ 202X = Population\ 2020\ (1 + g)^{x}$$

[1] https://protect.genasys.com/
[2] The schedule for release of Census data is provided on the Census website: https://www.census.gov/programs-surveys/popest/about/schedule.html
[3] www.census.gov
[4] https://www.census.gov/quickfacts/fact/table/US/PST045222
[5] https://www.census.gov/data/datasets/time-series/demo/popest/2020s-counties-total.html
[6] https://www.census.gov/data/datasets/time-series/demo/popest/2020s-total-cities-and-towns.html

Equation 2

$$(Solving\ for\ the\ annual\ growth\ rate): g = (Population\ 202X \div Population\ 2020)^{1/x} - 1$$

The 2020 and 2023 population data provided in Table 3-1 and Table 3-2 were used in Equation 2 to compute the annual growth rate for each county and municipality in the study area using X = 3.25 (3 years and 3 months from April 1, 2020 to July 1, 2023). The computed annual growth rate for each county and municipality is summarized in the final column of Table 3-1 and Table 3-2, respectively.

The most detailed data should always be used when forecasting population. In terms of detailed data, municipal data is the finest level of detail, then county data, and state data. The municipality growth rate was used first and if that was not available or applicable within the study area, then the county growth rate was used. County growth rates are available for the entire study area and were used (in the absence of municipal data) as they are the finest level of detail available for the entire study area. Thus, state data was not used.

The Census Bureau does not provide population data specific to the boundaries of the study area. As such, the county or municipality population was used to compute the annual growth rate. Then, the appropriate municipality or county growth rate was applied only to those census blocks located within the study area. All other blocks outside of the study area were not considered as part of the City of Berkeley or Shadow Region population, even if they are located within one of the municipalities or counties that intersect the study area.

The appropriate annual growth rate was applied to each census block in the study area depending on which county or municipality the block is located within. The population was extrapolated to December 1, 2024 using Equation 1 with X = 4.67 (4 years and 8 months from the April 1, 2020 Census date to December 1, 2024), as the base year for this study.

The permanent resident population is estimated by cutting the census block polygons by the boundaries of Evacuation Zones and Shadow Region using GIS software. A ratio of the original area of each census block and the updated area (after cutting) is multiplied by the total block population to estimate what the population is within the city. This methodology (referred to as the "area ratio method") assumes that the population is evenly distributed across a census block. Table 3-3 provides the permanent resident population within the city, by Area, for 2020 and for 2024 (based on the methodology above). As indicated, the permanent resident population within the city has decreased by -6.08% since the 2020 Census.

To estimate the number of vehicles, the 2024 extrapolated permanent resident population is divided by the average household size and then multiplied by the average number of evacuating vehicles per household. The average household size (2.37 persons/household) is based on the 2018-2022 American Community Survey 5-year estimates[7] and the number of evacuating vehicles per household (1.14 vehicles/household – See Appendix D, Sub-section D.3.2) was adapted from the demographic survey results. Permanent resident population and vehicle

[7] https://www.census.gov/programs-surveys/acs

estimates are presented in Table 3-4. Note, the 2020 Census includes residents living in group quarters, such as skilled nursing facilities, group homes, college/university student housing, juvenile homes, etc. These people are transit dependent (will not evacuate in personal vehicles) and are included in the special facility evacuation demand estimates. To avoid double counting vehicles, the vehicle estimates for these people have been removed. The resident vehicles in Table 3-4 have been adjusted accordingly.

3.2 Shadow Population

A portion of the population living outside the evacuation area may elect to evacuate without having been instructed to do so. This area is called the Shadow Region, which is bounded by I-580, Piedmont Ave and Moraga Ave to the south, State Route 13 and State Route 24 to the southeast, the eastern boundary of Tilden Park to the east, by Moeser Lane, San Pablo Avenue, Potrero Avenue, S 55th Street, and Bayview Avenue to the North, and I-580 and the San Francisco Bay to the West, as shown in Figure 3-8. Based upon NUREG/CR-7002, Rev. 1 guidance, it is assumed that 20% of the permanent resident population, based on U.S. Census Bureau data, in this Shadow Region will elect to evacuate.

Shadow population characteristics (household size, evacuating vehicles per household, mobilization time) are assumed to be the same as that of Berkeley's permanent resident population. As shown in Table 3-4, there are 114,671 permanent residents and 111,443 vehicles in the Shadow Region. Similar to the vehicle estimates for Berkeley residents, resident vehicles at group quarters have been removed from the shadow population vehicle demand in Table 3-4.

3.3 Visitor Population

Visitors are defined as those who are not permanent residents nor commuting employees but enter the City of Berkeley for a specific purpose (i.e., recreation or shopping). The visitor population was estimated based on the information provided by Visit Berkeley. Based on the data provided, the City of Berkeley had approximately 30,200,000 visits during a period of 364 days (from January 2023 to December 2023), and each visitor spends an average of 12 hours and 47 minutes (767 minutes) dwell time within the city. Based on the conversations with the city staff, it was assumed that 30% of these visits arrive via public transportation and the remaining 70% arrive via private vehicles. This computes to 44,192 visitors on a daily basis, on average, [(30,200,000 visits/364 days) x (767 minutes/1,440 minutes per day) = 44,192 visitors]. Of these 44,192 visitors, 13,258 (44,192 x 30%) of them arrive by public transportation, and 30,934 (44,192 – 13,258) visitors arrive in private vehicles.

Of the visitors that use public transportation (13,258 visitors), it was assumed that 50% of them would arrive by rail and 50% of them would arrive in the city using a bus. This results in 6,629 visitors arriving in the city via rail and 6,629 visitors arriving on 111 buses. (Unlike permanent residents, where the bus capacity is conservatively limited to 30 people per bus, visitors will have fewer belongings and will, therefore, need less space. Hence, it was assumed that buses for visitors can accommodate 60 visitors per bus[8].) These visitors were loaded along the AC Transit routes within the city, see Section 9.

Since the locations of these visits/visitors could be anywhere within the city, the visitor vehicles were assumed to be located along streets where street parking is allowed as well as in the parking garages available within the City of Berkeley. Assuming the visitors travel to recreational areas and facilities as a family/household, the average household size (2.37 persons per household – see Section 3.1) was used to estimate the visitor vehicles. As a result, there are approximately 13,052 (30,934 ÷ 2.37) evacuating tourist vehicles.

In addition, visitors within the Shadow Region at Tilden Regional Park and the Tilden Park Golf Course were included in the study since they need to enter the city limits to evacuate. Based on aerial imagery, Tilden Regional Park has approximately 419 parking spaces and Tilden Park Golf Course has approximately 130 parking spaces. Assuming the parking lots are fully occupied at peak times, this study estimates a total of 549 evacuating vehicles from Tilden Regional Park and the Tilden Park Golf Course. The average household size (2.37 persons per household – see Section 3.1) was used to estimate visitor population at Tilden Regional Park and 2 persons per vehicle were used to estimate visitor population at the Tilden Park Golf Course, resulting in a population of 993 visitors (419 x 2.37) at Tilden Regional Park and 260 visitors (130 x 2.00) at the Tilden Park Golf Course.

In summary, 6,629 visitors would evacuate using rail, 6,629 visitors would evacuate in 111 buses and the remaining 32,187 visitors would evacuate in 13,601 private vehicles.

3.4 Employees

The estimate of employees commuting into the City of Berkeley is based on the employment data provided by the city and the data obtained from the U.S. Census Bureau's OnTheMap Census analysis tool[9].

The employment data provided by the City of Berkeley, as of October 2022, includes the coordinates of employers and the average number of their employees. The employer locations were plotted using GIS software. Employees who work at small companies are likely local residents. Based on federal guidance on major employers and discussions with the city, to avoid double-counting residents who live within the city, only employers with 100 or more employees are considered as *major employers*. Employers with less than 100 employees were removed from the analysis.

Staff at major employers within Berkeley fall into two categories:

- Those who live and work in the City of Berkeley
- Those who live outside of the City of Berkeley and commute to jobs within the city

[8] According to the AC Transit website, buses can accommodate between 40 and 78 passengers. An average of 60 passengers per bus was assumed.
[9] http://onthemap.ces.census.gov/

Those of the first category are already counted as part of the permanent resident population. To avoid double counting, we focus only on those employees commuting from outside the city who will evacuate along with the permanent resident population. The LEHD (Longitudinal Employer-Household Dynamics) Origin-Destination Employment Statistics (LODES) data[10] from OnTheMap website was then used to estimate the percent of employees that work within the city but live outside. The data indicates approximately 84.4% of these employees live outside of the City of Berkeley. This value was applied to the average number of employee values to compute the number of employees commuting into the city. There are an estimated 25,341 employees who work within the city but live outside.

To estimate the employee vehicles, a vehicle occupancy of 1.08 employees per vehicle obtained from the demographic survey (see Appendix D, Sub-section D.3.1) was used for the major employers. Given the limited parking spaces within the City of Berkeley, based on the demographic survey 35.7%[11] of the employees would take public transit to the city and the remaining employees who drive to work would park their vehicles within a 10-minute walking distance (approximately 0.5 miles) from their workplaces. As such, employee vehicles were distributed evenly within a 10-minute walking radius from their place of employment.

Table 3-5 and Table C-4 in Appendix C summarize the estimates of employees and employee vehicles commuting into the City of Berkeley, by Area. As shown in the tables, there are approximately 25,341 employees, including 9,046 employees who take public transit (5,247 employees would use a bus and the remaining 3,799 employees would use rail)[12], and 16,296 employees who would use personal vehicles or rideshare. This results in 15,080 employee vehicles and 88[8] buses (full of employees) commuting into the city on a daily basis.

3.5 Special Facility Population Demand

3.5.1 Medical Facilities

There are 11 medical facilities within the City of Berkeley that provide inpatient care services, indicated in Table 3-6[13]. In addition to these 11 facilities, 2020 Census data was used to identify skilled nursing facilities throughout the city at the census block level. These are labeled in Table 3-6 as "Other Medical Facilities Throughout the City".

The breakdown of ambulatory, wheelchair-using and bedridden patients for some of the medical facilities was obtained by making phone calls to individual facilities. For those facilities wherein data could not be obtained, existing data was used to estimate the number of each type of patient (see Section 2.4, Assumption 2.c.ii) at each facility. Table C-3 in Appendix C summarizes

[10] The LODES data is part of the LEHD data products from the U.S. Census Bureau. This dataset provides detailed spatial distributions of workers' employment and residential locations and the relation between the two at the census block level. The latest LODES data available is as of 2019 when this study started. For detailed information, please refer to this site: https://lehd.ces.census.gov/data/

[11] As illustrated in Appendix D, Figure D-8, among employees commuting via bus, BART, a combination of public transit modes, driving alone, or carpooling, approximately 35.7% utilize public transportation. Employees who indicated that they would walk or bike as their primary mode of transportation were assumed to be local residents and thus excluded from the non-resident employee population.

[12] Based on the demographic survey, of the employees that take public transportation to work, approximately 58% use a bus and the remaining 42% use rail. See Appendix D Figure D-8.

[13] There are residential care facilities for the elderly (RCFE) or adult residential facilities (ARF) (maximum of 6 patients) that are not included as part of medical facilities. It is assumed that RCFE and ARF would be evacuated in personal vehicles of staff within the home and are already included in the vehicle estimates for the general population.

the data gathered. Table 3-6 presents the current census and transportation requirement of medical facilities in the City of Berkeley. As shown in this table, 861 people have been identified as living in, or being treated in, these facilities. The number of ambulances is determined by assuming that 2 bedridden patients can be accommodated per ambulance trip; the number of wheelchair vans assumes 2 wheelchairs per trip, and the number of buses estimated assumes 30 ambulatory patients per trip (see Section 2.4, Assumptions 3.c-e). As shown in Table 3-6, 20 buses, 111 wheelchair vans and 128 ambulances are needed to evacuate all medical facilities.

3.5.2 Juvenile Homes

As the 2020 Census data indicates, there are juvenile homes within the City of Berkeley. Their locations and population are listed in Appendix C, Table C-6. In total, there are 9 people in three different locations. It was assumed that these people would be evacuated with vehicles with 2 people per vehicle which would result in 5 vehicles to evacuate these facilities.

3.6 College/University, School, Preschool/Day Care Center Population Demand

3.6.1 School, Preschool/Day Care Center Population

Table 3-7 presents the population and transportation requirements for all schools and preschools/day care centers within the City of Berkeley. This information was provided by the City and supplemented by internet searches for schools where data was not provided. The column in Table 3-7 entitled "Buses Required" specifies the number of buses needed for each facility under the following set of assumptions and estimates:

- The demographic survey results indicate 83% of the households with school children would pick up their children prior to starting their evacuation trip. As such, the total enrollments were reduced by 83% to estimate the need for buses.
- Bus capacity, expressed in students per bus, was assumed to be 30 for colleges/universities, 50 for high school and middle school buses, and 70 for elementary school and preschool/day care center buses.
- Those staff members who do not accompany the students will evacuate in their private vehicles.
- No allowance is made for student absenteeism, which is typically 3 percent daily.

The need for buses could be further reduced by any high school students who have evacuated using private vehicles (if permitted by school authorities). Since the number of students who drive to school is unknown, these reductions were not considered. In total, an estimated 112 buses are required for all schools/preschools/day care centers within the city, as shown in Table 3-7. Those buses that are originally allocated to evacuate schoolchildren that are not needed due to children being picked up by their parents, can be gainfully assigned to service other facilities or those persons who do not have access to private vehicles or to ride-sharing. School buses are represented as two vehicles in the ETE simulation due to their larger size and more sluggish operating characteristics.

3.6.2 College/University Student Population

The City of Berkeley has 12 small colleges and 2 large colleges/universities: Berkeley City College

(BCC) and University of California – Berkeley (UC Berkeley). The data for all colleges/universities were provided by the City of Berkeley. It was assumed that students from most small local colleges are likely local residents living within the city or remote learning students living outside of the city. As such, these facilities were ignored to avoid double counting. Students at California Jazz Conservatory, Acupuncture and Integrative Medicine College, and Institute of Buddhist Studies would evacuate in personal vehicles. Although students may evacuate using rail, on foot, or on bike, this study conservatively assumes that students at BCC and UC Berkeley would either evacuate in personal vehicles or emergency evacuation buses.

Based on the data provided for UC Berkeley[14], there are 45,882 students and 3.94% of them telecommute or are remote. This equates to 44,075 students that are physically present on campus. Based on the data provided, 27% of students are On-Campus students (11,900 students), of which 18% own a personal vehicle (2,142 students). This equates to 1,983 On-Campus Student vehicles (using an average vehicle occupancy rate of 1.08 based on the demographic survey) for UC Berkeley. Of the remaining 82% of On-Campus students that do not own a personal vehicle, 87% of them would rideshare (based on the results of the demographic survey). The remaining students who do not own a vehicle, and will not rideshare, will require a bus to evacuate. This results in 1,269 On-Campus students evacuating on 43 buses (assuming 30 students per bus, see Section 2). Based on the data provided, 70% of students live within the city limits which includes both On-Campus students (11,900) and Off-Campus students that live within the city. As such, 18,953 ((44,075 x .070) – 11,900) Off-Campus students live within the city. The remaining 13,222 (44,075 – 11,900 – 18,953 = 13,222) are Off-Campus students that commute into UC Berkeley from outside of the city limits. Based on the data provided approximately 41% Off-Campus students drive to campus and the remaining approximately 59% utilize Bear Transit, AC Transit, BART, and other modes of public transit. Using the same vehicle occupancy rates, rideshare percentages (for those who would normally use public transit), and bus capacities as On-Campus students, this equates to 12,110 Off-Campus student vehicles and 75 Off-Campus student buses. The data indicates 25% of the non-city Off-Campus students that utilize public transit will utilize BART. As such, there are approximately 255 Off-Campus students that use BART to commute to UC Berkeley from outside of the city limits. There are a total of 14,093 student vehicles and 118 buses, and 255 students that use BART, at UC Berkeley.

Based on the data provided, there are 6,519 students that attend BCC. Of these students, 474 students live within Berkeley and commute to BCC, and 1,482 students live outside of Berkeley and commute to BCC. The remaining students do not commute to campus. Other detailed data was not available for BCC. As such, the vehicle ownership percentage (18%), vehicle occupancy rates (1.08), rideshare percentages (87%), and bus capacities (30) obtained for UC Berkeley were utilized for BCC. As such, there are an estimated 79 personal vehicles and 2 buses for students that live within Berkeley who attend BCC. Of the students that live outside of Berkeley (1,482 students), 36% of students would drive to campus and 41% would take public transportation[15]. Using the same vehicle occupancy rates, rideshare percentages, and bus capacities mentioned above, there are an estimated 494 personal vehicles and 5 buses for students that live outside of

[14] Annual Commuter Report, Berkeley University of California Parking & Transportation, 2023
[15] https://statics.teams.cdn.office.net/evergreen-assets/safelinks/1/atp-safelinks.html

Berkeley who commute to BCC. In total, there are 573 student vehicles and 7 buses evacuating from BCC.

In total, as shown in Table 3-8, students would evacuate in 14,938 personal vehicles and would require 125 buses to evacuate. Table 3-9 shows the breakdown of on/off campus students for UC Berkeley and Berkeley City College. As previously mentioned, buses are represented as two vehicles in the ETE simulation due to their larger size and more sluggish operating characteristics.

3.7 Transit Dependent Resident Population

The demographic survey (see Appendix D) results were used to estimate the portion of the population requiring transit service:

- Those people in households that do not have a vehicle available.
- Those people in households that do have vehicle(s) that would not be available at the time the evacuation is advised.

In the latter group, the vehicle(s) may be used by a commuter(s) who does not return (or is not expected to return) home to evacuate the household.

Table 3-10 presents estimates of transit-dependent people. Note:

- Estimates of people requiring transit vehicles include schoolchildren. For those evacuation scenarios where children are at school when an evacuation is ordered, separate transportation is provided for the schoolchildren. The actual need for transit vehicles by residents is thereby less than the given estimates. However, estimates of transit vehicles are conservatively not reduced when schools are in session.
- It is reasonable and appropriate to consider that many transit-dependent people will evacuate by ridesharing with neighbors, friends or family. The results from the demographic survey indicate that approximately 87% of those who do not own their own cars would share a ride with neighbors or friends. As such, 87% of transit dependent individuals were assumed to rideshare.

The estimated number of bus trips needed to service transit-dependent people is based on an estimate of average bus occupancy of 30 people at the conclusion of the bus run. Table 3-10 indicates that transportation must be provided for 1,686 people within the City of Berkeley. Therefore, a total of 57 buses are required from a capacity standpoint. In order to service all of the transit dependent population and have at least one bus drive through each of the Areas that contain transit dependent people, **112 buses** are used in the ETE calculations. These buses are represented as two vehicles in the ETE simulations due to their larger size and more sluggish operating characteristics.[16]

To illustrate this estimation procedure, we calculate the number of persons, P, requiring public transit or ride-share, and the number of buses B:

[16] Due to the inherent congestion during an evacuation, the incremental impedance caused by buses stopping for passenger boarding on roadways without dedicated shoulders or lanes is considered negligible. The pre-existing stop-and-go conditions mitigate any significant disruption.

$$P = No. of\ HH \times \sum_{i=0}^{n} \{(\%\ HH\ with\ i\ vehicles) \times [(Average\ HH\ Size) - i]\} \times A^i C^i$$

Where:

A = Percent of households with commuters

C = Percent of households who will not await the return of a commuter

$$P = 49{,}267 \times [0.0747 \times 1.51 + 0.428 \times (1.99 - 1) \times 0.416 \times 0.699 + 0.403 \times (2.74 - 2) \times (0.416 \times 0.699)^2] = 12{,}870$$

$$B = ([1 - 0.869] \times P) \div 30 = 57$$

These calculations are explained as follows:

- The number of households (HH) is computed by dividing the population by the average household size (116,762 ÷ 2.37) and is 49,267.
- All members (1.51 avg.) of households (HH) with no vehicles (7.47%) will evacuate by public transit or rideshare. The term 49,267 (number of households) x 0.0747 x 1.33, accounts for these people.
- The members of HH with 1 vehicle away (42.80%), who are at home, equal (1.99-1). The number of HH where the commuter will not return home is equal to (49,267 x 0.428 x 0.99 x 0.416 x 0.699), as 41.6% of households have a commuter, 69.9% of which would not return home in the event of an emergency. The number of persons who will evacuate by public transit or ride-share is equal to the product of these two terms.
- The members of HH with 2 vehicles that are away (40.30%), who are at home, equal (2.74 – 2). The number of HH where neither commuter will return home is equal to 49,267x 0.403 x 0.74 x $(0.416 \times 0.699)^2$. The number of persons who will evacuate by public transit or rideshare is equal to the product of these two terms (the last term is squared to represent the probability that neither commuter will return).
- Households with 3 or more vehicles are assumed to have no need for transit vehicles.
- The total number of persons requiring public transit is the sum of such people in HH with no vehicles, or with 1 or 2 vehicles that are away from home.
- The number of buses needed is computed as the product of the number of people requiring public transit and the percentage of people who will not rideshare (100% minus 87%) divided by the bus occupancy.
- Because the Census counts people experiencing homelessness, it is assumed that the homeless population are included inside these calculations of transit-dependent people.

KLD used AC Transit and other transit services within Berkeley to service the transit-dependent population within the city. These routes are shown in Figure 9-7 through Figure 9-9. It is assumed that transit dependent population would gather along the nearest transit route or transit stop to board a bus to evacuate the area.

3.7.1 Bay Area Rapid Transit and Caltrain (Rail) Demand

Data suggests that some employees, visitors and college students use Bay Area Rapid Transit (BART) and Caltrain for their daily commute. Since this study only considers vehicular demand on the City of Berkeley roadway system, it does not include evacuation using rail systems. As shown in Table 3-11, there are 6,629 visitors, 3,799 employees and 255 UC-Berkeley Off-Campus students that would evacuate using rail resources.

3.8 People Requiring Specialized Transportation Assistance

Based on data provided by the City of Berkeley, HHS emPOWER Program[17] (December 2023 update) identifies a total of 348 people within the city who are assumed to require transportation assistance to evacuate. The data from emPOWER does not provide details on the number of ambulatory, wheelchair-using and bedridden people. This study conservatively assumes that people who use motorized wheelchairs or scooters a wheelchair-accessible van and people using electric beds will require ambulances to evacuate. This equates to 99 motorized wheelchair/scooter users in 50 wheelchair accessible vans, and 249 bedbound people in 125 ambulances.

3.9 External Traffic

Vehicles will be traveling through the study area (external-external trips) at the time of an incident. After the evacuation order is announced, these through-travelers will also need to evacuate. These through vehicles are assumed to travel on the freeways traversing the study area – CA-24, Interstate 880 (I-880), I-580 and I-80. It is likely dynamic and variable message signs, and/or manual diversion, will be strategically positioned outside of the study area at logical diversion points to attempt to divert traffic away from the area at risk. As such, it is assumed this external traffic will cease at 2 hours after the evacuation order to allow emergency responders to facilitate evacuation.

Average Annual Daily Traffic (AADT) data was obtained from Caltrans[18] to estimate the number of vehicles per hour on the aforementioned routes. The AADT was multiplied by the K-Factor, which is the proportion of the AADT on a roadway segment or link during the design hour, resulting in the Design Hour Volume (DHV). The design hour is usually the 30th highest hourly traffic volume of the year, measured in vehicles per hour (vph). The DHV is then multiplied by the D-Factor, which is the proportion of the DHV occurring in the peak direction of travel (also known as the directional split).

The resulting values are the directional design hourly volumes (DDHV) and are presented in Table 3-12. The DDHV is then multiplied by 2 hours (dynamic messaging signs are assumed to be activated within the 120 minutes of the evacuation order) to estimate the total number of external vehicles loaded on the analysis network. As indicated, there are 47,962 external traffic vehicles within the study area prior to the activation of the roadblocks and the diversion of this

[17] https://empowerprogram.hhs.gov/
[18] https://dot.ca.gov/programs/traffic-operations/census/

traffic. This number is reduced by 60% for nighttime scenarios (Scenarios 3 and 6) as discussed in Section 6.

3.10 Background Traffic

Section 5 discusses the time needed for the people in the study area to mobilize and begin their evacuation trips. There are 14 time periods during which traffic is loaded on to roadways in the study area to model the mobilization time of people in the study area, see Table 5-9. All traffic is loaded within these 14 time periods. Note, there is no traffic generated during the 15^{th} time period, as this time period is intended to allow traffic that has already begun evacuating to clear the study area boundaries.

In traffic simulations, the network is initially empty. Thus, for this study, the network needs to be filled (to represent routine travel conditions just prior to an evacuation order) so that system performance can be assessed under a more realistic set of conditions. As such, there is an initialization time period (often referred to as "fill time" in traffic simulation) wherein a portion of the traffic volumes from the start of the evacuation (Time Period 1) are loaded onto roadways in the study area. The amount of initialization/fill traffic that is on the roadways in the study area at the start of Time Period 1 depends on the scenario and the region being evacuated (see Section 6). For example, there are 5,545 vehicles on the roadways in the study area for Region R01 under Scenario 4 (winter, midweek, midday, normal conditions).

3.11 Summary of Demand

A summary of population and vehicle demand is provided in Table 3-13 and Table 3-14, respectively. This summary includes all population groups described in this section. A total of 274,376 people and 150,994 vehicles are considered in this study.

Table 3-1. County Population Change from April 1, 2020 to July 1, 2023

County	2020 Population	2023 Population	Percent Change	Annual Growth Rate
City of Berkeley				
Alameda	1,682,349	1,622,188	-3.58%	-1.11%
Shadow Region				
Contra Costa	1,165,930	1,155,025	-0.94%	-0.29%

Table 3-2. Municipality Population Change from April 1, 2020 to July 1, 2023

Municipality	2020 Population	2023 Population	Percent Change	Annual Growth Rate
Alameda County, CA				
City of Berkeley				
Berkeley	124,326	118,962	-4.31%	-1.35%
Shadow Region				
Albany	20,271	19,097	-5.79%	-1.82%
Emeryville	12,902	12,732	-1.32%	-0.41%
Oakland	440,669	436,504	-0.95%	-0.29%
Piedmont	11,277	10,635	-5.69%	-1.79%
Contra Costa County, CA				
Shadow Region				
El Cerrito	25,955	25,552	-1.55%	-0.48%
Orinda	19,505	19,364	-0.72%	-0.22%
Richmond	116,324	114,106	-1.91%	-0.59%

Table 3-3. Permanent Resident Population within the City of Berkeley and Shadow Region

Refer to Figure 3-1 for geographic representation of these areas.

Area	2020 Population	2024 Extrapolated Population
Berkeley Flats	81,753	76,770
North Berkeley Hills	23,223	21,819
South Berkeley Hills	7,238	6,799
West Berkeley	9,785	9,188
UC Berkeley	2,327	2,186
Lawrence Berkeley National Lab	0	0
TOTAL	**124,326**	**116,762**
Population Growth (2020-2024):		**-6.08%**
Shadow Region	**114,671**	**111,443**
STUDY AREA TOTAL	**238,997**	**228,205**

Table 3-4. Permanent Resident Population and Vehicles

Area	2024 Extrapolated Population	2024 Resident Vehicles
Berkeley Flats	76,770	32,193
North Berkeley Hills	21,819	9,426
South Berkeley Hills	6,799	2,078
West Berkeley	9,188	3,680
UC Berkeley[19]	2,186	237
Lawrence Berkeley National Lab	0	0
TOTAL	**116,762**	**47,614**
Shadow Region	**111,443**	**52,094**
STUDY AREA TOTAL	**228,205**	**99,708**

[19] The population estimates shown within the UC Berkeley Area only include the data produced by the Census, not the estimated student population. The estimated student population, and evacuating student vehicles (including transit dependent students), is contained within Section 3.6.2 and Table 3-8.

Table 3-5. Summary of Employees and Employee Vehicles Commuting into the City of Berkeley

Area	Employees	Employee Vehicles[20,21]
Berkeley Flats	5,553	6,059
North Berkeley Hills	0	853
South Berkeley Hills	172	103
West Berkeley	5,035	2,831
UC Berkeley	11,553	3,563
Lawrence Berkeley National Lab	3,028	1,847
TOTAL	**25,341**	**15,256**

[20] As described in Section 3.4, the employees driving to the city would park their vehicles within a 10-minute walking distance from their workplaces due to the limited parking spaces. As a result, the vehicle numbers in Berkeley Flats and North Berkely Hills are greater than the population numbers, while the vehicle number in UC Berkeley is significantly less than the vehicle estimate.
[21] Includes 88 buses (176 vehicles) for employees who commute using buses.

Table 3-6. Medical Facilities Transit Demand Estimates

Area	Facility Name	Municipality	Current Census	Ambu-latory	Wheel-chair Users	Bed-ridden	Buses	Wheelchair Vans	Ambu-lances
Berkeley Flats	Silverado Memory Care Center	Berkeley	87	37	22	28	2	11	14
Berkeley Flats	Chaparral House	Berkeley	42	6	18	18	1	9	9
Berkeley Flats	Elegance Berkeley	Berkeley	47	20	12	15	1	6	8
Berkeley Flats	Alta Bates Summit Medical Center - Herrick Campus	Berkeley	58	58	0	0	2	0	0
Berkeley Flats	Kyakameena Care Center	Berkeley	60	26	15	19	1	8	10
Berkeley Flats	Berkeley Pines Care Center	Berkeley	32	4	18	10	1	9	5
Berkeley Flats	Elmwood Care Center	Berkeley	77	33	19	25	2	10	13
Berkeley Flats	Alta Bates Summit Medical Center - Alta Bates Campus	Berkeley	183	73	37	73	3	19	37
Berkeley Flats	Ashby Care Center	Berkeley	29	5	14	10	1	7	5
North Berkeley Hills	New Bridge Foundation	Berkeley	45	20	14	11	1	7	6
UC Berkeley	Redwood Gardens Apartments	Berkeley	168	76	50	42	3	25	21
Berkeley Flats	Other Medical Facilities Throughout the City	Berkeley	33	33	0	0	2	0	0
TOTAL:			**861**	**391**	**219**	**251**	**20**	**111**	**128**

Table 3-7. School and Preschool/Day Care Center Population Demand Estimates

Area	School Name	Enrollment	Buses Required
Berkeley Flats	Berkeley Rose Waldorf School	97	1
Berkeley Flats	Ruth Acty Elementary School	433	2
Berkeley Flats	The Crowden School	75	1
Berkeley Flats	Martin Luther King Middle School	1,007	4
Berkeley Flats	School of the Madeleine	337	1
Berkeley Flats	Bayhill High School	73	1
Berkeley Flats	Berkeley Arts Magnet at Whittier School	407	1
Berkeley Flats	Berkeley High School	3,427	12
Berkeley Flats	Pacific Boychoir Academy	30	1
Berkeley Flats	Berkwood Hedge School	128	1
Berkeley Flats	Oxford Elementary at West Campus	256	1
Berkeley Flats	The Berkeley School	236	1
Berkeley Flats	Longfellow Arts and Technology Middle School	504	2
Berkeley Flats	Berkeley Technology Academy	36	1
Berkeley Flats	Walden Center & School	84	1
Berkeley Flats	Washington Elementary School	416	2
Berkeley Flats	East Bay School for Boys	105	1
Berkeley Flats	Sylvia Mendez Elementary School	409	1
Berkeley Flats	The Elmwood Academy	100	1
Berkeley Flats	Willard Middle School	669	3
Berkeley Flats	Malcolm X Elementary School	552	2
Berkeley Flats	Escuela Bilingue Internacional	324	1
Berkeley Flats	Emerson Elementary	323	1
Berkeley Flats	Maybeck High School	121	1
North Berkeley Hills	Thousand Oaks Elementary	382	1
North Berkeley Hills	Cragmont Elementary School	331	1
South Berkeley Hills	John Muir Elementary School	306	1

Area	School Name	Enrollment	Buses Required
West Berkeley	Black Pine Circle School	347	1
West Berkeley	Rosa Parks Environmental Science School	442	2
West Berkeley	VIA Center	20	1
	SCHOOL TOTAL:	**11,977**	**51**

Area	Preschool/Daycare Name	Enrollment	Buses Required
Berkeley Flats	Berkeley Rose Waldorf School	24	1
Berkeley Flats	Hearts Leap Beginnings	40	1
Berkeley Flats	Hearts Leap ICRI Preschool	70	1
Berkeley Flats	Berkeley Little School	42	1
Berkeley Flats	Ala Costa Center for the Developmentally Disabled	58	1
Berkeley Flats	BUSD - Hopkins Street	140	1
Berkeley Flats	Mustard Seed Preschool	66	1
Berkeley Flats	Jewish Community Ctr of The East Bay-Berkeley	75	1
Berkeley Flats	Cedar Creek Montessori School	40	1
Berkeley Flats	Woolly Mammoth Childcare & Preschool	69	1
Berkeley Flats	Berkeley Montessori School	119	1
Berkeley Flats	The New School of Berkeley	48	1
Berkeley Flats	The New School of Berkeley-Schoolage	45	1
Berkeley Flats	Hearts Leap North	45	1
Berkeley Flats	Berkeley Special Education Preschool	90	1
Berkeley Flats	Berkeley YMCA EHS - Vera Casey	26	1
Berkeley Flats	Congregation Beth Israel-Gan Shalom	32	1
Berkeley Flats	Little Elephant Montessori, Inc.	24	1
Berkeley Flats	Shu Ren International School	179	1
Berkeley Flats	Berkeley International Montessori School	21	1
Berkeley Flats	Child Education Center	107	1
Berkeley Flats	Congregation Netivot Shalom	30	1

Area	School Name	Enrollment	Buses Required
Berkeley Flats	Little Beans Preschool	40	1
Berkeley Flats	Rosemarie's Motivational Preschool	22	1
Berkeley Flats	BUSD - King Child Development Center	108	1
Berkeley Flats	Cornerstone Children's Center	112	1
Berkeley Flats	UCB - Dwight Way Center	42	1
Berkeley Flats	UCB - Harold E. Jones Child Study Ctr/Childcare	56	1
Berkeley Flats	UCB - Haste Street Child Development Center	92	1
Berkeley Flats	Berkeley YMCA Head Start - South YMCA	94	1
Berkeley Flats	Model School Comprehensive Humanistic Learning Ctr	63	1
Berkeley Flats	Through the Looking Glass Early Head Start	24	1
Berkeley Flats	American International Montessori School	117	1
Berkeley Flats	Ephesian Children's Center	36	1
Berkeley Flats	Mi Mundo Preschool	29	1
Berkeley Flats	VIA Nova Children's School	45	1
Berkeley Flats	The Monteverde School	30	1
Berkeley Flats	St. John's Child Care Center	45	1
North Berkeley Hills	Step One School	108	1
North Berkeley Hills	Berkeley Hills Nursery School	40	1
North Berkeley Hills	Childrens Community Center	52	1
North Berkeley Hills	Dandelion Nursery School, Inc	24	1
North Berkeley Hills	Beth El Nursery School	74	1
UC Berkeley	UCB - Clark Kerr Campus Children's Center	29	1
UC Berkeley	UCB - Clark Kerr Preschool	29	1
South Berkeley Hills	Kids In Motion	70	1
South Berkeley Hills	Arbor Preschool East	22	1
West Berkeley	BUSD - Franklin Preschool	192	1
West Berkeley	Centro Vida Bilingual Childcare Center	64	1
West Berkeley	Duck's Nest - Berkeley	91	1

Area	School Name	Enrollment	Buses Required
West Berkeley	Golden Gate Learning Center	57	1
West Berkeley	Bahia School Age Program	65	1
West Berkeley	Dolma Child Care Center	14	1
West Berkeley	Berkeley YMCA Head Start - West	86	1
West Berkeley	Nia House Learning Center	94	1
West Berkeley	Ecole Bilingue De Berkeley	426	2
West Berkeley	Global Montessori International School	90	1
West Berkeley	Pixar Child Development Center	108	1
West Berkeley	Sunshine Preschool (CEID)	45	1
West Berkeley	Aquatic Park School	77	1
	PRESCHOOL/DAYCARE TOTAL:	**4,202**	**61**
	GRAND TOTAL	**16,179**	**112**

Table 3-8. College/University Student Estimates

Area	College/University Name	Enrollment	Student Vehicles	Buses Required
Berkeley Flats	Berkeley School of Theology	65	0	0
Berkeley Flats	Berkeley City College	6,519	573	7
Berkeley Flats	California Jazz Conservatory	88	81	0
Berkeley Flats	Acupuncture and Integrative Medicine College-Berkeley	153	142	0
Berkeley Flats	Institute of Buddhist Studies	53	49	0
North Berkeley Hills	Pacific Lutheran Theological Seminary	50	0	0
North Berkeley Hills	Dominican School of Philosophy & Theology	100	0	0
North Berkeley Hills	Church Divinity School of the Pacific	122	0	0
North Berkeley Hills	Graduate Theological Union	275	0	0
North Berkeley Hills	Jesuit School of Theology	112	0	0
North Berkeley Hills	Pacific School of Religion	139	0	0
North Berkeley Hills	Zaytuna College	43	0	0
South Berkeley Hills	The Wright Institute	638	0	0
UC Berkeley	University of California - Berkeley	44,075	14,093	118
	COLLEGE/UNIVERSITY TOTAL:	**52,432**	**14,938**	**125**

Table 3-9. UC Berkeley and City College On/Off Student Estimates

Area	College/University Name[22]	Enrollment	On-Campus Students	Off-Campus Commuter Students	Total Student Vehicles	On-Campus Student Vehicles	Off-Campus Student Vehicles	Buses Required	On-Campus Student Buses	Off-Campus Student Buses
Berkeley Flats	Berkeley City College	6,519	474[23]	1,482	573	79	494	7	2	5
UC Berkeley	University of California - Berkeley	44,075	11,900	13,222	14,093	1,983	12,110	118	43	75
	TOTAL:	**50,594**	**12,374**	**14,704**	**14,666**	**2,062**	**12,604**	**125**	**45**	**80**

[22] The difference between on/off campus students are students who reside within Berkeley and are included as permanent residents

[23] Berkeley City College does not offer On-Campus housing, these 474 students live within Berkeley and are assumed to be near houses/apartments within the vicinity of the college. Census Blocks within the vicinity of the college were adjusted to avoid double counting these students as residents.

Table 3-10. Transit-Dependent Population Estimates

2024 Extrapolated Population	Survey: Average HH Size with Indicated No. of Vehicles			Estimated No. of Households	Survey: Percent HH with Indicated No. of Vehicles			Survey: Percent HH with Commuters	Survey: Percent HH with Non-Returning Commuters	Total People Requiring Transport	Survey: Estimated Ridesharing Percentage	People Requiring Public Transit	Percent Population Requiring Public Transit
	0	1	2		0	1	2						
116,762	1.51	1.99	2.74	49,267	7.47%	42.80%	40.30%	41.60%	69.90%	12,870	86.9%	1,686	1.4%

Table 3-11. Rapid Transit (Rail) Demand Estimates

Population group	People
Visitors	6,629
Employees	3,799
College Students	255
TOTAL:	**10,683**

Table 3-12. External Traffic Estimates

Road Name	Direction	CA DOT AADT[24]	K-Factor[25]	D-Factor[25]	Hourly Volume	External Traffic
CA-24	Southbound	169,000	0.082	0.25	3,465	6,930
I-880	Northbound	128,000	0.082	0.33	3,464	6,928
I-580	Northbound	169,000	0.082	0.33	4,573	9,146
I-580	Southbound	257,000	0.067	0.25	4,305	8,610
I-80	Northbound	231,000	0.067	0.25	3,869	7,738
I-80	Southbound	257,000	0.067	0.25	4,305	8,610
					TOTAL	**47,962**

[24] California Department of Transportation (Caltrans), https://dot.ca.gov/programs/traffic-operations/census/
[25] Highway Capacity Manual (HCM) 2022

Table 3-13. Summary of Population Demand

Area	Residents[26]	Transit-Dependent Residents[27]	Visitors	Employees	Special Facilities[28]	College Students[29]	Schools and Preschools	Shadow Population[30]	External Traffic	Total
Berkeley Flats	76,770	1,111	37,563[31]	5,553	650[32]	6,878	12,494	0	0	110,968
North Berkeley Hills	21,819	315		0	45	841	1,011	0	0	31,544
South Berkeley Hills	6,799	96		172	0	638	398	0	0	15,616
West Berkeley	9,188	134		5,035	7[33]	0	2,218	0	0	24,095
UC Berkeley	1,955	31		11,553	168	44,075	58	0	0	65,583
Lawrence Berkeley National Lab	0	0	0	3,028	0	0	0	0	0	3,028
Shadow Region	0	0	1,253	0	0	0	0	22,289	0	23,542
Total	**116,762**	**1,686**	**32,187**	**25,341**	**870**	**52,432**	**16,179**	**22,289**	**0**	**274,376**

[26] Computed from the Census.
[27] Computed from the Census and the demographic survey.
[28] Special Facilities represent the population at medical facilities and juvenile homes.
[29] College students includes on-campus student populations.
[30] Shadow Population has been reduced to 20%. Refer to Section 2.
[31] For simplicity, these visitors were distributed equally within each Area inside the Total column of this table for a representative value of the total number of visitors within each Area.
[32] Includes 2 people at a juvenile home.
[33] Includes 7 people at two juvenile homes within this Area.

Table 3-14. Summary of Vehicle Demand[34]

Area	Residents	Transit-Dependent Residents	Visitors	Employees	Special Facilities[35]	College Students	Schools and Preschools	Shadow Population[30]	External Traffic	Total
Berkeley Flats	32,193	112	13,274[31]	6,059	213[36]	859	164	0	0	42,254
North Berkeley Hills	9,426	56		853	15	0	14	0	0	13,019
South Berkeley Hills	2,078	27		103	0	0	6	0	0	4,869
West Berkeley	3,680	24		2,831	4[37]	0	36	0	0	9,230
UC Berkeley	193	5		3,563	52	14,329	4	0	0	20,845
Lawrence Berkeley National Lab	0	0	0	1,847	0	0	0	0	0	1,847
Shadow Region	0	0	549	0	0	0	0	10,419	47,962	58,930
Total	**47,614**	**224**	**13,823**	**15,256**	**285**	**15,188**	**224**	**10,419**	**47,962**	**150,994**

[34] Buses (including Transit-Dependent Buses) are represented as two passenger vehicles. Excludes rapid transit demand since rail has its own dedicated roadway.
[35] Special Facilities represent the vehicles at medical facilities and juvenile homes.
[36] Includes 1 vehicle at a juvenile home.
[37] Includes 4 vehicles at two juvenile homes within this Area.

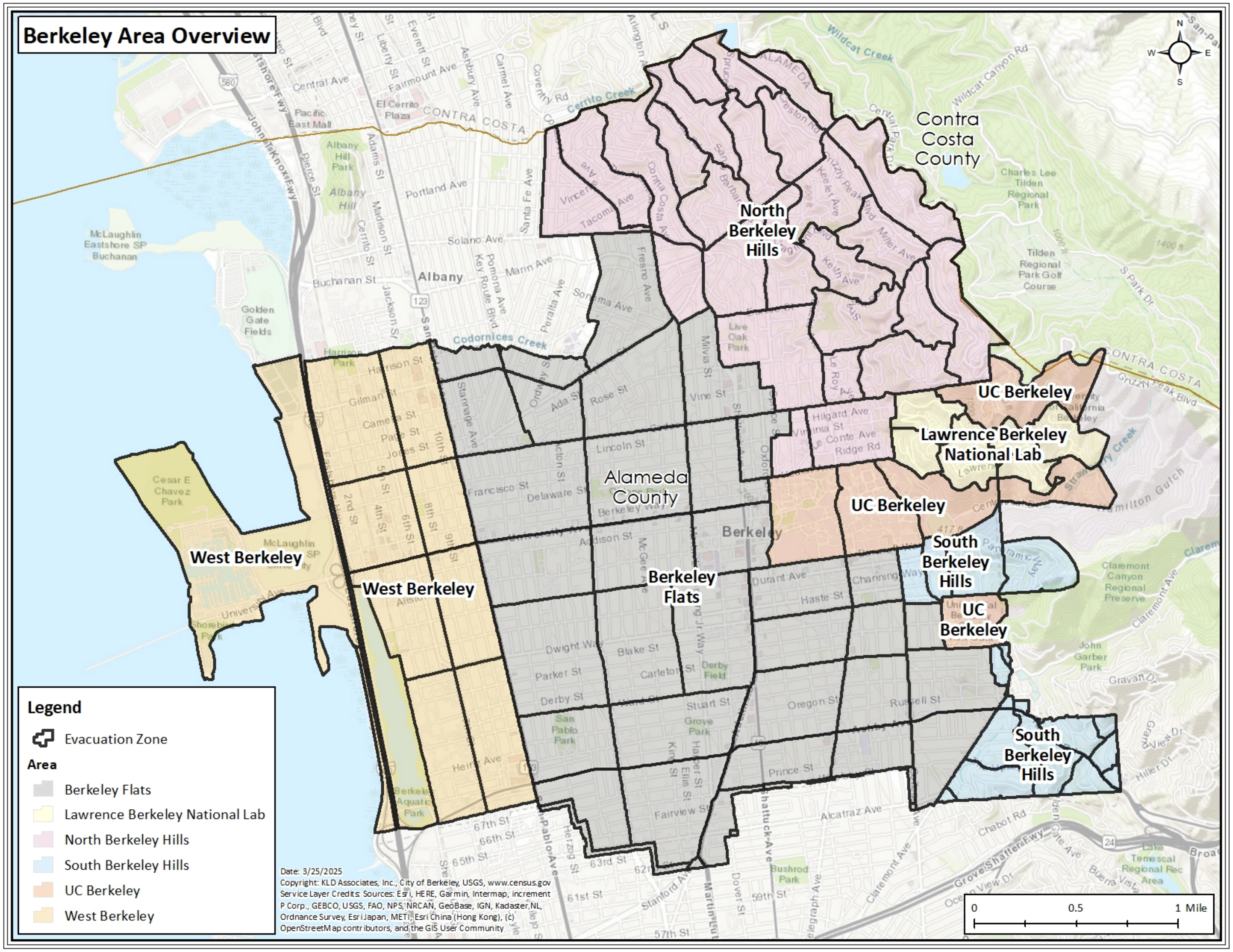


Figure 3-1. Overview of Evacuation Zone and Area Boundaries

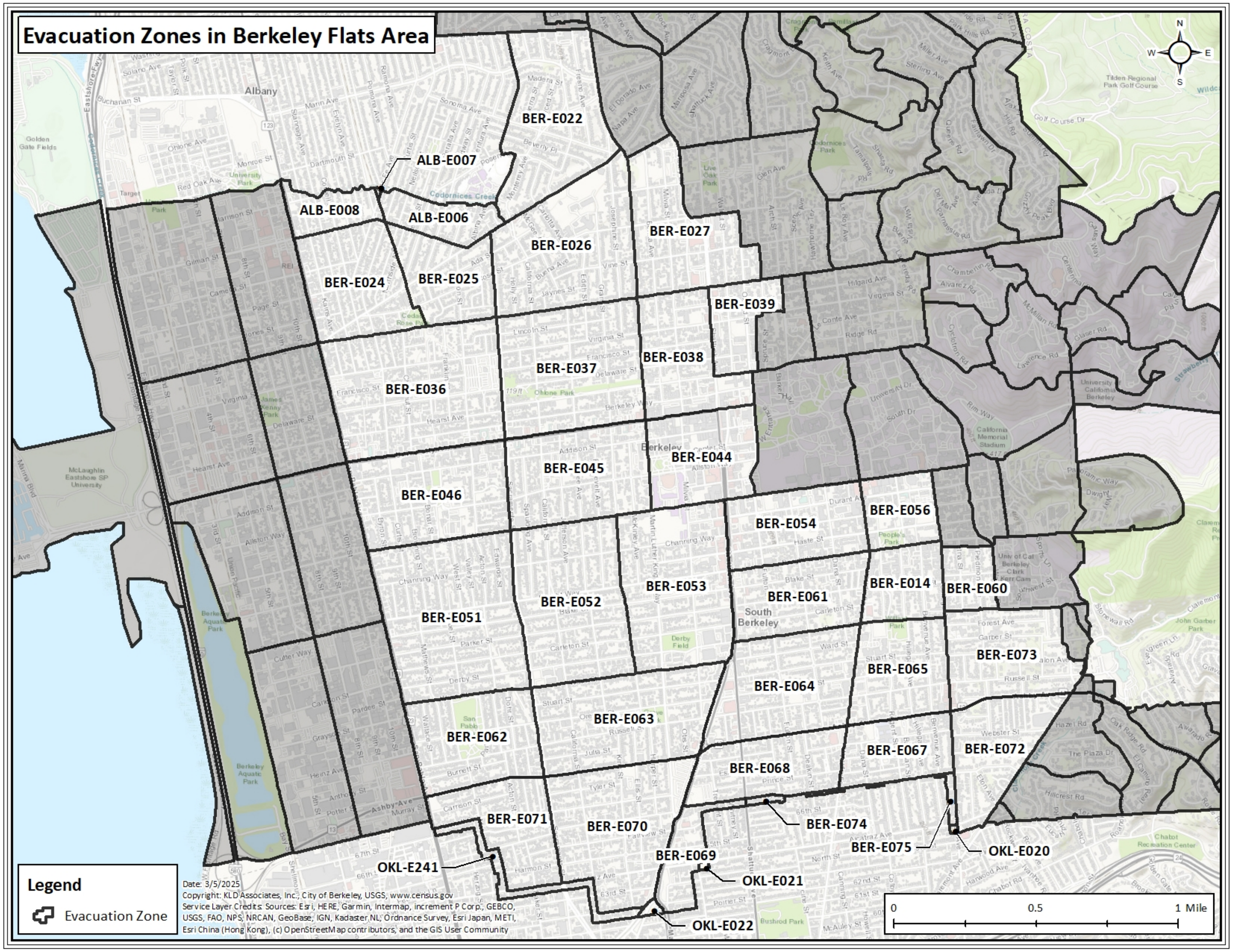


Figure 3-2. Evacuation Zones in the Berkeley Flats Area

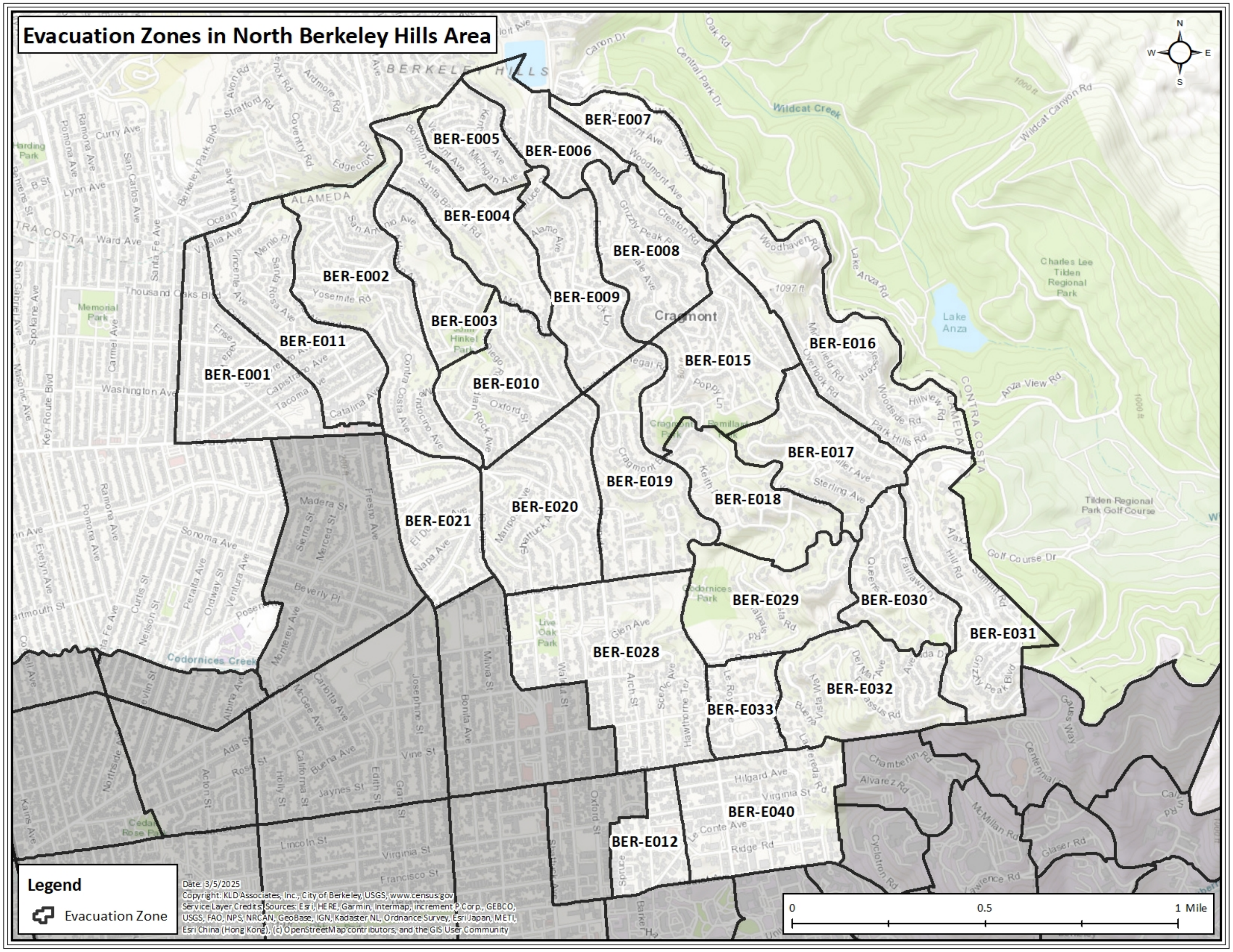


Figure 3-3. Evacuation Zones in the North Berkeley Hills Area

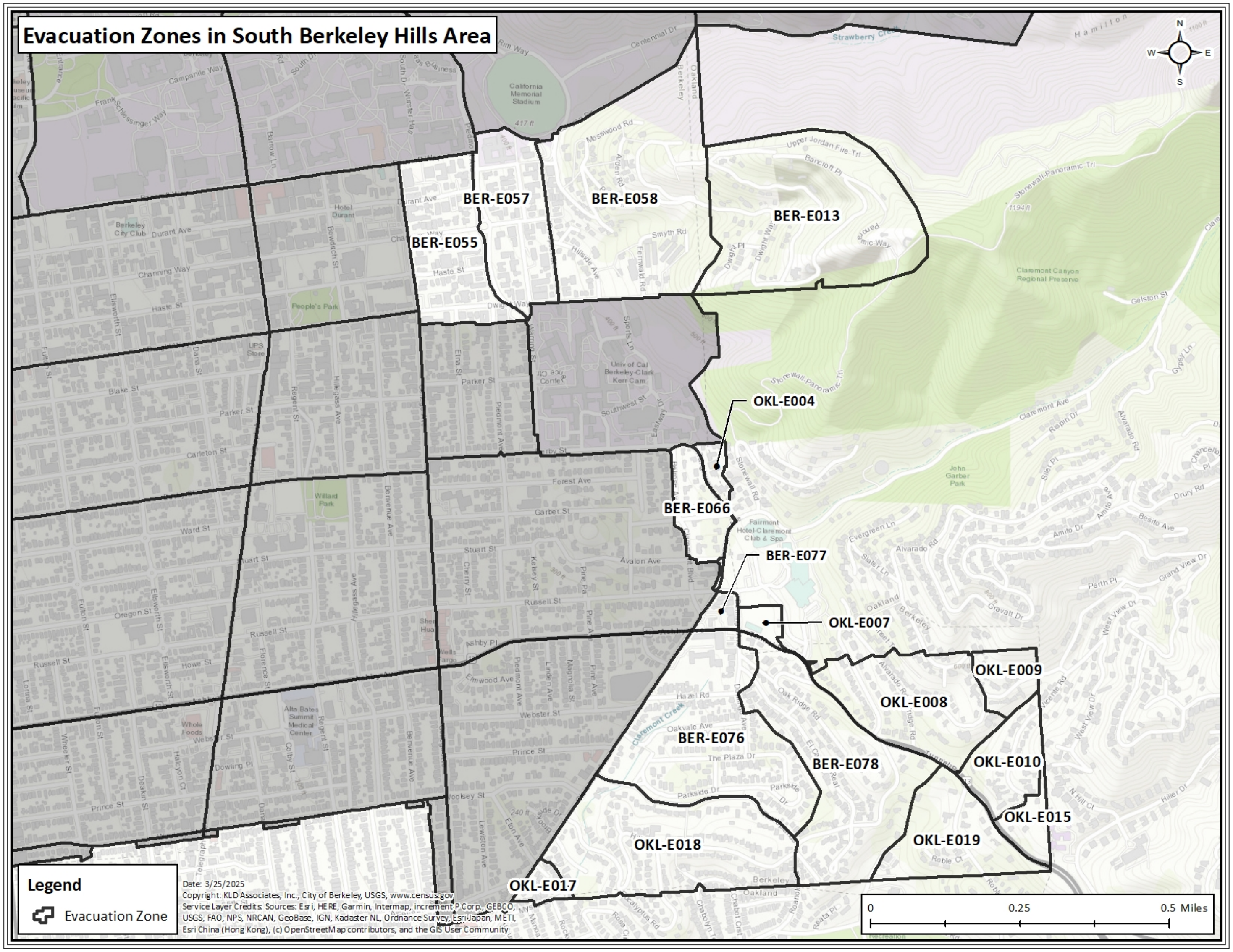


Figure 3-4. Evacuation Zones in the South Berkeley Hills Area

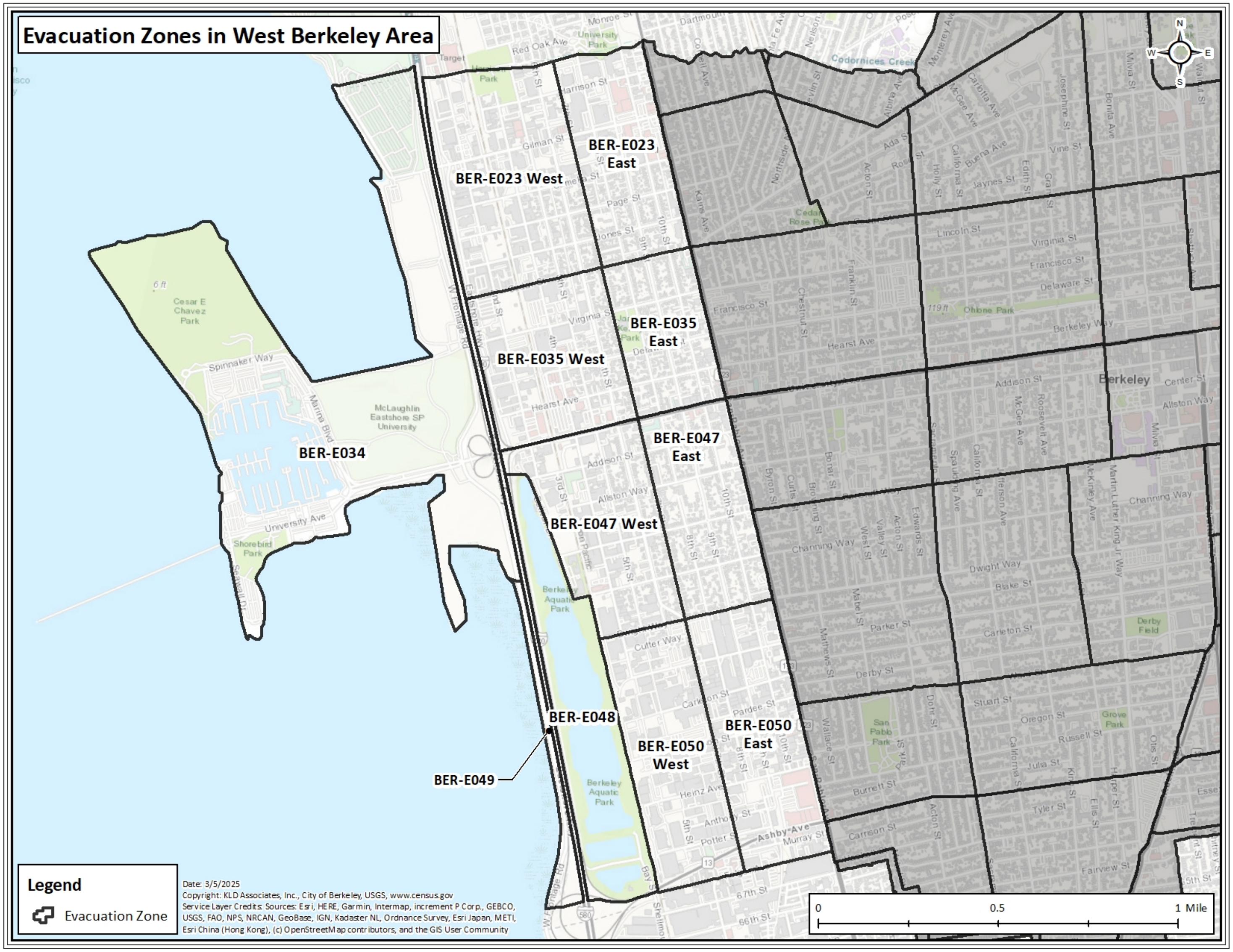


Figure 3-5. Evacuation Zones in the West Berkeley Area

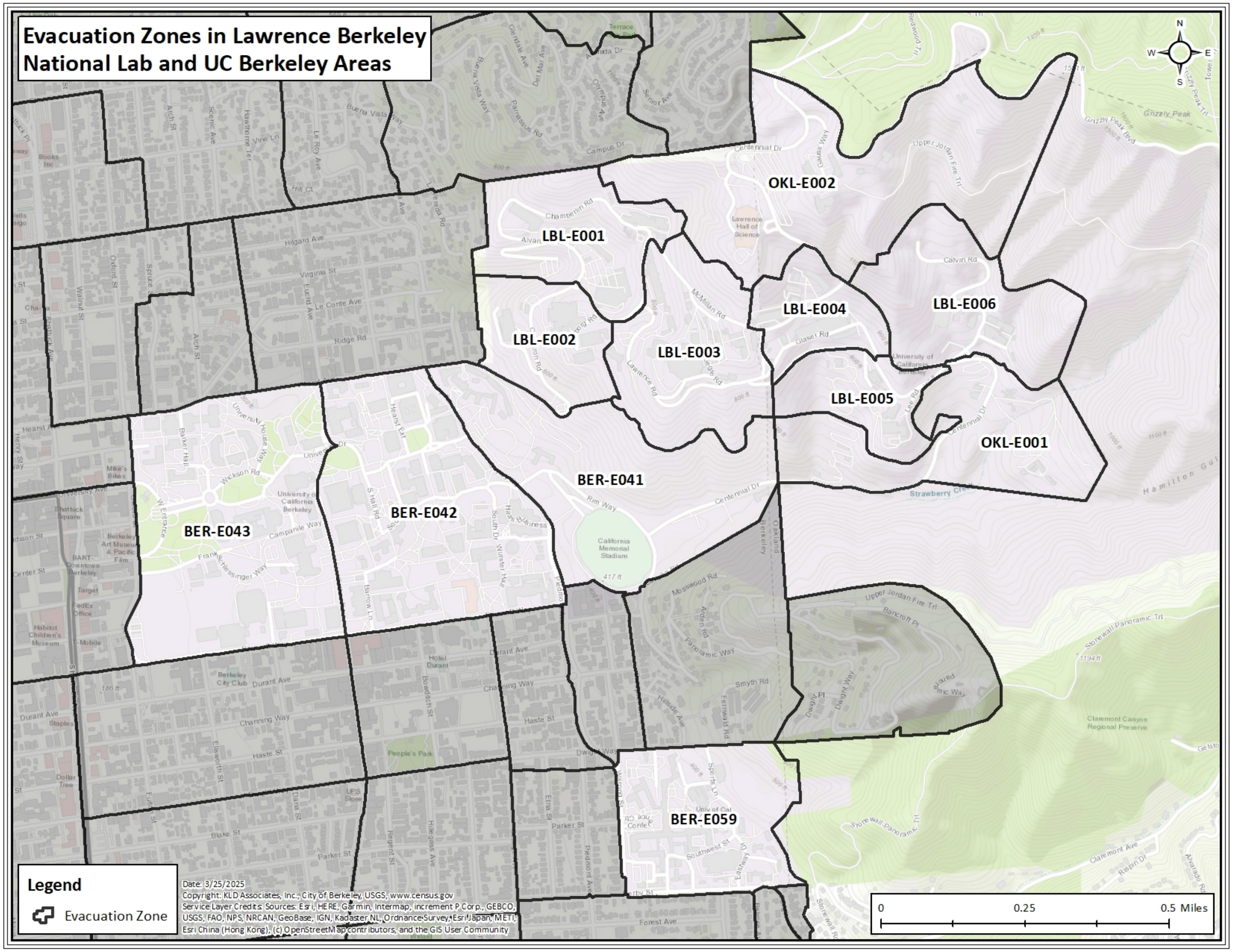


Figure 3-6. Evacuation Zones in the Lawrence Berkeley National Lab and UC Berkeley Areas

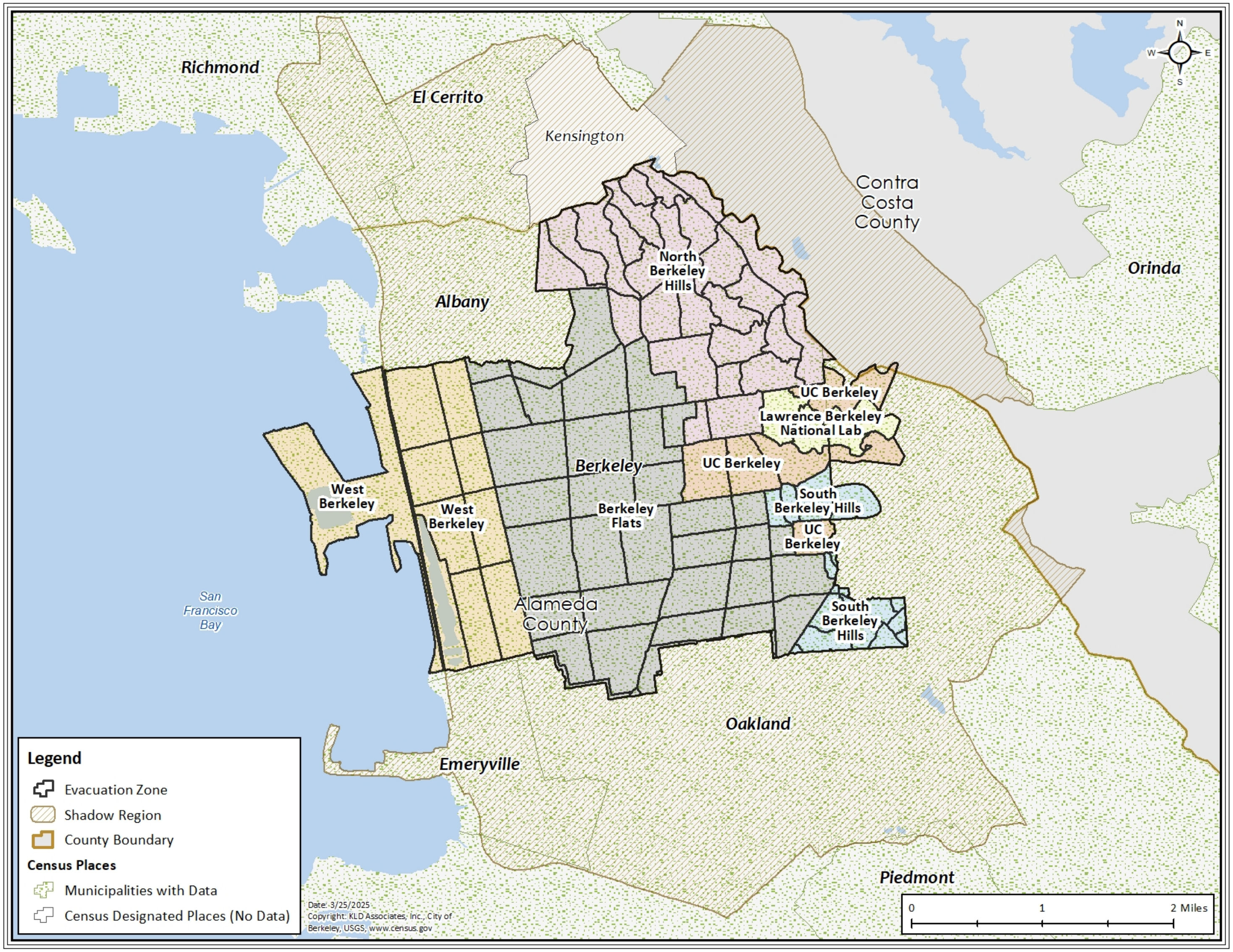


Figure 3-7. Census Boundaries within the Study Area

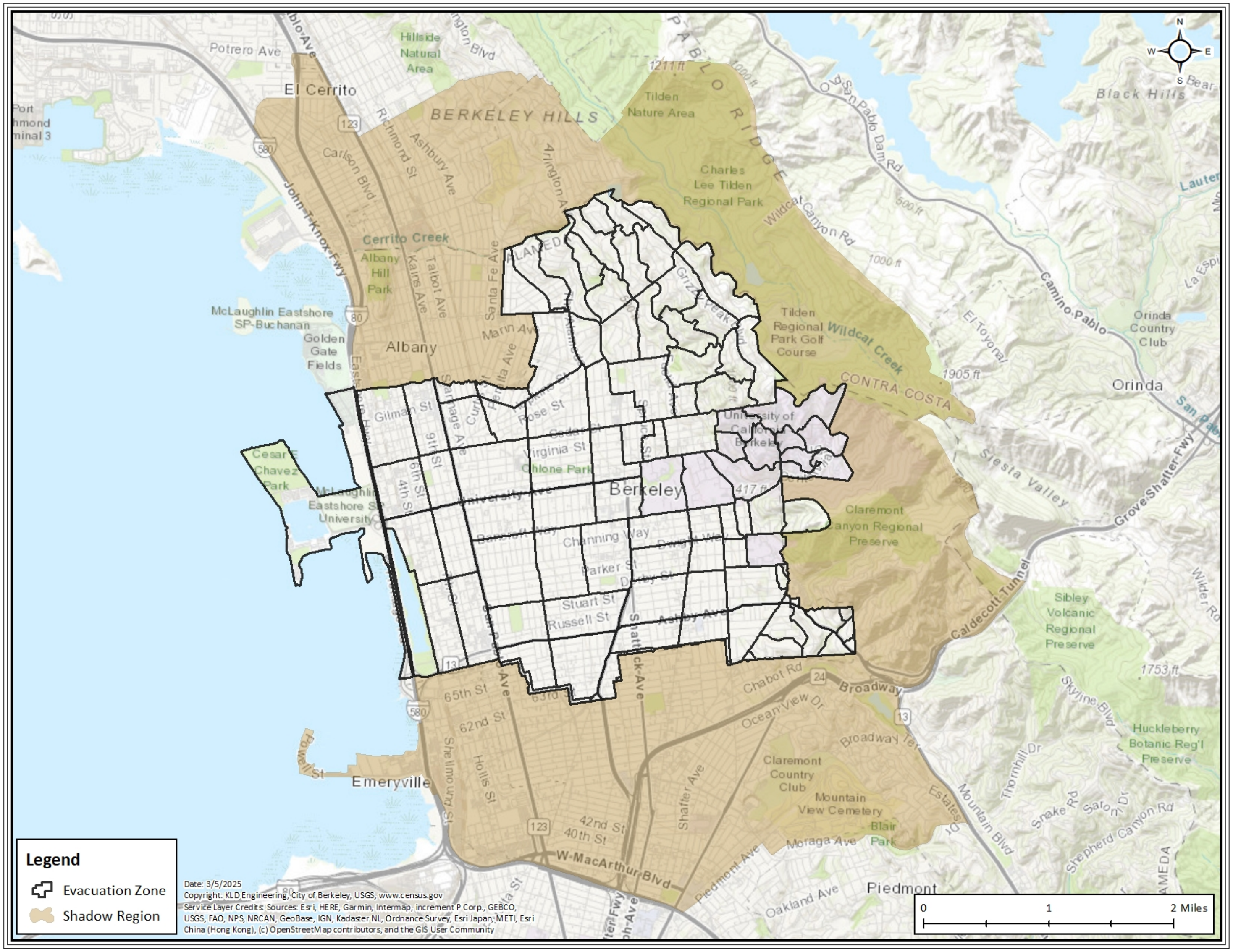


Figure 3-8. Shadow Region

4 ESTIMATION OF ROADWAY CAPACITY

The ability of the road network to service vehicle demand is a major factor in determining how rapidly an evacuation can be completed. The capacity of a road is defined as the maximum sustainable hourly rate at which persons or vehicles can reasonably be expected to traverse a point or uniform section of a lane of roadway during a given time period under prevailing roadway, environmental, traffic and control conditions, as stated in the 2022 Highway Capacity Manual 7th Edition (HCM 2022). This section discusses how the capacity of the roadway network was estimated.

In discussing capacity, different operating conditions have been assigned alphabetical designations, A through F, to reflect the range of traffic operational characteristics. These designations have been termed "Levels of Service" (LOS). For example, LOS A represents free-flow and high-speed operating conditions; LOS F represents a forced flow condition. LOS E describes traffic operating at or near capacity.

Another concept, closely associated with capacity, is “Service Volume”. Service volume (SV) is defined as “The maximum hourly rate at which vehicles, bicycles or persons reasonably can be expected to traverse a point or uniform section of a roadway during an hour under specific assumed conditions while maintaining a designated level of service.” This definition is similar to that for capacity. The major distinction is that values of SV vary from one LOS to another, while capacity is the SV at the upper bound of LOS E, only.

Thus, in simple terms, SV is the maximum traffic that can travel on a road and still maintain a certain perceived level of quality to a driver based on the A, B, C, rating system (LOS). Any additional vehicles above the SV would drop the rating to a lower letter grade.

This distinction is illustrated in Exhibit 12-37 of the HCM 2022. As indicated there, the SV varies with Free Flow Speed (FFS), and LOS. The SV is calculated by the DYNEV II simulation model, based on the specified link attributes, FFS, capacity, control device and traffic demand.

Other factors also influence capacity. These include, but are not limited to:

- Lane width
- Shoulder width
- Pavement condition
- Horizontal and vertical alignment (curvature and grade)
- Percent truck traffic
- Control device (and timing, if it is a signal)
- Weather conditions (rain, fog, wind speed, smoke)

These factors are considered during the road survey and in the capacity estimation process; some factors have greater influence on capacity than others. For example, lane and shoulder width have only a limited influence on FFS and capacity based on the HCM 2022. Consequently, lane and shoulder widths at the narrowest points were observed during the road survey (or aerial imagery for roadways that could not be driven) and these observations were recorded, but no detailed measurements of lane or shoulder width were taken. Horizontal and vertical alignment can influence both FFS and capacity. The estimated FFS were measured using the survey vehicle's speedometer and observing local traffic, under free flow conditions. The FFS ranged from 10 mph to 70 mph within the City of Berkeley area. Capacity is estimated from the procedures of the HCM 2022. For example, HCM 2022 Exhibit 7-1(b) shows the sensitivity of SV at the upper bound of LOS D to grade (capacity is the SV at the upper bound of LOS E).

The amount of traffic that can flow on a roadway is effectively governed by vehicle speed and spacing. The faster that vehicles can travel when closely spaced, the higher the amount of flow.

Since congestion arising from evacuation may be significant, estimates of roadway capacity must be determined with great care. Because of its importance, a brief discussion of the major factors that influence roadway capacity is presented in this section.

4.1 Capacity Estimations on Approaches to Intersections

At-grade intersections are apt to become the first bottleneck locations under local heavy traffic volume conditions. This characteristic reflects the need to allocate access time to the respective competing traffic streams by exerting some form of control. During evacuation, control at critical intersections will often be provided by traffic control personnel assigned for that purpose, whose directions may supersede traffic control devices. See Section 9 for more information.

The per-lane capacity of an approach to a signalized intersection can be expressed (simplistically) in the following form:

$$Q_{cap,m} = \left(\frac{3600}{h_m}\right) \times \left(\frac{G - L}{C}\right)_m = \left(\frac{3600}{h_m}\right) \times P_m$$

where:

$Q_{cap,m}$	=	Capacity of a single lane of traffic on an approach, which executes movement, *m*, upon entering the intersection; vehicles per hour (vph)
h_m	=	Mean queue discharge headway of vehicles on this lane that are executing movement, *m*; seconds per vehicle
G	=	Mean duration of GREEN time servicing vehicles that are executing movement, *m*, for each signal cycle; seconds
L	=	Mean "lost time" for each signal phase servicing movement, *m*; seconds
C	=	Duration of each signal cycle; seconds
P_m	=	Proportion of GREEN time allocated for vehicles executing movement, *m*, from this lane. This value is specified as part of the control treatment.
m	=	The movement executed by vehicles after they enter the intersection: through, left-turn, right-turn, and diagonal.

The turn-movement-specific mean discharge headway h_m, depends in a complex way upon many factors: roadway geometrics, turn percentages, the extent of conflicting traffic streams, the control treatment, and others. A primary factor is the value of "saturation queue discharge headway", h_{sat}, which applies to through vehicles that are not impeded by other conflicting traffic streams. This value, itself, depends upon many factors including motorist behavior. Formally, we can write,

$$h_m = f_m(h_{sat}, F_1, F_2, \dots)$$

where:

h_{sat}	=	Saturation discharge headway for through vehicles; seconds per vehicle
F_1, F_2	=	The various known factors influencing h_m
$f_m(\ )$	=	Complex function relating h_m to the known (or estimated) values of h_{sat}, F_1, F_2, …

The estimation of h_m for specified values of h_{sat}, F_1, F_2, ... is undertaken within the DYNEV II simulation model by a mathematical model[1]. The resulting values for h_m always satisfy the condition:

$$h_m \geq h_{sat}$$

That is, the turn-movement-specific discharge headways are always greater than, or equal to the saturation discharge headway for through vehicles. These headways (or its inverse equivalent, “saturation flow rate”), may be determined by observation or using the procedures of the HCM 2022.

The above discussion is necessarily brief given the scope of this Evacuation Time Estimate (ETE) study and the complexity of the subject of intersection capacity. In fact, Chapters 19, 20 and 21 in the HCM 2022 address this topic. The factors, F_1, F_2, ..., influencing saturation flow rate are identified in equation (19-8) of the HCM 2022.

The traffic signals within the Evacuation Zones and Shadow Region are modeled using representative phasing plans and phase durations obtained as part of the field data collection. Traffic responsive signal installations allow the proportion of green time allocated (P_m) for each approach to each intersection to be determined by the expected traffic volumes on each approach during evacuation circumstances. The amount of green time (G) allocated is subject to maximum and minimum phase duration constraints; 4 seconds of yellow time are indicated for each signal phase and 1 second of all-red time is assigned between signal phases, typically. If

[1]Lieberman, E., "Determining Lateral Deployment of Traffic on an Approach to an Intersection", McShane, W. & Lieberman, E., "Service Rates of Mixed Traffic on the far Left Lane of an Approach". Both papers appear in Transportation Research Record 772, 1980. Lieberman, E., Xin, W., “Macroscopic Traffic Modeling For Large-Scale Evacuation Planning”, presented at the TRB 2012 Annual Meeting, January 22-26, 2012.

a signal is pre-timed, the yellow and all-red times observed during the road survey are used. A lost time (L) of 5.0 seconds is used for each signal phase in the analysis.

4.2 Capacity Estimation along Sections of Roadway

The capacity of roadway sections[2] - as distinct from approaches to intersections- is a function of roadway geometrics, traffic composition (-e.g. percent heavy trucks and buses in the traffic stream) and, of course, motorist behavior. There is a fundamental relationship which relates SV (i.e. the number of vehicles serviced within a uniform roadway section in a given time period) to traffic density. The top curve in Figure 4-1 illustrates this relationship.

As indicated, there are two flow regimes: (1) Free Flow (left side of curve); and (2) Forced Flow (right side). In the Free Flow regime, the traffic demand is fully serviced; the SV increases as demand volume and density increase, until the service volume attains its maximum value, which is the capacity of the roadway section. As traffic demand and the resulting roadway density increase beyond this "critical" value, the rate at which traffic can be serviced (i.e. the SV) can actually decline below capacity ("capacity drop"). Therefore, in order to realistically represent traffic performance during congested conditions (i.e. when demand exceeds capacity), it is necessary to estimate the service volume, V_F, under congested conditions.

The value of V_F can be expressed as:

$$V_F = R \times Capacity$$

where:

R = Reduction factor which is less than unity

We have employed a value of R=0.90. The advisability of such a capacity reduction factor is based upon empirical studies that identified a fall-off in the service flow rate when congestion occurs at "bottlenecks" or "choke points" on a freeway system. Zhang and Levinson[3] describe a research program that collected data from a computer-based surveillance system (loop detectors) installed on the Interstate Highway System, at 27 active bottlenecks in the twin cities metro area in Minnesota over a 7-week period. When flow breakdown occurs, queues are formed which discharge at lower flow rates than the maximum capacity prior to observed breakdown. These queue discharge flow (QDF) rates vary from one location to the next and also vary by day of week and time of day based upon local circumstances. The cited reference presents a mean QDF of 2,016 passenger cars per hour per lane (pcphpl). This figure compares with the nominal capacity estimate of 2,250 pcphpl estimated for the ETE. The ratio of these two numbers is 0.896 which translates into a capacity reduction factor of 0.90.

Since the principal objective of the ETE analyses is to develop a "realistic" estimate of evacuation times, use of the representative value for this capacity reduction factor (R=0.90) is justified. This factor is applied only when flow breaks down, as determined by the simulation

[2] This analysis is based on computed capacity alone and does not consider the time-varying demand impact on actual capacity.

[3] Lei Zhang and David Levinson, "Some Properties of Flows at Freeway Bottlenecks," Transportation Research Record 1883, 2004.

model.

The estimated value of capacity is based primarily upon the type of facility and on roadway geometrics. Sections of roadway with adverse geometrics are characterized by lower free-flow speeds and lane capacity. The impact of narrow lanes and shoulders on free-flow speed and on capacity is not material, particularly when flow is predominantly in one direction as is the case during an evacuation.

The procedure used here was to estimate "section" capacity, V_E, based on observations made traveling over each section of the evacuation network, based on the posted speed limits and travel behavior of other motorists and by reference to the HCM 2022. The DYNEV II simulation model determines for each roadway section, represented as a network link, whether its capacity would be limited by the "section specific" service volume, V_E, or by the intersection specific capacity. For each link, the model selects the lower value of capacity.

4.3 Application to the City of Berkeley Study Area

As part of the development of the link-node analysis network for the study area, an estimate of roadway capacity is required. The source material for the capacity estimates presented herein is contained in:

> 2022 Highway Capacity Manual 7th Edition (HCM 2022)
> Transportation Research Board
> National Research Council
> Washington, D.C.

The roadway system in the study area consists primarily of three categories of roads and, of course, intersections:

- Two-Lane roads: Local, State
- Multilane Highways (at-grade)
- Freeways

Each of these classifications will be discussed below.

4.3.1 Two Lane Roads

Note: Data collected on the road survey conducted in May 20-26, 2023, and aerial imagery for roadways that could not be driven (like LBNL), was used to accurately model the speeds on roads within Berkeley. See Section 1.3 for details.

Ref: HCM 2022 Chapter 15

Two lane roads comprise the majority of roadways within the study area. The per-lane capacity of a two-lane roadway is estimated at 1,700 passenger cars per hour (pc/h). This estimate is essentially independent of the directional distribution of traffic volume except that, for extended distances, the two-way capacity will not exceed 3,200 pc/h. The HCM 2022 procedures then estimate LOS and Average Travel Speed. The DYNEV II simulation model accepts the specified value of capacity as input and computes average speed based on the time-varying demand: capacity relations.

Based on the field survey and on expected traffic operations associated with evacuation scenarios:

- Most sections of two-lane roads within the study area are classified as “Class I”, with "level terrain"; some are “rolling terrain”.
- “Class II” highways [roadways] are mostly those within urban and suburban centers.

4.3.2 Multilane Roadway

Ref: HCM 2022 Chapter 12

Exhibit 12-8 of the HCM 2022 presents a set of curves that indicate a per-lane capacity ranging from approximately 1,900 to 2,300 pc/h, for free-speeds of 45 to 70 mph, respectively. Based on observation, the multilane roadways outside of urban areas within the study area service traffic with free-speeds in this range. The actual time-varying speeds computed by the simulation model reflect the demand and capacity relationship and the impact of control at intersections.

4.3.3 Freeways

Ref: HCM 2022 Chapters 10, 12, 13, 14

Chapter 10 of the HCM 2022 describes a procedure for integrating the results obtained in Chapters 12, 13 and 14, which compute capacity and LOS for freeway components. Chapter 10 also presents a discussion of simulation models. The DYNEV II simulation model automatically performs this integration process.

Chapter 12 of the HCM 2022 presents procedures for estimating capacity and LOS for “Basic Freeway Segments". Exhibit 12-37 of the HCM 2022 presents capacity vs. free speed estimates, which are provided below.

Free Speed (mph):	55	60	65	70+
Per-Lane Capacity (pc/h):	2,250	2,300	2,350	2,400

The inputs to the simulation model are roadway geometrics, free-speeds and capacity based on field observations. The simulation logic calculates actual time-varying speeds based on demand: capacity relationships. A conservative estimate of per-lane capacity of 2,250 pc/h is adopted for this study for freeways.

Chapter 13 of the HCM 2022 presents procedures for estimating capacity, speed, density and LOS for freeway weaving sections. The simulation model contains logic that relates speed to demand volume: capacity ratio. The value of capacity obtained from the computational procedures detailed in Chapter 13 depends on the "Type" and geometrics of the weaving segment and on the "Volume Ratio" (ratio of weaving volume to total volume).

Chapter 14 of the HCM 2022 presents procedures for estimating capacities of ramps and of "merge" areas. There are three significant factors to the determination of capacity of a ramp-freeway junction: The capacity of the freeway immediately downstream of an on-ramp or immediately upstream of an off-ramp; the capacity of the ramp roadway; and the maximum flow rate entering the ramp influence area. In most cases, the freeway capacity is the controlling factor. Values of this merge area capacity are presented in Exhibit 14-10 of the HCM 2022 and depend on the number of freeway lanes and on the freeway free speeds. Ramp capacity is presented in Exhibit 14-12 and is a function of the ramp's FFS. The DYNEV II simulation model logic simulates the merging operations of the ramp and freeway traffic in accord with the procedures in Chapter 14 of the HCM 2022. If congestion results from an excess of demand relative to capacity, then the model allocates service appropriately to the two entering traffic streams and produces LOS F conditions (The HCM 2022 does not address LOS F explicitly).

4.3.4 Intersections

Ref: HCM 2022 Chapters 19, 20, 21, 22

Procedures for estimating capacity and LOS for approaches to intersections are presented in Chapter 19 (signalized intersections), Chapters 20, 21 (un-signalized intersections) and Chapter 22 (roundabouts). The complexity of these computations is indicated by the aggregate length of these chapters. The DYNEV II simulation logic is likewise complex.

The simulation model explicitly models intersections: Stop/yield-controlled intersections (both 2-way and all-way) and traffic signal-controlled intersections. Where intersections are controlled by fixed time controllers, traffic signal timings are set to reflect average (non-evacuation) traffic conditions. Actuated traffic signal settings respond to the time-varying demands of evacuation traffic to adjust the relative capacities of the competing intersection approaches.

The model is also capable of modeling the presence of manned traffic control. At specific locations where it is advisable or where existing plans call for overriding existing traffic control to implement manned control, the model will use actuated signal timings that reflect the presence of traffic guides. At locations where a special traffic control strategy (continuous left-turns, contra-flow lanes) is used, the strategy is modeled explicitly.

4.4 Simulation and Capacity Estimation

Chapter 6 of the HCM 2022 is entitled, "HCM and Alternative Analysis Tools." The chapter discusses the use of alternative tools such as simulation modeling to evaluate the operational performance of roadway networks. Among the reasons cited in Chapter 6 to consider using simulation as an alternative analysis tool is:

> *"The system under study involves a group of different facilities or travel modes with mutual interactions involving several HCM chapters. Alternative tools are able to analyze these facilities as a single system."*

This statement succinctly describes the analyses required to determine traffic operations across an area encompassing a study area operating under evacuation conditions. The model utilized for this study is DYNEV II[4]. It is essential to recognize that simulation models do not replicate the methodology and procedures of the HCM – they *replace* these procedures by describing the complex interactions of traffic flow and computing Measures of Effectiveness (MOE) detailing the operational performance of traffic over time and by location. The DYNEV II simulation model includes some HCM 2022 procedures only for the purpose of estimating capacity.

All simulation models must be calibrated properly with field observations that quantify the performance parameters applicable to the analysis network. Two of the most important of these are: (1) FFS; and (2) saturation headway, h_{sat}. The first of these is estimated by direct observation during the road survey or aerial imagery; the second is estimated using the concepts of the HCM 2022, as described earlier.

It is important to note that simulation represents a mathematical representation of an assumed set of conditions using the best available knowledge and understanding of traffic flow and available inputs. Simulation should not be assumed to be a prediction of what will happen under any event because a real evacuation can be impacted by an infinite number of things – many of which will differ from these test cases – and many others cannot be taken into account with the tools available.

4.5 Boundary Conditions

As illustrated in Figure 1-2, the link-node analysis network used for this study is finite. The analysis network extends well beyond the Evacuation Zones in order to model intersections with other major population areas and evacuation routes beyond the study area. However, the network does have an end at the destination (exit) nodes[4]. Beyond these destination nodes, there may be signalized intersections or merge points that impact the capacity of the evacuation routes leaving the study area. Rather than neglect these "boundary conditions," this study assumes a 25% reduction in capacity on two-lane roads (Section 4.3.1 above) and multilane roadways (Section 4.3.2 above). There is no reduction in capacity for freeways due to boundary conditions. The 25% reduction in capacity is based on the prevalence of actuated traffic signals outside the study area and the fact that the evacuating traffic volume ("main street") will be more significant than the competing traffic volume ("side street") at any downstream signalized intersections, thereby warranting a more significant percentage (75% in this case) of the signal green time.

[4] https://kldassociates.com/wp-content/uploads/2024/10/DTRAD-DYNEV.pdf

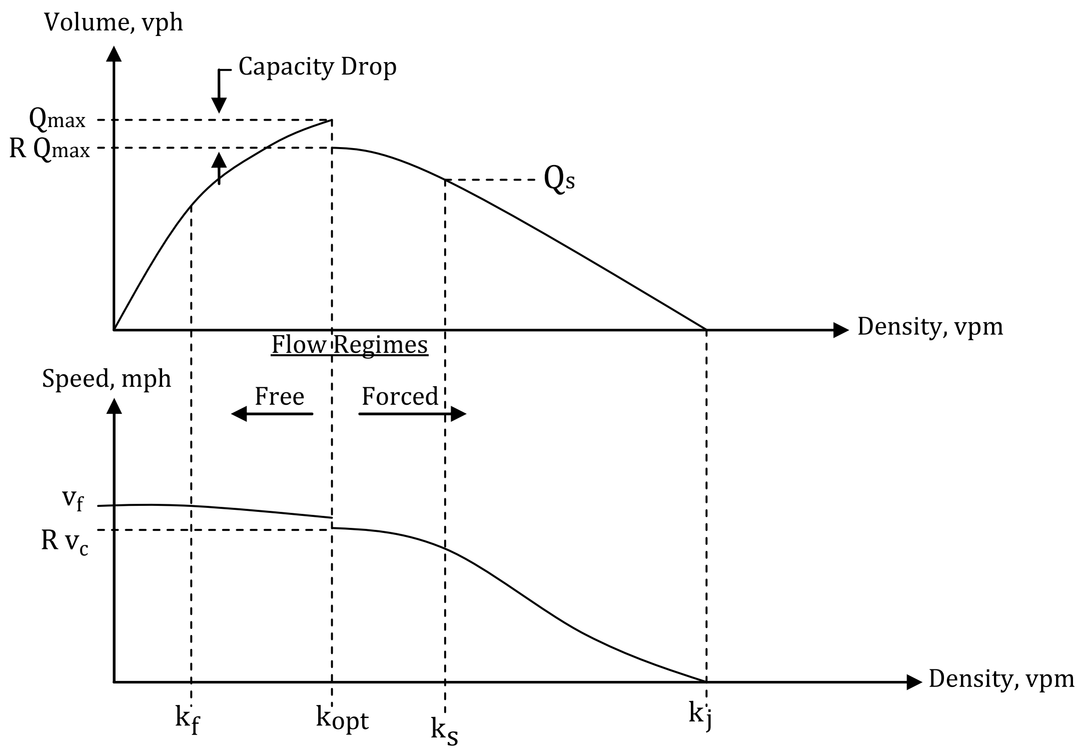


Figure 4-1. Fundamental Diagrams

5 ESTIMATION OF TRIP GENERATION TIME

It is general practice for planners to estimate the distributions of elapsed times associated with mobilization activities undertaken by the public to prepare for the evacuation trip. The elapsed time associated with each activity is represented as a statistical distribution reflecting differences between members of the public. The quantification of these activity-based distributions relies largely on the results of the demographic survey. We define the sum of these distributions of elapsed times as the Trip Generation Time Distribution. This section documents how the trip generation time distributions were estimated.

5.1 Background

In general, during an emergency, priorities are given to life safety, preservation of property and resource conservation. To ensure life safety, depending on the severity of the emergency, emergency officials may issue warnings or orders that include evacuation.

As a Planning Basis, we will adopt a conservative posture, a rapidly escalating wildfire or tsunami situation, wherein evacuation is required, ordered promptly and no early protective actions have been implemented when calculating the Trip Generation Time. In these analyses, we have assumed:

1. The evacuation order will be announced coincident with local emergency alerts (e.g., AC Alert/IPAWS, Genasys Protect, Outdoor Warning System Sirens, Nixle, social media, local news and similar communication systems).
2. Mobilization of the general population will commence within 15 minutes after the order to evacuate.
3. The ETE are measured relative to the order to evacuate being issued by officials.

We emphasize that the adoption of this planning basis is not a representation that these events will occur within the indicated time frame. Rather, these assumptions are necessary in order to:

1. Establish a temporal framework for estimating the Trip Generation distribution
2. Identify temporal points of reference that uniquely define "Clear Time" and ETE.

The notification process consists of two events:

1. Transmitting information using the alert and notification systems mentioned above.
2. Receiving and correctly interpreting the information that is transmitted.

The population within Berkeley is engaged in a wide variety of activities. It must be anticipated that some time will elapse between the transmission and receipt of the information advising the public of an event.

The amount of elapsed time will vary from one individual to the next depending on where that person is, what that person is doing, and related factors. Furthermore, some persons who will be directly involved with the evacuation process may be outside the city at the time the evacuation is ordered. These people may be commuters, and other travelers who reside within the city and who will return to join the other household members upon receiving notification of an emergency.

As indicated in Section 2.13 of NUREG/CR-6863, the estimated elapsed times for the receipt of notification can be expressed as a distribution reflecting the different notification times for different people within, and outside, the city. By using time distributions, it is also possible to distinguish between different population groups and different day-of-week and time-of-day scenarios, so that accurate ETE may be computed.

For example, people at home or at work within Berkeley might be notified by wireless emergency alerts, other alerts to their mobile or home phones, emails, outdoor warning sirens, television and/or radio (if available). Those well outside the city might be notified by word-of--mouth, with potentially longer time lags. Furthermore, the spatial distribution of the population will differ with time of day: families- will be united in the evenings but dispersed during the day. In this respect, weekends will differ from weekdays.

The information required to compute trip generation times is typically obtained from a demographic survey of residents. Such a survey was conducted for this study. Appendix D discusses the survey sampling plan, the number of completed surveys obtained, documents the survey instrument utilized, and provides the survey results. The remaining discussion will focus on the application of the trip generation data obtained from the online demographic survey to the development of the ETE documented in this report.

5.2 Fundamental Considerations

The environment leading up to the time that people begin their evacuation trips consists of a sequence of events and activities. Each event (other than the first) occurs at an instant in time and is the outcome of an activity.

Activities are undertaken over a period of time. Activities may be in "series" (i.e. to undertake an activity implies the completion of all preceding events) or may be in parallel (two or more activities may take place over the same period of time). Activities conducted in series are functionally dependent on the completion of prior activities; activities conducted in parallel are functionally independent of one another. The relevant events associated with the public's preparation for evacuation are:

Event Number	Event Description
1	Notification
2	Awareness of Situation
3	Depart Work
4	Arrive Home
5	Depart on Evacuation Trip

Associated with each sequence of events are one or more activities, as outlined in Table 5-1.

These relationships are shown graphically in Figure 5-1.

- An Event is a 'state' that exists at a point in time (e.g., depart work, arrive home)
- An Activity is a 'process' that takes place over some elapsed time (e.g., prepare to leave work, travel home)

As such, a completed Activity changes the 'state' of an individual (i.e., the activity, 'travel home' changes the state from 'depart work' to 'arrive home'). Therefore, an Activity can be described as an 'Event Sequence'; the elapsed times to perform an event sequence vary from one person to the next and are described as statistical distributions on the following pages.

An employee who lives outside of Berkeley will follow sequence (c) of Figure 5-1. A household within Berkeley that has one or more commuters at work and will await their return before beginning the evacuation trip will follow the first sequence of Figure 5-1(a). A household within the city that has no commuters at work, or that will not await the return of any commuters, will follow the second sequence of Figure 5-1(a), regardless of day of week or time of day.

Households with no commuters on weekends or in the evening/night-time will follow the applicable sequence in Figure 5-1(b). Visitors will always follow one of the sequences of Figure 5-1(b). Some visitors away from their residence could elect to evacuate immediately without returning to the residence, as indicated in the second sequence.

It is seen from Figure 5-1, that the Trip Generation time (i.e., the total elapsed time from Event 1 to Event 5) depends on the scenario and will vary from one household to the next. Furthermore, Event 5 depends, in a complicated way, on the time distributions of all activities preceding that event. That is, to estimate the time distribution of Event 5, we must obtain estimates of the time distributions of all preceding events. For this study, we adopt the conservative posture that all activities will occur in sequence.

In some cases, assuming certain events occur in series rather than in parallel (for instance, commuter returning home before beginning preparation to leave, or picking up school children only after the preparation to leave) can result in rather ***conservative*** (that is, longer) estimates of mobilization times. It is reasonable to expect that at least some parts of these events will overlap for many households, but that assumption is not made in this study.

5.3 Estimated Time Distributions of Activities Preceding Event 5

The time distribution of an event is obtained by "summing" the time distributions of all prior contributing activities. (This "summing" process is quite different than an algebraic sum since it is performed on distributions – not scalar numbers).

<u>Time Distribution No. 1, Notification Process: Activity 1 → 2</u>

A demographic survey of Berkeley residents was conducted to study the evacuation behavior of the population. The survey results were used to create the notification time distribution. The survey asked specific questions about notifying neighbors and friends during an emergency using various methods like phone calls, text messages, social media, and in person conversation. The City of Berkeley also uses Outdoor Warning System sirens, Genasys Protect, and AC Alert/IPAWS/Nixle to notify their residents. Because of the indiscriminate reach of these systems, it is possible that people who receive the alerts and are outside of the intended evacuation area will choose to leave, adding to demand on the roadways.

Given the presence of the existing emergency alert systems and the responses to the demographic survey regarding notification of friends and neighbors, assumptions were made about the notification of people in Berkeley (including residents outside of the Berkeley City limits at the time of the emergency). It was assumed that about 37% of residents are notified within 5 minutes of an emergency, 93% of the residents are notified within 25 minutes, and 100% of the residents are notified within 35 minutes. The distribution of Activity 1 → 2 shown in Table 5-2 and plotted in Figure 5-2 reflects data obtained by the demographic survey and the above assumptions.

<u>Distribution No. 2, Prepare to Leave Work: Activity 2 → 3</u>

It is reasonable to expect that the vast majority of business enterprises within Berkeley will elect to shut down following an evacuation order and most employees would leave work quickly. Commuters who work outside the city could, in all probability, also leave quickly since facilities outside Berkeley would remain open and other personnel would remain to maintain business operations. The distribution of Activity 2 → 3 shown in Table 5-3 reflects data obtained by the demographic survey. This distribution is also applicable for residents to leave stores, restaurants, parks and other locations within the city. This distribution is plotted in Figure 5-2.

<u>Distribution No. 3, Travel Home: Activity 3 → 4</u>

These data are provided directly by households that responded to the demographic survey. This distribution is plotted in Figure 5-2 and listed in Table 5-4.

<u>Distribution No. 4, Prepare to Leave Home: Activity 2, 4 → 5</u>

These data are provided directly by households that responded to the demographic survey. This distribution is plotted in Figure 5-2 and listed in Table 5-5.

Distribution No. 5, Pickup School Children:

Approximately 22% of households have children within the city (see Appendix D). Of these households, approximately 83% of them will pick up their children at the school during an emergency. Picking up children from school take time; this time must be incorporated into the trip generation time distributions. This distribution is Figure 5-2 and listed in Table 5-6.

5.4 Calculation of Trip Generation Time Distribution

The time distributions for each of the mobilization activities presented herein must be combined to form the appropriate Trip Generation Distributions. As discussed above, this study assumes that the stated events take place in sequence such that all preceding events must be completed before the current event can occur. For example, if a household awaits the return of a commuter, the work-to-home trip (Activity 3 $\rightarrow$ 4) must precede Activity 4 $\rightarrow$ 5.

To calculate the time distribution of an event that is dependent on two sequential activities, it is necessary to "sum" the distributions associated with these prior activities. The distribution summing algorithm is applied repeatedly to form the required distribution. As an outcome of this procedure, new time distributions are formed; we assign "letter" designations to these intermediate distributions to describe the procedure. Table 5-7 presents the summing procedure to arrive at each designated distribution.

Table 5-8 presents a description of each of the final trip generation distributions achieved after the summing process is completed.

5.4.1 Statistical Outliers

As already mentioned, some portion of the survey respondents answer "don't know/prefer not to say" to some questions or choose to not respond to a question. The mobilization activity distributions are based upon actual responses. But it is the nature of surveys that a few numeric responses are inconsistent with the overall pattern of results. An example would be a case in which for 500 responses, almost all of them estimate less than two hours for a given answer, but 3 say "four hours" and 4 say "six or more hours".

These "outliers" must be considered: are they valid responses, or so atypical that they should be dropped from the sample?

In assessing outliers, there are three alternatives to consider:

1. Some responses with very long times may be valid, but reflect the reality that the respondent really needs to be classified in a different population subgroup, based upon special transportation needs;
2. Other responses may be unrealistic (6 hours to return home from commuting distance, or 2 days to prepare the home for departure);
3. Some high values are representative and plausible, and one must not cut them as part of the consideration of outliers.

The issue is how to make the decision that a given response or set of responses are to be considered "outliers" for the component mobilization activities, using a method that objectively quantifies the process.

There is considerable statistical literature on the identification and treatment of outliers singly or in groups, much of which assumes the data is normally distributed and some of which uses non-parametric methods to avoid that assumption. The literature cites that limited work has been done directly on outliers in sample survey responses.

In establishing the overall mobilization time/trip generation distributions, the following principles are used:

1. It is recognized that the overall trip generation distributions are conservative estimates, because they assume a household will do the mobilization activities sequentially, with no overlap of activities;
2. The individual mobilization activities (receive notification, prepare to leave work, travel home, prepare home, pickup school children) are reviewed for outliers, and then the overall trip generation distributions are created (see Figure 5-1, Table 5-7, Table 5-8);
3. Outliers can be eliminated either because the response reflects a special population (e.g., special transportation needs, transit dependent) or lack of realism, because the purpose is to estimate trip generation patterns for personal vehicles;
4. To eliminate outliers,
    a) the mean and standard deviation of the specific activity are estimated from the responses,
    b) the median of the same data is estimated, with its position relative to the mean noted,
    c) the histogram of the data is inspected, and
    d) all values greater than 3.0 standard deviations are flagged for attention, taking special note of whether there are gaps (categories with zero entries) in the histogram display.

    In general, only flagged values more than 3.5 standard deviations from the mean are allowed to be considered outliers, with gaps in the histogram expected.

    When flagged values are classified as outliers and dropped, steps "a" to "d" are repeated.
5. As a practical matter, even with outliers eliminated by the above, the resultant histogram, viewed as a cumulative distribution, is not a normal distribution. A typical situation that results is shown in Figure 5-3.
6. In particular, the cumulative distribution differs from the normal distribution in two key aspects, both very important in loading a network to estimate evacuation times:
    - Most of the real data is to the left of the "normal" curve above, indicating that the network loads faster for the first 80-85% of the vehicles, potentially causing more (and earlier) congestion than otherwise modeled;

- The last 10-15% of the real data "tails off" slower than the comparable "normal" curve, indicating that there is significant traffic still loading at later times.

Because these two features are important to preserve, it is the histogram of the data that is used to describe the mobilization activities, not a "normal" curve fit to the data. One could consider other distributions, but using the shape of the *actual* data curve is unambiguous and preserves these important features;

7. With the mobilization activities each modeled according to Steps 1-6, including preserving the features cited in Step 6, the overall (or total) mobilization times are constructed.

This is done by using the data sets and distributions under different scenarios (e.g., commuter returning, no commuter returning, and children pickup or no children pickup). In general, these are additive, using weighting based upon the probability distributions of each element; Figure 5-4 presents the combined trip generation distributions designated for each population group considered. These distributions are presented on the same time scale. (As discussed earlier, the use of strictly additive activities is a conservative approach, because it makes all activities sequential – preparation for departure follows the return of the commuter; children pickup follows the preparation for departure, and so forth. In practice, it is reasonable that some of these activities are done in parallel, at least to some extent – for instance, preparation to depart begins by a household member at home while the commuter is still on the road.)

The mobilization distribution results are used in their tabular/graphical form as direct inputs to later computations that lead to the ETE.

The DYNEV II simulation model is designed to accept varying rates of vehicle trip generation for each origin centroid, expressed in the form of histograms. These histograms, which represent Distributions A, C, D, E, and F properly displaced with respect to one another, are tabulated in Table 5-9 (Distribution B, Arrive Home, omitted for clarity).

The final time period (15) is 600 minutes long. This time period is added to allow the analysis network to clear, in the event congestion persists beyond the trip generation period. Note that there are no trips generated during this final time period.

5.4.2 Phased Evacuation Trip Generation

As detailed in Section 6: Evacuation Cases, Region R03 studies a phased evacuation for a repeat of the 1923 Berkeley Fire.

In a phased evacuation, permanent residents in imminent danger will be given an evacuation order while other areas will receive an evacuation warning or no protective action. The evacuation orders are issued subsequently at specified times after the initial evacuation order.

Region R03 considers the spread pattern from the 1923 fire. Per Berkeley Fire Department direction, zone status may change up to three times over the course of the tri-phased analysis as the simulated fire spreads. This means that individual zones may shift from no action necessary, to Evacuation Warning and/or Evacuation Order status based on patterns of fire spread.

Assumptions

1. It is assumed that 100% of residents in Evacuation Zones ordered to evacuate will evacuate, 50% of residents in Evacuation Zones that receive an evacuation warning will evacuate, and 20% of residents in Evacuation Zones with no protective action instructions will evacuate.
2. The population in the Shadow Region beyond Berkeley boundaries will react as they do for all non-phased evacuation scenarios. That is 20% of these households will elect to evacuate without delay.
3. Only permanent residents are expected to phase their evacuation. Non-resident population groups (employees, tourists, etc.) start following their mobilization times immediately.
4. Residents still follow their regular mobilization curve starting at the time of the first evacuation order (0 minutes/Phase a), 90 minutes after the first evacuation order (Phase b), or 180 minutes after the evacuation order (Phase c).

Procedure

1. Permanent residents in Evacuation Zones in Region R03 will be phased as follows:
    a. Phase a (0 minutes):
        i. The following Evacuation Zones will be under Evacuation Order - BER-E031, LBL-E006, OKL-E002, BER-E016
        ii. The following Evacuation Zones will be under Evacuation Warning - BER-E015, BER-E032, LBL-E004, LBL-E005, LBL-E001, BER-E008, BER-E017, BER-E007, BER-E030, OKL-E001, LBL-E003
    b. Phase b (90 minutes):
        i. The following Evacuation Zones will be under Evacuation Order - BER-E031, BER-E015, BER-E032, LBL-E006, LBL-E004, LBL-E005, LBL-E001, BER-E017, BER-E030, OKL-E001, LBL-E003, OKL-E002, BER-E016
        ii. The following Evacuation Zones will be under Evacuation Warning - BER-E018, BER-E040, BER-E013, BER-E041, LBL-E002, BER-E019, BER-E029, BER-E008, BER-E007, BER-E058, BER-E033
    c. Phase c (180 minutes):
        i. The following Evacuation Zones will be under Evacuation Order - BER-E018, BER-E057, BER-E012, BER-E040, BER-E013, BER-E031, BER-E041, BER-E015, BER-E032, LBL-E006, LBL-E004, LBL-E005, LBL-E001, LBL-E002, BER-E026, BER-E019, BER-E029, BER-E017, BER-E030, OKL-E001, LBL-E003, BER-E058, BER-E059, BER-E027, BER-E020, BER-E033, BER-E028, BER-E038, BER-E039, BER-E043, BER-E042, OKL-E002, BER-E016

ii. The following Evacuation Zones will be under Evacuation Warning - BER-E056, BER-E021, BER-E044, BER-E009, BER-E037, BER-E022, BER-E010, BER-E055, BER-E066, BER-E025, BER-E008, BER-E007, OKL-E004, BER-E073, BER-E060, BER-E054, ALB-E006

Table 5-1. Event Sequence for Evacuation Activities

Event Sequence	Activity	Distribution
1 → 2	Receive Notification	1
2 → 3	Prepare to Leave Work	2
2,3 → 4	Travel Home	3
2,4 → 5	Prepare to Leave to Evacuate	4
N/A	Children Pickup	5

Table 5-2. Time Distribution for Notifying the Public

Elapsed Time (Minutes)	Cumulative Percent of Population Notified
0	0.0%
5	37.0%
10	41.0%
15	46.0%
20	71.0%
25	93.0%
30	99.0%
35	100.0%

Table 5-3. Time Distribution for Employees to Prepare to Leave Work/College[1]

Elapsed Time (Minutes)	Cumulative Percent Employees Leaving Work
0	0.0%
5	25.7%
10	56.0%
15	75.6%
20	86.9%
25	90.3%
30	98.7%
35	100.0%

[1] The survey data was normalized to distribute the "prefer not to say" response. That is, the sample was reduced in size to include only those households who responded to this question. The underlying assumption is that the distribution of this activity for the "prefer not to say" responders, if the event takes place, would be the same as those responders who provided estimates.

Table 5-4. Time Distribution for Commuters to Travel Home

Elapsed Time (Minutes)	Cumulative Percent Returning Home
0	0.0%
5	9.8%
10	16.3%
15	25.2%
20	36.1%
25	48.2%
30	60.5%
35	71.9%
40	81.4%
45	88.6%
50	93.5%
55	96.6%
60	98.4%
75	99.7%
90	100.0%

NOTE: The survey data was normalized to distribute the "prefer not to say" response.

Table 5-5. Time Distribution for Population to Prepare to Evacuate

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	0.0%
15	15.3%
30	33.9%
45	57.7%
60	78.9%
75	92.1%
90	97.8%
105	99.6%
120	99.9%
135	100.0%

NOTE: The survey data was normalized to distribute the "prefer not to say" response.

Table 5-6. Time Distribution for Population to Pick-up School Children from School

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	0.0%
5	4.5%
10	23.0%
15	48.1%
20	63.8%
25	71.1%
30	85.4%
35	89.2%
40	94.8%
45	100.0%

NOTE: The survey data was normalized to distribute the "prefer not to say" response.

Table 5-7. Mapping Distributions to Events

Apply "Summing" Algorithm To:	Distribution Obtained	Event Defined
Distributions 1 and 2	Distribution A	Event 3
Distributions A and 3	Distribution B	Event 4
Distributions B and 4	Distribution C	Event 5
Distributions 1 and 4	Distribution D	Event 5
Distributions C and 5	Distribution E	Event 5
Distributions D and 5	Distribution F	Event 5

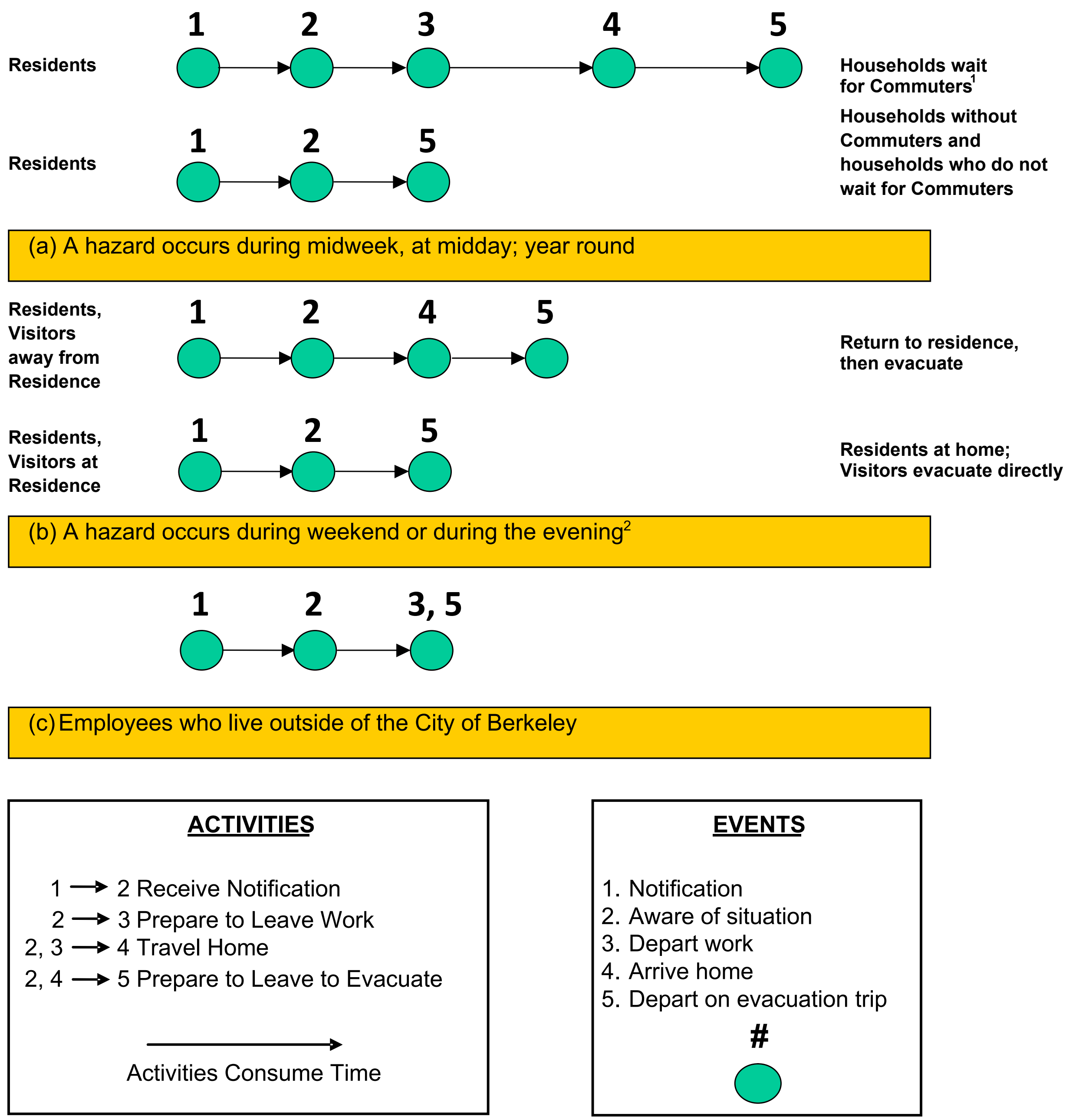
Table 5-8. Description of the Distributions

Distribution	Description
A	Time distribution of commuters departing place of work (Event 3). Also applies to employees who work within the city who live outside, and to visitors within the city.
B	Time distribution of commuters arriving home (Event 4).
C	Time distribution of residents with commuters who return home, leaving home to begin the evacuation trip (Event 5).
D	Time distribution of residents without commuters returning home, leaving home to begin the evacuation trip (Event 5).
E	Time distribution of residents with commuters who pick-up school children from school, return home, leaving home to begin the evacuation trip (Event 5).
F	Time distribution of residents with no commuters who pickup school children from school, leaving home to begin the evacuation trip (Event 5).

Table 5-9. Trip Generation Histograms for the City of Berkeley Population[2]

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period					
		Employees (Distribution A)	Visitors (Distribution A)	Residents with Commuters (Distribution C)	Residents without Commuters (Distribution D)	Residents with Commuters Child Pick Up (Distribution E)	Residents without Commuters Child Pick Up (Distribution F)
1	15	22%	22%	0%	4%	0%	0%
2	15	38%	38%	0%	12%	0%	3%
3	15	33%	33%	3%	18%	0%	9%
4	15	7%	7%	7%	22%	2%	16%
5	15	0%	0%	13%	20%	6%	20%
6	15	0%	0%	17%	14%	10%	20%
7	15	0%	0%	19%	7%	16%	15%
8	15	0%	0%	17%	2%	17%	10%
9	15	0%	0%	12%	1%	17%	5%
10	15	0%	0%	7%	0%	14%	1%
11	15	0%	0%	3%	0%	9%	1%
12	15	0%	0%	1%	0%	5%	0%
13	15	0%	0%	1%	0%	3%	0%
14	15	0%	0%	0%	0%	1%	0%
15	600	0%	0%	0%	0%	0%	0%

[2] Shadow vehicles are loaded onto the analysis network (Figure 1-2) using Distribution C.



[1] Applies for evening and weekends also if commuters are at work.
[2] Applies throughout the year for visitors.

Figure 5-1. Events and Activities Preceding the Evacuation Trip

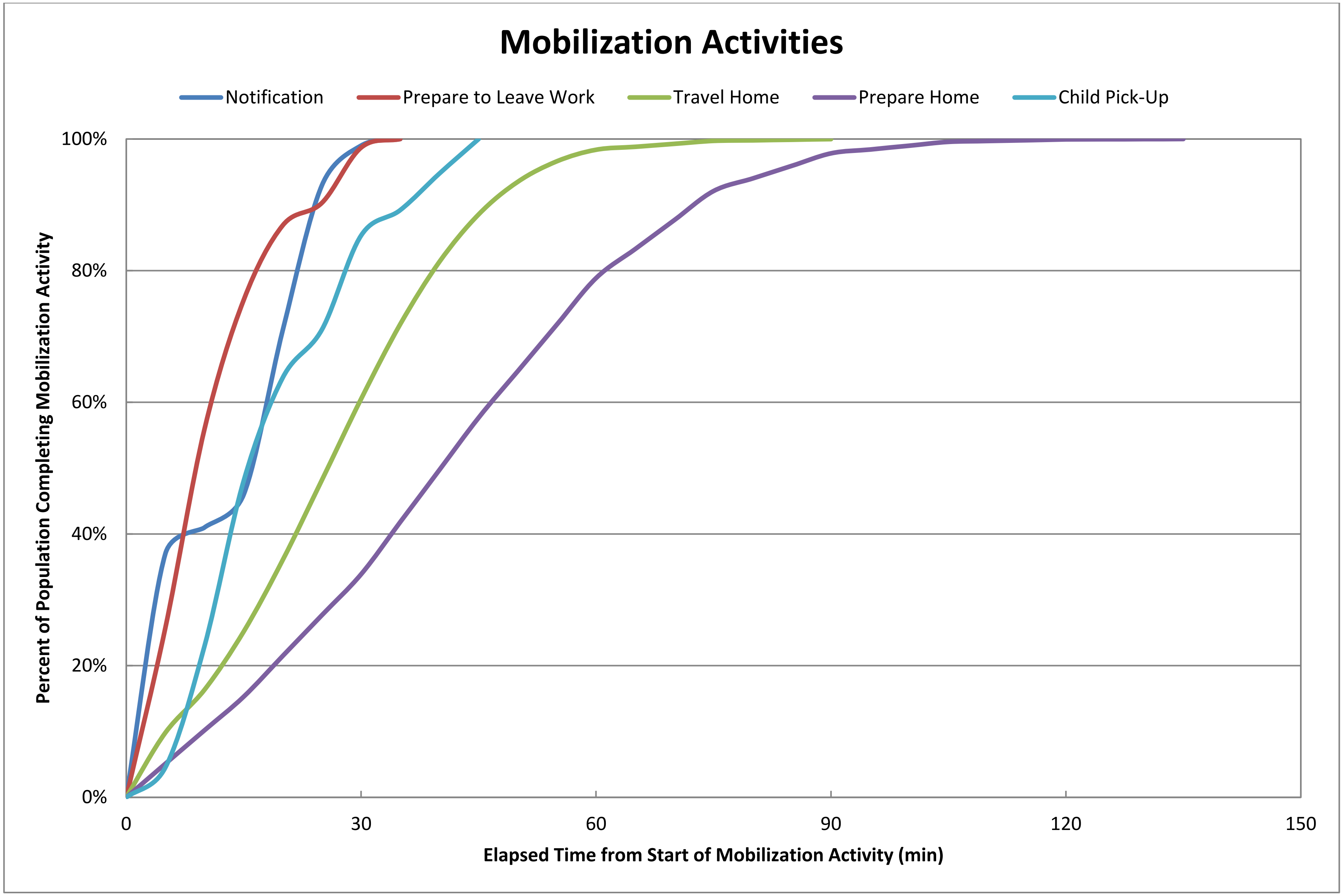


Figure 5-2. Time Distributions for Evacuation Mobilization Activities

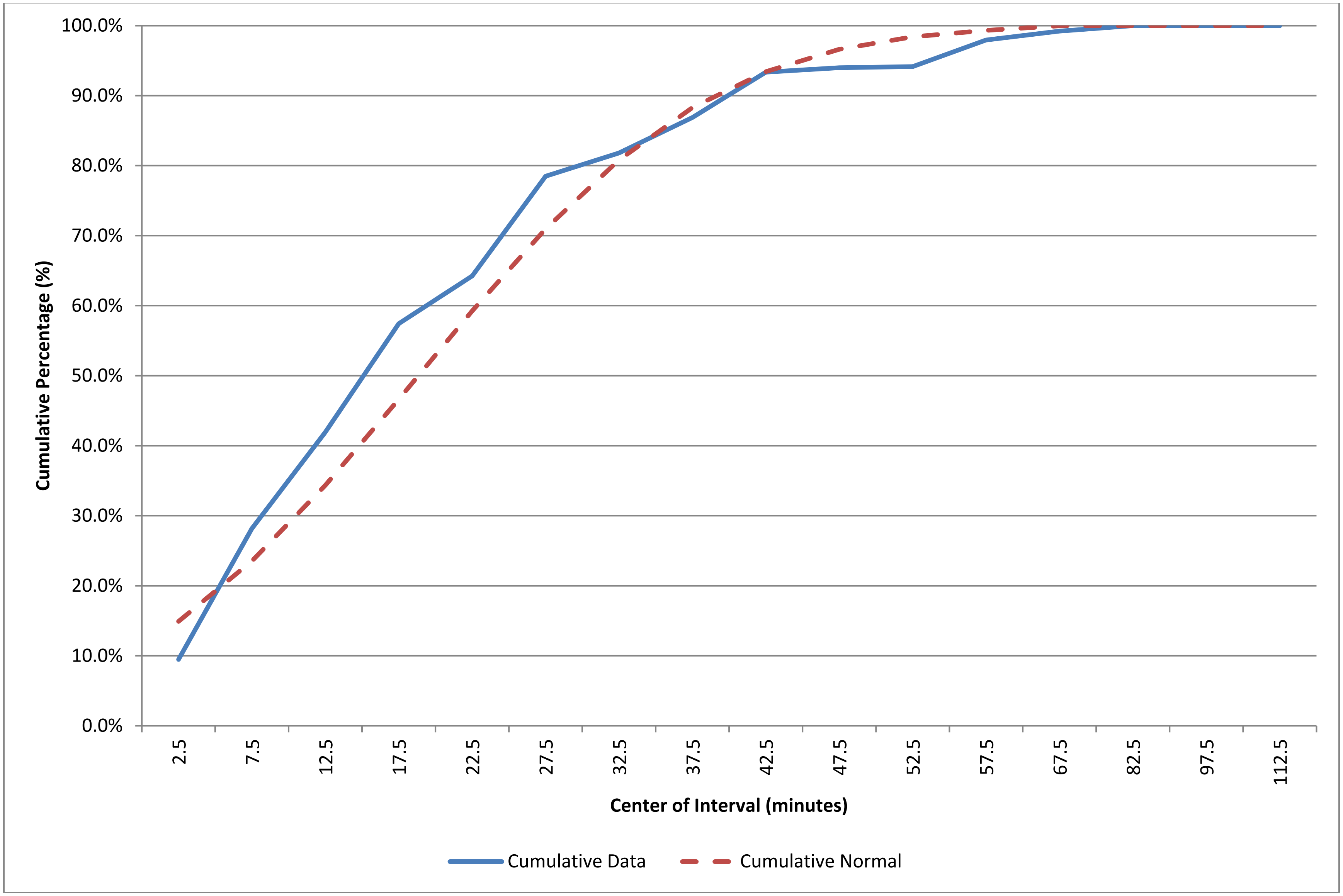


Figure 5-3. Comparison of Data Distribution and Normal Distribution

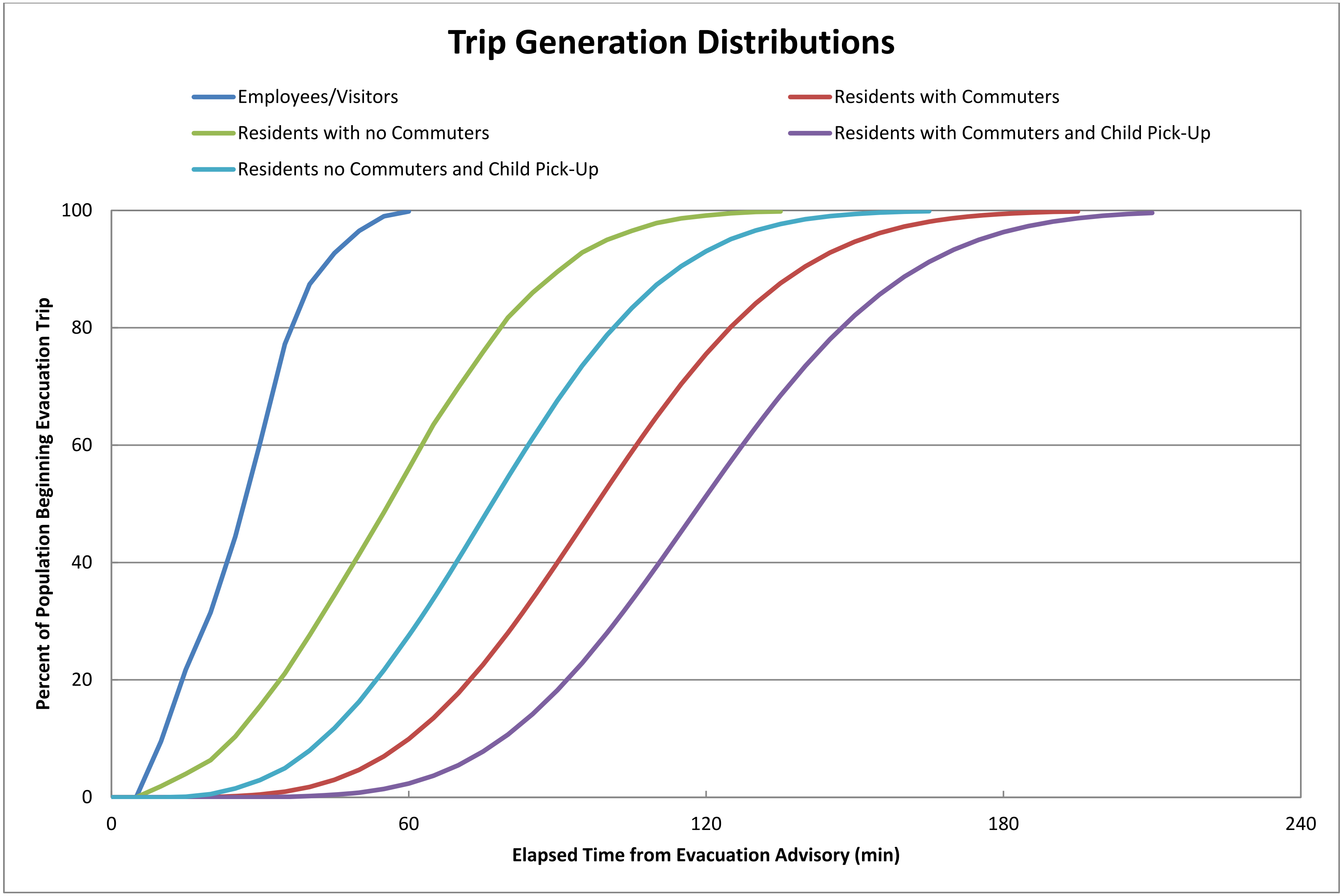


Figure 5-4. Comparison of Trip Generation Distributions

6 EVACUATION CASES

This section discusses the spatial and temporal variations in evacuation situations. The regions outlined in the study were created based on various geometric areas that would be evacuated in response to a wildfire, tsunami, or other potential emergency. The Evacuation Zones[1]were used as Zone boundaries for this study. The scenarios outlined in the study were created based on the various temporal changes that affect the number of vehicles evacuating. This section provides an overview of all the possible evacuation cases that were studied. An evacuation "case" defines a combination of Evacuation Region and Evacuation Scenario. For this specific study, the definitions of "Region" and "Scenario" are as follows:

Region A grouping of evacuating Evacuation Zones that must be evacuated in response to a wildfire, tsunami, or other emergency.

Scenario A combination of circumstances, including time of day, day of week, and season. Scenarios define the number of people in each of the affected population groups and their respective mobilization time distributions.

A total of 14 Regions were defined which encompass all the groupings of Evacuation Zones considered. These Regions are defined in Table 6-1. Table 6-2 shows which Evacuation Zones evacuate for each Region, as well as which Evacuation Zones receive an Evacuation Order and/or an Evacuation Warning (specifically for Region R03, the only phased evacuation case). Table 6-3 shows the phases, or stages, of the phased evacuation case (Region R03). A phased evacuation means that the Evacuation Zones receive Evacuation Orders and/or Evacuation Warnings in phases, rather than all at once. The Evacuation Zone boundaries are identified in Figure 6-1. Appendix E shows individual maps of all the regions shown in Table 6-1.

Region R01 is the evacuation of all Evacuation Zones within the city at once.

Region R02 and Region R04 are fire evacuations in which some Evacuation Zones receive an Evacuation Order while other Evacuation Zones simultaneously receive an Evacuation Warning. As discussed in Section 2, 50% of people are assumed to voluntarily evacuate from Evacuation Zones that receive an Evacuation Warning. One hundred percent (100%) of people are assumed to evacuate Evacuation Zones that receive an Evacuation Order.

Region R03 is a fire evacuation in which groups of Evacuation Zones receive an Evacuation Warning and/or an Evacuation Order in phases. It should be noted that Region R02 is the same geographic evacuation as Region R03 Phase C, but Region R03 is phased and Region R02 is all at once.

Regions R05 through R14 are evacuations of combinations of Evacuation Zones likely to be evacuated concurrently. These regions were defined based on discussions with Planning and

[1] https://protect.genasys.com/search

Fire Department personnel at the City of Berkeley.

- Region R05 is an evacuation of Berkeley Fire Zones 2 and 3.
- Regions R06 and R07 simulate a warning-level tsunami.
- Regions R08-R11 are geographic groupings of Berkeley that could be evacuated concurrently based on their geographic proximity but do not have a distinct hazard identified to trigger evacuation.
- Regions R12-R14 are geographic groupings of UC Berkeley and LBNL properties, which have distinct evacuation authorities from the City of Berkeley and could be evacuated in tandem with, or separate from, City property.

A total of 6 Scenarios were evaluated for all Regions. Thus, there are a total of 84 (14 x 6 = 84) unique evacuation cases. Table 6-4 provides a description of all Scenarios that were considered.

Each combination of Region and Scenario implies a specific population to be evacuated. The population group and the vehicle estimates presented in Section 3 and in Appendix C are peak values. These peak values are adjusted depending on the scenario and region being considered, using Scenario and Region-specific percentages, such that the average population is considered for each evacuation case. The Scenario percentages are presented in Table 6-5. Table 6-6 presents the vehicle counts for each scenario for an evacuation of Region R01 – all Evacuation Zones within the City.

The percentages presented in Table 6-5 were determined as follows:

The number of residents with commuters during the week (when workforce is at its peak) is equal to the product of 41.6% (the number of households with at least one commuter) and 30.1% (the number of households with a commuter that would await the return of the commuter prior to evacuating) – approximately 13%. See assumption 3 in Section 2.3. It is estimated for weekend and nighttime scenarios that 10% of households with returning commuters will have a commuter at work during those times.

It can be argued that the estimate of permanent residents overstates, somewhat, the number of evacuating vehicles, especially during the summer. It is certainly reasonable to assert that some portion of the population would be on vacation during the summer and would travel elsewhere. A rough estimate of this reduction can be obtained as follows:

- Assume 50 percent of all household's vacation for a two-week period over the summer.
- Assume these vacations, in aggregate, are uniformly dispersed over 10 weeks, i.e. 10 percent of the population is on vacation during each two-week interval.
- Assume half of these vacationers leave the area.

On this basis, the permanent resident population would be reduced by 5 percent in the summer and by a lesser amount in the off-season. Given the uncertainty in this estimate, we elected to apply no reductions in permanent resident population for the summer scenarios to account for residents who may be out of the area.

When schools are in session (Scenarios 4 and 6), approximately 18 percent of households citywide who a) have school children, and b) would elect to pick their school children from school during an emergency (see Section 2.4).

Employment is assumed to be at its peak during the fall, midweek, midday scenarios. Employment is reduced slightly (96%) for summer, midweek, midday scenarios. This is based on the estimation that 50% of the employees commuting into the City of Berkeley will be on vacation for a week during the approximately 12 weeks of summer. It is further estimated that those taking vacation will be uniformly dispersed throughout the summer with approximately 4% of employees vacationing each week. It is further estimated that only 10% of the employees are at work during the evening/overnight and on weekends.

Based on the data provided by Visit Berkeley[2], there are approximately 30,200,000 visits on average throughout the year. This equates to approximately 2,516,667 visits per month on average. During the fall and summer months, there are 2,166,667 and 3,225,000 visits on average, respectively. Since the average yearly number of visits was used to calculate the number of average daily visitors in Berkeley (see Section 3), factors of 0.86 (2,166,667 ÷ 2,516,667 = 0.86) and 1.28 (3,225,000 ÷ 2,516,667 = 1.28) were used to estimate the number of daily visitors for fall and summer, respectively.

Furthermore, there are 4,314,286 weekly average visits in Berkeley. For weekdays, the number of visits is 4,300,000 visits and for the weekend it is 4,666,667 visits. As previously mentioned, the average weekly number was used to estimate the number of total visitors. Hence, factors of (4,300,000 ÷ 4,314,286 ≈ 1) 1.00 and (4,666,667 ÷ 4,314,286 = 1.08) 1.08 were used to estimate the number of visits for weekdays and weekends, respectively. As shown in Table 6-5, these factors were used to estimate the number of tourists for fall weekends (0.86 x 1.08 = 0.93), fall weekdays (0.86 x 1.00 = 0.86), summer weekends (1.28 x 1.08 = 1.39) and summer weekdays (1.28 x 1.00 = 1.28). Since nighttime data was not available, it was assumed that there are 60% fewer visits during the nighttime. As such, scenario percentages for summer and fall during the night were estimated to be (0.40 x 1.39 = 0.56) 0.56 and (0.40 x 0.93 = 0.37) 0.37 in the summer and fall, respectively.

As noted in the shadow footnote to Table 6-5, the shadow percentages are computed using a base of 20% (see assumption 10 in Section 2.2).

Transit buses for the transit-dependent population and medical patients and vehicles for juvenile homes are set to 100% for all scenarios as it is assumed that these population groups are present in the City of Berkeley for all evacuation scenarios.

As discussed in Section 8, schools are in session during the fall season, midweek, midday and 100% of buses and student vehicles will be needed and present under those circumstances. It is estimated that summer school/college enrollment is approximately 10% of enrollment during

[2] https://www.visitberkeley.com/

the regular school year for summer scenarios. K-12 schools are not in session during weekends and at nighttime, thus buses for school children are not needed and off campus college students are not present under those circumstances; It is estimated that 10% of on campus students will be present during the summer, and 100% of on campus students will be present during fall.

External traffic is estimated to be reduced by 60% during nighttime scenarios and is 100% for all other scenarios.

Table 6-1. Evacuation Regions

See Appendix E for maps visualizing these Regions.

Region	
R01	**Citywide Evacuation**
R02	**Fire - 1923 - All**
R03	**Fire - 1923 - Phase a (0 minutes)**
	Fire - 1923 - Phase b (0 + 90 minutes)
	Fire - 1923 - Phase c (0 + 180 minutes)
R04	**Panoramic Hill Fire**
R05	**Fire Zones - Fire Zones 2 & 3 Combined**
R06	**Tsunami - Phase 3**
R07	**Tsunami - Max Phase**
R08	**Berkeley Flats**
R09	**North Berkeley Hills**
R10	**South Berkeley Hills**
R11	**West Berkeley**
R12	**UC Berkeley**
R13	**Lawrence Berkeley National Lab**
R14	**UC Berkeley + Lawrence Berkeley National Lab**

Table 6-2. Regions by Evacuation Zones

Region	Description	Evacuation Zones
R01	Citywide Evacuation	BER-E018, BER-E005, BER-E057, BER-E012, BER-E040, BER-E046, BER-E056, OKL-E010, OKL-E021, BER-E021, BER-E074, BER-E077, BER-E044, BER-E023 West, BER-E013, BER-E031, BER-E009, BER-E078, BER-E037, BER-E004, BER-E041, BER-E015, BER-E052, BER-E062, BER-E064, BER-E002, BER-E032, BER-E011, BER-E022, BER-E061, BER-E075, BER-E036, BER-E063, LBL-E006, LBL-E004, LBL-E005, LBL-E001, LBL-E002, BER-E026, BER-E003, BER-E010, BER-E019, BER-E029, BER-E055, BER-E066, BER-E025, BER-E051, BER-E008, BER-E017, BER-E048, BER-E068, BER-E007, BER-E030, OKL-E004, BER-E071, OKL-E008, OKL-E009, OKL-E007, OKL-E241, BER-E065, OKL-E001, OKL-E019, ALB-E008, BER-E047 West, LBL-E003, BER-E073, BER-E058, BER-E049, BER-E059, BER-E006, BER-E035 West, OKL-E018, BER-E027, BER-E020, BER-E024, OKL-E022, BER-E060, OKL-E020, BER-E053, BER-E014, BER-E033, BER-E054, OKL-E015, BER-E067, BER-E028, BER-E034, BER-E045, BER-E038, BER-E070, BER-E039, BER-E043, BER-E001, BER-E069, BER-E042, BER-E072, OKL-E002, BER-E016, BER-E050 East, OKL-E017, ALB-E006, BER-E076, ALB-E007, BER-E023 East, BER-E047 East, BER-E035 East, BER-E050 West
R02	Fire 1923	**Order** BER-E018, BER-E057, BER-E012, BER-E040, BER-E013, BER-E031, BER-E041, BER-E015, BER-E032, LBL-E006, LBL-E004, LBL-E005, LBL-E001, LBL-E002, BER-E026, BER-E019, BER-E029, BER-E017, BER-E030, OKL-E001, LBL-E003, BER-E058, BER-E059, BER-E027, BER-E020, BER-E033, BER-E028, BER-E038, BER-E039, BER-E043, BER-E042, OKL-E002, BER-E016, **Warning** BER-E056, BER-E021, BER-E044, BER-E009, BER-E037, BER-E022, BER-E010, BER-E055, BER-E066, BER-E025, BER-E008, BER-E007, OKL-E004, BER-E073, BER-E060, BER-E054, ALB-E006
R03 a	Fire 1923 Phased	**Order** BER-E031, LBL-E006, OKL-E002, BER-E016 **Warning** BER-E015, BER-E032, LBL-E004, LBL-E005, LBL-E001, BER-E008, BER-E017, BER-E007, BER-E030, OKL-E001, LBL-E003

Region	Description	Evacuation Zones
R03 b	Fire 1923 Phased	**Order** BER-E031, BER-E015, BER-E032, LBL-E006, LBL-E004, LBL-E005, LBL-E001, BER-E017, BER-E030, OKL-E001, LBL-E003, OKL-E002, BER-E016 **Warning** BER-E018, BER-E040, BER-E013, BER-E041, LBL-E002, BER-E019, BER-E029, BER-E008, BER-E007, BER-E058, BER-E033
R03 c	Fire 1923 Phased	**Order** BER-E018, BER-E057, BER-E012, BER-E040, BER-E013, BER-E031, BER-E041, BER-E015, BER-E032, LBL-E006, LBL-E004, LBL-E005, LBL-E001, LBL-E002, BER-E026, BER-E019, BER-E029, BER-E017, BER-E030, OKL-E001, LBL-E003, BER-E058, BER-E059, BER-E027, BER-E020, BER-E033, BER-E028, BER-E038, BER-E039, BER-E043, BER-E042, OKL-E002, BER-E016 **Warning** BER-E056, BER-E021, BER-E044, BER-E009, BER-E037, BER-E022, BER-E010, BER-E055, BER-E066, BER-E025, BER-E008, BER-E007, OKL-E004, BER-E073, BER-E060, BER-E054, ALB-E006
R04	Panoramic Hill Fire	**Order** OAK-E003, OAK-E004, OAK-E005, BER-E013, BER-E058, BER-E059, BER-E066 **Warning** OAK-E006, OAK-E007, OAK-E009, BER-E041, BER-E055, BER-E057, BER-E060, BER-E073, BER-E077
R05	Fire Zones 2 & 3 Combined	BER-E018, BER-E005, BER-E057, BER-E012, BER-E040, OKL-E010, BER-E021, BER-E031, BER-E009, BER-E078, BER-E004, BER-E041, BER-E015, BER-E002, BER-E032, BER-E011, BER-E003, BER-E010, BER-E019, BER-E029, BER-E055, BER-E066, BER-E008, BER-E017, BER-E007, BER-E030, OKL-E004, OKL-E008, OKL-E009, OKL-E007, OKL-E019, BER-E058, BER-E059, BER-E006, OKL-E018, BER-E020, BER-E033, OKL-E015, BER-E028, BER-E016, OKL-E017, BER-E076
R06	Tsunami – Phase 3	BER-E049, BER-E034

Region	Description	Evacuation Zones
R07	Tsunami – Max Phase	BER-E023 West, BER-E048, BER-E047 West, BER-E049, BER-E035 West, BER-E034, BER-E050 West
R08	Berkeley Flats	BER-E046, BER-E056, OKL-E021, BER-E074, BER-E044, BER-E037, BER-E052, BER-E062, BER-E064, BER-E022, BER-E061, BER-E075, BER-E036, BER-E063, BER-E026, BER-E025, BER-E051, BER-E068, BER-E071, OKL-E241, BER-E065, ALB-E008, BER-E073, BER-E027, BER-E024, OKL-E022, BER-E060, OKL-E020, BER-E053, BER-E014, BER-E054, BER-E067, BER-E045, BER-E038, BER-E070, BER-E039, BER-E069, BER-E072, ALB-E006, ALB-E007
R09	North Berkeley Hills	BER-E018, BER-E005, BER-E012, BER-E040, BER-E021, BER-E031, BER-E009, BER-E004, BER-E015, BER-E002, BER-E032, BER-E011, BER-E003, BER-E010, BER-E019, BER-E029, BER-E008, BER-E017, BER-E007, BER-E030, BER-E006, BER-E020, BER-E033, BER-E028, BER-E001, BER-E016
R10	South Berkeley Hills	BER-E057, OKL-E010, BER-E077, BER-E013, BER-E078, BER-E055, BER-E066, OKL-E004, OKL-E008, OKL-E009, OKL-E007, OKL-E019, BER-E058, BER-E059, OKL-E018, OKL-E015, OKL-E017, BER-E076
R11	West Berkeley	BER-E023 West, BER-E048, BER-E047 West, BER-E035 West, BER-E050 East, BER-E023 East, BER-E047 East, BER-E035 East, BER-E050 West, BER-E049, BER-E034
R12	UC Berkeley	BER-E041, OKL-E001, BER-E059, BER-E043, BER-E042, OKL-E002
R13	Lawrence Berkeley National Lab	LBL-E006, LBL-E004, LBL-E005, LBL-E001, LBL-E002, LBL-E003
R14	UC Berkeley and Lawrence Berkeley National Lab	BER-E041, LBL-E006, LBL-E004, LBL-E005, LBL-E001, LBL-E002, OKL-E001, LBL-E003, BER-E059, BER-E043, BER-E042, OKL-E002

Table 6-3. Region R03 Phased Evacuation Zones

Region R03			
Zone	Phase a - Immediate Action	Phase b - 30 Minutes After Initial Action	Phase c - 60 Minutes After the Initial Action
ALB-E006	N/A	N/A	Warning
BER-E007	Warning	Warning	Warning
BER-E008	Warning	Warning	Warning
BER-E009	N/A	N/A	Warning
BER-E010	N/A	N/A	Warning
BER-E012	N/A	N/A	Order
BER-E013	N/A	Warning	Order
BER-E015	Warning	Order	Order
BER-E016	Order	Order	Order
BER-E017	Warning	Order	Order
BER-E018	N/A	Warning	Order
BER-E019	N/A	Warning	Order
BER-E020	N/A	N/A	Order
BER-E021	N/A	N/A	Warning
BER-E022	N/A	N/A	Warning
BER-E025	N/A	N/A	Warning
BER-E026	N/A	N/A	Order
BER-E027	N/A	N/A	Order
BER-E028	N/A	N/A	Order
BER-E029	N/A	Warning	Order
BER-E030	Warning	Order	Order
BER-E031	Order	Order	Order
BER-E032	Warning	Order	Order
BER-E033	N/A	Warning	Order
BER-E037	N/A	N/A	Warning
BER-E038	N/A	N/A	Order
BER-E039	N/A	N/A	Order
BER-E040	N/A	Warning	Order
BER-E041	N/A	Warning	Order
BER-E042	N/A	N/A	Order
BER-E043	N/A	N/A	Order
BER-E044	N/A	N/A	Warning
BER-E054	N/A	N/A	Warning
BER-E055	N/A	N/A	Warning
BER-E056	N/A	N/A	Warning
BER-E057	N/A	N/A	Order
BER-E058	N/A	Warning	Order

Region R03			
Zone	Phase a - Immediate Action	Phase b - 30 Minutes After Initial Action	Phase c - 60 Minutes After the Initial Action
BER-E059	N/A	N/A	Order
BER-E060	N/A	N/A	Warning
BER-E066	N/A	N/A	Warning
BER-E073	N/A	N/A	Warning
LBL-E001	Warning	Order	Order
LBL-E002	N/A	Warning	Order
LBL-E003	Warning	Order	Order
LBL-E004	Warning	Order	Order
LBL-E005	Warning	Order	Order
LBL-E006	Order	Order	Order
OKL-E001	Warning	Order	Order
OKL-E002	Order	Order	Order
OKL-E004	N/A	N/A	Warning
All Other Zones	N/A	N/A	N/A
No Protective Action (N/A) (20% Evacuate)		Evacuation Warning (50% Evacuate)	Evacuation Order (100% Evacuate)

Table 6-4. Evacuation Scenario Definitions

Scenario	Season	Day of Week	Time of Day
1	Summer	Midweek	Midday
2	Summer	Weekend	Midday
3	Summer	Midweek, Weekend	Nighttime
4	Fall	Midweek	Midday
5	Fall	Weekend	Midday
6	Fall	Midweek, Weekend	Nighttime

Table 6-5. Percent of Population Groups Evacuating for Various Scenarios

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Tourists	Shadow Region	Special Facilities[3]	Transit Buses	Off Campus College Vehicles	On Campus College Vehicles	School Buses	External Through Traffic
1	13%	87%	96%	128%	20%	100%	100%	10%	10%	10%	100%
2	1%	99%	10%	139%	20%	100%	100%	0%	10%	0%	100%
3	1%	99%	10%	56%	20%	100%	100%	0%	10%	0%	40%
4	13%	87%	100%	86%	20%	100%	100%	100%	100%	100%	100%
5	1%	99%	10%	93%	20%	100%	100%	0%	100%	0%	100%
6	1%	99%	10%	37%	20%	100%	100%	0%	100%	0%	40%

Notes:

Households with Returning Commuters are Households of the City of Berkeley residents who await the return of commuters prior to beginning the evacuation trip.

Households Without Returning Commuters are Households of the City of Berkeley residents who do not have commuters or will not await the return of commuters prior to beginning the evacuation trip.

Employees are those who live outside the City of Berkeley but work within.

Tourists are people who are in the City of Berkeley at the time of an event for recreational or other (non-employment) purposes.

Shadow Region represents residents in the shadow region (outside of the City of Berkeley) who will spontaneously decide to relocate during the evacuation. The basis for the values shown is a 20% relocation of shadow residents.

Off Campus College Vehicles are students who live off campus, both inside and outside of Berkeley, and will evacuate using a private vehicle or public transit (bus or rail).

On Campus College Vehicles are students who live on campus at the time of an event and will evacuate using a private vehicle or public transit (bus or rail).

Special Facility, School and Transit Buses represent vehicle-equivalents present on the road during evacuation servicing medical facilities, schools and transit-dependent people (1 bus is equivalent to 2 passenger vehicles).

External Through Traffic is traffic on interstates and major arterial roads at the start of the evacuation. This traffic is assumed to stop within approximately 2 hours of the evacuation begins.

[3] Special Facilities represent the vehicles at medical facilities and juvenile homes.

Table 6-6. Vehicle Estimates by Scenario[4]

Scenarios	Households with Returning Commuters	Households without Returning Commuters	Employees	Tourists	Shadow[5]	Special Facilities	Transit Buses	Off Campus College Vehicles	On Campus College Vehicles	School Buses	External Traffic	Total Scenario Vehicles
1	5,952	41,662	14,646	17,693	10,419	285	224	1,312	207	22	47,962	140,384
2	598	47,016	1,526	19,214	10,419	285	224	0	207	0	47,962	127,451
3	598	47,016	1,543	7,741	10,419	285	224	0	207	0	19,185	87,218
4	5,952	41,662	15,256	11,888	10,419	285	224	13,119	2,069	224	47,962	149,060
5	598	47,016	1,526	12,855	10,419	285	224	0	2,069	0	47,962	122,954
6	598	47,016	1,526	5,115	10,419	285	224	0	2,069	0	19,185	86,437

[4] Vehicle estimates are for an evacuation of the entire city (Region R01).
[5] Shadow vehicles have been reduced to 20%. Refer to Section 2.

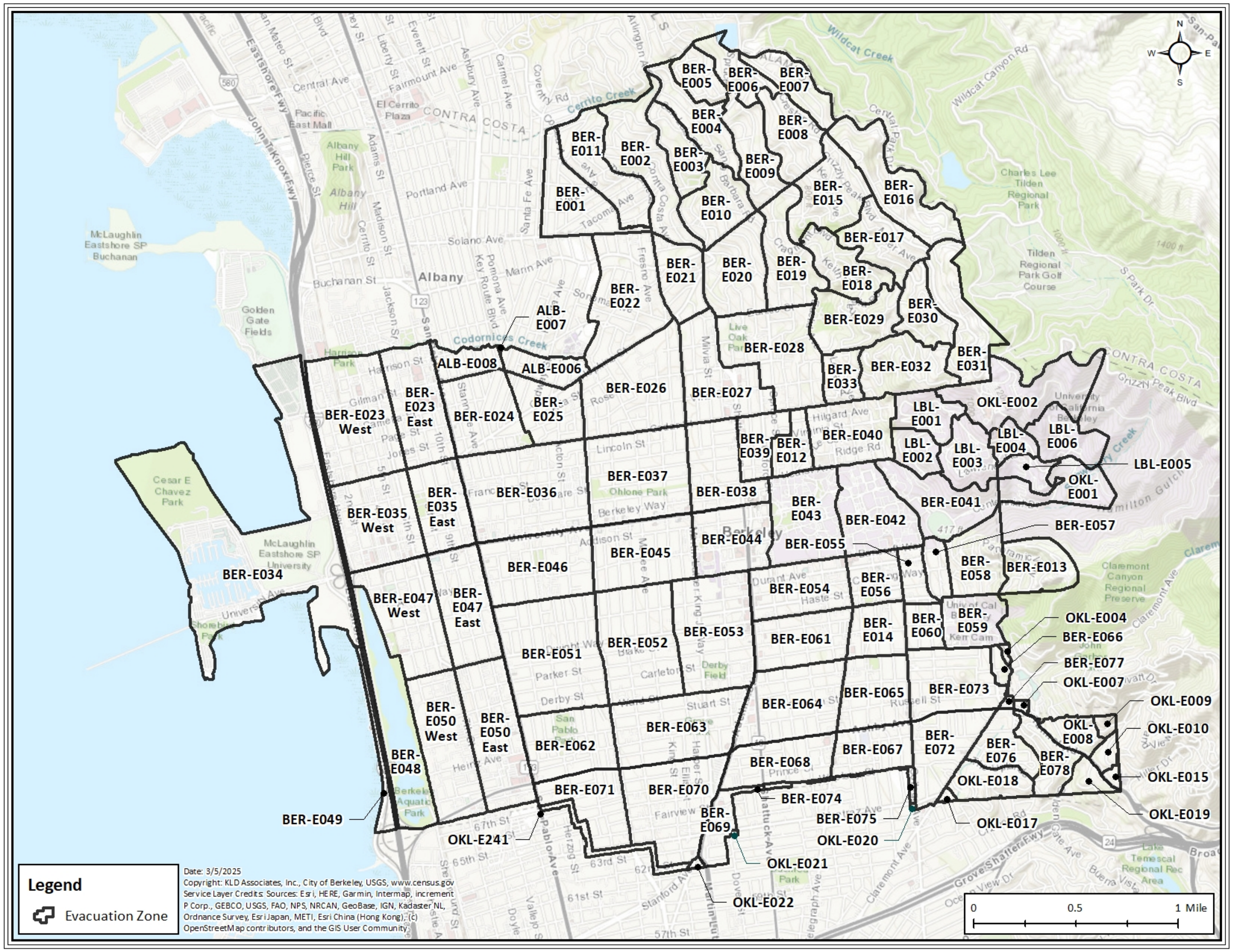


Figure 6-1. Evacuation Zones Boundaries

7 GENERAL POPULATION EVACUATION TIME ESTIMATES (ETE)

This section presents the ETE results of the computer analyses using the DYNEV II System[1]. These results cover 14 Evacuation Regions and the 6 Evacuation Scenarios discussed in Section 6.

The ETE for all Evacuation Cases are presented in Table 7-1 and Table 7-2. These tables present the estimated **times to clear** the indicated population percentages from the Evacuation Regions for all Evacuation Scenarios. **The ETE does not represent the time experienced by an individual evacuee nor does it account for the time to reach a destination.** Table 6-1 defines the Evacuation Regions considered. The tabulated values of ETE are obtained from the DYNEV II System outputs which are generated at 5-minute intervals.

7.1 Voluntary Evacuation and Shadow Evacuation

"Voluntary evacuees" are people within the city for which an Evacuation Order or Warning has not been issued, yet who elect to evacuate. "Shadow evacuation" is the outward movement of some people from outside of the city limits (also for whom no Evacuation Order or Warning has been issued). Both voluntary and shadow evacuations are assumed to take place over the same time frame as the evacuation from within the impacted Evacuation Region.

Within the city:

- 100% of permanent residents who are issued an Evacuation Order are assumed to evacuate. (See Section 6).
- 50% of permanent residents who are issued an Evacuation Warning are assumed to evacuate.
- 20% of permanent residents located outside of the evacuation region who are not given an Evacuation Order or Warning, are assumed to evacuate. Outside of the city, it is assumed that 20% of people in the Shadow Region will also choose to leave the area.

Figure 7-1 presents the area identified as the Shadow Region. The Shadow Region extends beyond the City of Berkeley. The Shadow Region is bounded by I-580, Piedmont Ave and Moraga Ave to the south, State Route 13 and State Route 24 to the southeast, the eastern boundary of Tilden Park to the east, by Moeser Lane, San Pablo Avenue, Potrero Avenue, S 55th Street, and Bayview Avenue to the North, and I-580 and the San Francisco Bay to the west. The population and number of evacuating vehicles in the Shadow Region were estimated using the same methodology that was used for permanent residents within the City of Berkeley (see Section 3.1). As discussed in Section 3.2, it is estimated that a total of 111,443 permanent residents reside in the Shadow Region; 20% of them would evacuate. See Table 6-6 for the number of evacuating vehicles from the Shadow Region.

[1] https://kldassociates.com/wp-content/uploads/2024/10/DTRAD-DYNEV.pdf

Traffic generated within this Shadow Region including external-external traffic, traveling away from the hazard, has the potential for impeding evacuating vehicles from within the city or Evacuation Region. All ETE calculations include this shadow traffic movement.

7.2 Evacuation Rates

Evacuation is a continuous process, as implied by Figure 7-2 through Figure 7-7. These figures indicate the rate at which traffic flows out of the city (Region R01) under the indicated conditions. One figure is presented for each scenario considered.

The distance between the trip generation and ETE curves is the travel time. Plots of trip generation versus ETE are indicative of the level of traffic congestion during evacuation. The evacuation population mobilizes over 3 hours and 15 minutes, or 3 hours and 30 minutes on school days, as discussed in Section 5. Despite evacuees mobilizing over a lengthy period of time, pronounced congestion can be seen throughout the city when the entire city evacuates at once (as shown in Appendix F). Thus, as seen in Figure 7-2 through Figure 7-7, the two curves are spatially separated. In Scenario 4 (fall, midweek, midday) for example, evacuees that leave within 30 minutes of the evacuation order experience travel times of up to 40 minutes. Those that leave later experience travel times of up to 2 hours and 35 minutes.

It should be noted that slower mobilization can actually reduce congestion, as it distributes vehicles over a longer period, allowing the road network to handle evacuation traffic more effectively. This could lead to shorter evacuation times and reduced travel times, assuming there is sufficient time for longer mobilization before the hazard reaches the city limits.

7.3 Evacuation Time Estimate (ETE) Results

Table 7-1 and Table 7-2 present the ETE values for all 14 Evacuation Regions and all 6 Evacuation Scenarios.

This analysis presents ETE for both the 90th and 100th percentile, as described below:

Table	Contents
7-1	**90th Percentile ETE:** ETE represents the time required for 90 percent of the population within a Region **to evacuate out of the Zone(s) of the Region under Evacuation Order**. An evacuation is considered 90% complete when 90% of all evacuating vehicles/people in Evacuation Order zones have arrived in Zones that are either a) under Evacuation Warning or b) not under threat. This includes vehicles used by the transit-dependent population. All Scenarios (time of day, day of week, season) are considered.
7-2	**100th Percentile ETE:** ETE represents the time required for 100 percent of the population within a Region **to evacuate out of the Zone(s) of the Region under Evacuation Order**. An evacuation is considered 100% complete when 100% of all evacuating vehicles/people in Evacuation Order zones have arrived in Zones that are either a) under Evacuation Warning or b) not under threat. This includes vehicles used by the transit-dependent population. All Scenarios (time of day, day of week, season) are considered.
7-4	**ETE for Response Planning:** Presents the ETE (90th or 100th) most appropriate for response planning.

The 90th and 100th percentile ETEs present different information. The US NRC recommends emergency planners and responders use the 90th percentile ETE when making protective action decisions, instead of the 100th percentile. This is because frequently, the last 10% of vehicles take an unusually long time to prepare to leave (“Trip Generation”). This extended trip generation time results in a long evacuation “tail” that is unrelated to traffic congestion. This tail can reflect highly variable individual evacuee behaviors (such as individual households with an extremely long mobilization time as compared to their neighbors). Therefore, using the 100th percentile ETEs for community-wide evacuation planning is not recommended, although it is provided in this report for completeness.

Although counterintuitive, the 90th percentile ETE for a case with a large number of evacuating vehicles can be less than a case with fewer evacuating vehicles. This is because the 90th percentile ETE depends on the composition of the evacuating vehicular traffic (e.g., residents, employees, visitors). Areas with a higher proportion of quickly mobilizing evacuees (such as employees or visitors) can reach the 90th percentile ETE more quickly compared to areas predominantly populated by permanent residents, who typically require a longer time to mobilize even if they have a higher total demand. Often, this anomaly is seen in cases without traffic congestion, or where traffic congestion clears prior to the end of trip generation.

This analysis determined the Trip Generation Time using the results of the community survey (Appendix D). Survey respondents reported how long it would take them to prepare to leave (trip generation time.) Some respondents indicated that it would take multiple hours to leave, which creates this long evacuation “tail.” However, survey results may not accurately reflect the Trip Generation times for no-notice events such as a fire immediately adjacent to the home. Therefore, a truncation of the mobilization time was tested in Section 10 for Region R02 and R04.

It can be seen that when mobilization times are shorter, the 100th percentile ETE are also shorter, validating the NRC concepts.

Snapshots of congestion at certain times into the evacuation for some cases are presented in Appendix F. These diagrams reflect the ETE statistics for the evacuation scenarios and regions for which they represent. The majority of the congestion is located on higher capacity routes that serve a majority of the evacuating population – discussed further in Section 9.

7.3.1 Prepare to Evacuate Time Can Dictate Time to Escape Hazard Area

As described above, an analysis comparing the 90th and 100th percentile ETE shows that for most of the 14 Evacuation Regions and their 6 Evacuation Scenarios, the 100th percentile ETE is dictated by trip generation[2]. This means that generally, the extended time it takes the final evacuees to get on the road is the reason for the extended evacuation time.

However, there are exceptions to this statement listed below. This means that under the circumstances below, traffic congestion causes extended evacuation times, and even if evacuees got on the road more quickly, the area would not be cleared more quickly.

- Region R01: A citywide evacuation, during the day
- Region R02: An unphased evacuation of the 1923 Fire during the fall, midweek, midday
- Region R03 Phase a and Phase b: A phased evacuation of the Fire 1923 (due to the "spike"), during the day, and
- Region R08: An evacuation of Berkeley Flats on weekdays during the day.
- Region R13: An evacuation of LBNL on weekdays during the day.

For the cases above, it is recommended that the City considers the 100th percentile ETE when making protective action decisions. For all other cases, trip generation time dictates 100th percentile ETE, and for those other cases it is recommended that the city considers the 90th percentile ETE when making protective action decisions.

Section 10 presents analysis of how evacuation times change when mobilization times are truncated, representing what would happen if evacuees got onto roadways more quickly when they receive an evacuation order. The impacts of reduced trip generation times varied across different Evacuation Regions and cases. ETEs were reduced by up to 65% in some cases. In others the reductions were smaller. In others, the ETE actually increased because the concentrated demand on the roadway network overwhelmed the system. See Section 10 for details.

Roadway Impacts from Picking up Schoolchildren

It should be noted that some parents will pick up their children from school prior to beginning their evacuation trip (see Assumption 2.a.i in Section 2.4). While the estimated trip mobilization time includes the time for parents to pick up their children prior to evacuating (see Section 5), the potential for localized congestion at schools during this process was not factored into the study. It's important to note that while the total number of evacuating vehicles remains the same,

[2] Since LBNL only has employees within the region, the mobilization of this region is 1:05, rather than 3:40 or 3:25, which is only for residents as discussed in Section 5.

the shift in trip origin from homes to schools for these evacuees could create altered congestion patterns than those represented in this study. Consequently, the Estimated Evacuation Time (ETE) could experience slight variations depending on the efficiency of parent pick-up procedures and the resulting traffic flow around school zones.

7.3.2 Region R01: Citywide Evacuation

It should be first noted that **Region R01 does not reflect a realistic emergency or disaster**. An event requiring simultaneous evacuation of all of Berkeley would have regional impacts to roadway and transportation systems that are far beyond the scope of this analysis.

Rather, Citywide evacuation was included in this document in order to stress Berkeley's roadway network to identify areas of potential traffic congestion that may not have been apparent from other evacuation cases.

Analysis Results

For a citywide evacuation, the 90th percentile ETE for midweek midday scenarios is 3 hours and 50 minutes, 3 hours for weekend middays and 2 hours and 30 minutes for nighttime scenarios, on average. The 90th percentile ETE is the highest for midweek midday scenarios because of the increased traffic demand due to employees within the city. The 90th percentile ETE is at its peak (4 hours) for fall midweek midday scenarios as schools are in session, especially UC Berkeley, compared to the summer scenarios where the school population is lower. Nighttime scenarios have the lowest 90th ETE due to the decreased numbers of employees, visitors and commuting students within the city. As mentioned before, the 100th percentile ETE is dictated by congestion for midday scenarios and trip mobilization time for nighttime scenarios. During the day, increased vehicular demand overwhelms the roadway network within the city, causing delays and increasing ETE. At night, the demand is reduced, hence, the 100th percentile ETE is dictated by when the last vehicle departs for an evacuation.

7.3.3 Region R02: 1923 Berkeley Fire Repeat

The city pursued an ETE analysis for a repeat of the 1923 Berkeley Fire. Region R02 uses the final perimeter of the fire and assigns zones to evacuation order or warning status based on the final impact of the fire. This means that the Region R02 analysis identifies the ETE if the full area of impact received evacuation warnings/orders at the same time.

Analysis Results

For Region R02, the 90th percentile ETE ranges between 1 hour and 45 minutes and 2 hours and 55 minutes. The 100th percentile ETE ranges between 3 hours and 25 minutes to 4 hours and 10 minutes. Similar to a citywide evacuation (Region R01), the variance in ETE between different scenarios is to the fluctuations in demand in different seasons, time of day, and day of the week within Berkeley. Additionally, for Region R02, there are Evacuation Warning zones around the periphery of the fire extent. The increase in shadow evacuation (50% compared to 20% in other areas) in these areas slows down vehicles leaving the zones that receive an Evacuation Order, further delaying their evacuation time.

Evacuee Experience

Figure 7-8 shows the ETE and trip generation time (mobilization time) for Region R02 Scenario 4. As discussed in Section 7.2, the distance between these curves is the average travel time experienced for an evacuee that mobilizes at a specific time after the Evacuation Order. For example, if an evacuee mobilizes 45 minutes after the Evacuation Order, it will take them approximately 65 minutes to leave the area at risk. (Find 0:45 on the x-axis, follow a straight vertical line up until it hits the red line, follow a straight horizontal line to the right until it hits the blue line, follow a straight vertical line down until it hits the x-axis; read the time and subtract 0:45 to compute the average travel time for a vehicle that departs at 0:45 after the evacuation order.)

The travel time experienced for different time periods are summarized below (the sum of these two times can be used to calculate the ETE):

- Mobilized 30 minutes after the Evacuation Order – Travel Time 40 minutes
- Mobilized 60 minutes after the Evacuation Order – Travel Time 75 minutes
- Mobilized 90 minutes after the Evacuation Order – Travel Time 80 minutes
- Mobilized 150 minutes after the Evacuation Order – Travel Time 80 minutes

7.3.4 Regions R02 and R03: Analyzing the Impacts of a Phased Fire Evacuation

The city pursued two separate ETE analyses for a repeat of the 1923 Berkeley Fire.

- As discussed above, the Region R02 analysis identifies the ETE if the full area of impact received evacuation warnings/orders at the same time.
- Region R03 uses the same fire perimeter, exploring the impact to evacuation times from issuing evacuation warnings/orders sequentially based on real-time fire spread. The zones in the fire area are assigned to phases based on historical fire spread data. The phases are a (eastern zones), b (middle zones), and c (western zones).

This analysis is designed to answer 2 questions:

- Does phasing evacuation speed or slow the overall evacuation times for the entire region affected by a repeat of the 1923 Fire?
- How does phasing the evacuation affect the evacuation times for individual evacuation zones? The fire is presumed to move from the east to the west. Even if the overall evacuation time slows with a phased evacuation, does the phased evacuation enable people nearest to the fire to more quickly get out of the way of the hazard?

Overall Analysis Results

Analysis shows that overall, phasing the evacuation of the same area increases the overall evacuation time for the area. Comparing the simultaneous (R02) and phased (R03 – phase c) evacuations, Table 7-1 reveals that the phased evacuation has an average increase of 2 hours and 15 minutes at the 90th percentile ETE across all scenarios. The extended ETE in the R03 Phased evacuation is caused by a combination of:

- The delayed evacuation order timing for Phase c: The final and westernmost area in the Region receives the evacuation order 180 minutes after Phase a; and
- A “spike” (sharp increase) in the mobilization (trip-generation rate) of evacuating vehicles. Once evacuation orders were issued for Phase a, many people in surrounding areas (phase b and c) were preparing to evacuate. Once Phase b and then c received their official evacuation warning or order, many of these evacuees were more ready to go than they would have been if they received their evacuation order/warning at the beginning of the event. This decreases the mobilization times for Phases b and c, and the associated spike in vehicles entering the roadway oversaturates evacuation routes, which increases traffic congestion and prolongs ETE.

Impacts on Areas Closest to Fire Ignition

To determine how phasing affects evacuation times for areas closest to a fire ignition (phases a and b), additional data was extracted from the simulation results for the simultaneous (R02) and phased (R03) evacuations. The results are shown in Table 7-3. They indicate that a phased evacuation approach can actually increase the ETE for those areas closest to the hazard, (phase a and phase b).

This counterintuitive phenomenon is attributable to vehicles evacuating eastward toward the fire area and into phase a and b, in an attempt to escape severe congestion further west. The model generally routes evacuating vehicles away from the hazard, but if roadways are not specifically blocked from entry, drivers may still temporarily route toward the hazard if they find a less congested roadway option. As such, evacuation times are not improved for areas closer to the fire when a phased evacuation is implemented. Details include the following:

- For Phase a, the easternmost zones closest to the fire, the 90^{th} percentile ETE increases by 10 minutes, on average, when remaining zones are phased. This increase is due to traffic from outside of Phase a entering Phase a. This traffic starts entering Phase a when the initial evacuation order is issued, as voluntary evacuees (outside of Phase a) move through the area. It continues and increases after the 90-minute mark when Phase b is instructed to evacuate.
- For central zones (Phase b), the 90^{th} percentile ETE increases by an average of 25 minutes in a phased evacuation (Region R03) compared to the corresponding phase under Region R02 (simultaneous evacuation). Combined with a longer mobilization time, the results indicate a spike in evacuating traffic that increases congestion and prolongs ETE.
- As stated above, for the western zones of impact (Phase c), the 90^{th} percentile ETE increases by 65 to 170 minutes in a phased evacuation (Region R03) compared to the simultaneous evacuation (Region R02).

These results support implementing a simultaneous evacuation, rather than a phased evacuation, in a case similar to the 1923 Fire.

<u>Evacuee Experience</u>

Simultaneous Evacuation: Discussed above in Section 7.3.3.

Phased Evacuation: shows the ETE and trip generation time (mobilization time) for Region R03 Scenario 4. The travel time experienced for different time periods are summarized below (the sum of these two times can be used to calculate the ETE):

- Mobilized 30 minutes after the Evacuation Order – Travel Time 65 minutes
- Mobilized 60 minutes after the Evacuation Order – Travel Time 110 minutes
- Mobilized 90 minutes after the Evacuation Order – Travel Time 100 minutes
- Mobilized 150 minutes after the Evacuation Order – Travel Time 60 minutes

7.3.5 Region R04: Panoramic Hills Fire

This region was selected due to the extremely limited roadway options in the Panoramic Hills area, which has one way in and out. This area is also Berkeley Fire Zone 3, reflecting the high risk to residents from its wildland-urban interface, along with its evacuation challenges.

Analysis Results

For Region R04, the 90th percentile ETE ranges between 1 hour and 35 minutes and 1 hour and 45 minutes. The 100th percentile ETE ranges between 3 hours and 25 minutes to 3 hours and 40 minutes. Due to its comparatively smaller area, Region R04 involves fewer evacuation zones than other regions. Consequently, the reduced vehicular demand on the roadway system results in congestion that clears quickly, as shown in Figure F-12 and Figure F-13. The 100th percentile ETE is primarily governed by the time required for complete mobilization.

Evacuee Experience

Figure 7-10 shows the ETE and trip generation time (mobilization time) for Region R04 Scenario 4. The figure further reinforces the fact that there is little congestion, ETE mimics trip generation, and travel times to exit the region are low. The travel time experienced for different time periods are summarized below (the sum of these two times can be used to calculate the ETE):

- Mobilized 15 minutes after the Evacuation Order – Travel Time 5 minutes
- Mobilized 30 minutes after the Evacuation Order – Travel Time 5 minutes
- Mobilized 45 minutes after the Evacuation Order – Travel Time 10 minutes
- Mobilized 90 minutes after the Evacuation Order – Travel Time 5 minutes

7.3.6 Region R05: Fire Zones 2 & 3

It is unlikely that there would be a simultaneous evacuation of Fire Zones 2 and 3 (the Berkeley hills) in association with a particular emergency or disaster. This region is included to help analyze impacts of the Berkeley Hills from administrative changes that could affect development in the area.

Analysis Results

For Region R05, the 90th percentile ETE ranges between 1 hour and 45 minutes and 2 hours and 20 minutes. The 100th percentile ETE ranges between 3 hours and 25 minutes to 3 hours and 40 minutes. Depending on the scenario, 90% of the population could mobilize within 1 hour and 30 minutes to 1 hour and 45 minutes for Region R05. This indicates the 90th percentile ETE is dictated by congestion for midday scenarios and mobilization time nighttime scenarios. The 100th percentile ETE is primarily governed by the time required for complete mobilization.

<u>Evacuee Experience</u>

Figure 7-11 shows the ETE and trip generation time (mobilization time) for Region R05 Scenario 4. The travel time experienced for different time periods are summarized below (the sum of these two times can be used to calculate the ETE):

- Mobilized 30 minutes after the Evacuation Order – Travel Time 20 minutes
- Mobilized 60 minutes after the Evacuation Order – Travel Time 40 minutes
- Mobilized 90 minutes after the Evacuation Order – Travel Time 45 minutes
- Mobilized 150 minutes after the Evacuation Order – Travel Time 35 minutes

7.3.7 Regions R06 and R07: Tsunami Warning

These regions are included to analyze areas of potential impact from a warning-level tsunami, which is the highest level of tsunami alert. Two separate regions are included in alignment with the State of California's Tsunami Evacuation Playbooks. Region R07 is the "Max Phase," including all areas of Berkeley that could be impacted by tsunami inundation. Region R06 is a slightly scaled back area limited to the zones to the east of I-80. Under select Warning-level tsunamis, State responders may be able to confirm that the tsunami's impact will be less than the worst-case scenario and may in turn be able to advise local responders to limit areas of evacuation to this narrower area represented by Region R06. Both regions are included for analysis.

<u>Analysis Results</u>

For Region R06 and R07, the 90th percentile ETE ranges between 55 minutes and 2 hours and 15 minutes. The 100th percentile ETE ranges between 3 hours and 25 minutes to 3 hours and 40 minutes. For Region R06, 90% of the evacuating traffic can mobilize within approximately 45 minutes and approximately 1 hour 30 minutes for Region R07. All 90th percentile ETE are higher than the mobilization time indicating that there is congestion within the network that dictates the 90th percentile ETE. Region R06 has two ways to exit the region: University Avenue and Frontage Road. Congestion on these two roadways delays the 90th percentile ETE by 30 minutes on average. For Region R07, there are more ways out of the area being evacuated, but there is more demand as the area under the Evacuation Order is expanded to Seventh St. As shown in Figure F-17 and Figure F-19, most of the congestion clears by 2 hours and 30 minutes for Region R06 and R07, respectively. The 100th percentile ETE is dictated by mobilization for both regions.

<u>Evacuee Experience</u>

Tsunami Warning (East of I-80): Figure 7-12 shows the ETE and trip generation time (mobilization time) for Region R06 Scenario 4. The travel time experienced for different time periods are summarized below (the sum of these two times can be used to calculate the ETE):

- Mobilized 15 minutes after the Evacuation Order – Travel Time 10 minutes
- Mobilized 30 minutes after the Evacuation Order – Travel Time 20 minutes

- Mobilized 45 minutes after the Evacuation Order – Travel Time 60 minutes
- Mobilized 60 minutes after the Evacuation Order – Travel Time 65 minutes

Tsunami Warning (Max Phase): Figure 7-13 shows the ETE and trip generation time (mobilization time) for Region R07 Scenario 4. The travel time experienced for different time periods are summarized below (the sum of these two times can be used to calculate the ETE):

- Mobilized 15 minutes after the Evacuation Order – Travel Time 5 minutes
- Mobilized 30 minutes after the Evacuation Order – Travel Time 30 minutes
- Mobilized 45 minutes after the Evacuation Order – Travel Time 65 minutes
- Mobilized 90 minutes after the Evacuation Order – Travel Time 50 minutes

7.3.8 Regions R08 through R11: Geographic Areas of Berkeley

Regions R08 through R11 are not associated with particular hazards, and instead break down Berkeley's geography into associated areas "Berkeley Flats, North Berkeley Hills," etc. These regions are included in the analysis to provide responders with details for use should a hazard without a geographic limit (such as a hazardous materials release) impact one of these areas.

<u>Analysis Results</u>

The 90th and 100th percentile ETE for these regions are as follows:

- Region R08 (Berkeley Flats)
  - 90th percentile – Between 2 hours and 5 minutes to 3 hours and 10 minutes.
  - 100th percentile – Between 3 hours and 25 to 4 hours and 20 minutes.
- Region R09 (North Berkeley Hills)
  - 90th percentile – Between 1 hour and 45 minutes to 2 hours and 10 minutes.
  - 100th percentile – Between 3 hours and 25 to 3 hours and 40 minutes.
- Region R10 (South Berkeley Hills)
  - 90th percentile – Between 1 hour and 30 minutes to 2 hours and 15 minutes.
  - 100th percentile – Between 3 hours and 25 to 3 hours and 40 minutes.
- Region R11 (West Berkeley)
  - 90th percentile – Between 1 hour and 35 minutes to 1 hour and 45 minutes.
  - 100th percentile – Between 3 hours and 25 to 3 hours and 40 minutes.

The 90th percentile ETE for these regions depends on the number of evacuating vehicles. As expected, the 90th percentile ETE for Berkeley Flats is the highest as it has the highest demand among these regions. The 100th percentile ETE is dictated by mobilization time with the exception of the Berkeley Flats (Region R08) during weekdays during the day (when employment is highest).

7.3.9 Regions R12 through R14: UC Berkeley and Lawrence Berkeley National Laboratory (LBNL)

UC Berkeley and Lawrence Berkeley National Laboratory (LBNL) zones have been included in the study as Regions R12 (UC Berkeley, including Clark Kerr Campus), R13 (LBNL) and R14 (UC Berkeley and LBNL). These Regions were established in this analysis in acknowledgement of these entities' evacuation authorities separate from the City of Berkeley. In addition, these regions were separately analyzed to understand the impacts of an evacuation limited to UC Berkeley property (Region R12), LBNL (Region R13), and UC Berkeley and LBNL together (Region R14).

Analysis Results

For UC Berkeley, the 90th percentile ETE is between 1 hour and 5 minutes to 1 hour 35 minutes. Evacuating traffic within UC Berkeley is mostly comprised of employees and college students, with a maximum mobilization time of 60 minutes (more than 90% are mobilized in 45 minutes). The 20-to-50-minute difference between the mobilization time of employees and college students, when compared against the higher 90th percentile ETE values, indicates how congestion impacts the 90th percentile ETE. The 100th percentile ETE is dictated by trip mobilization time.

LBNL experiences the lowest 90th percentile ETE (45 minutes) during weekend and nighttime scenarios. During the day, the increased numbers of shadow evacuees outside of LBNL coupled with the higher LBNL evacuee demand lead to congestion at the intersection of Gayley Rd/La Loma Ave/Hearst Ave, delaying the 90th percentile ETE for an evacuation of LBNL and resulting in ETEs as high as 2 hours during the day. This increase in ETE when compared to weekend and nighttime scenarios is attributed to the Lab's reduced operational activity and consequently lower vehicular demand during weekend and nighttime scenarios, compared to midweek and midday scenarios. The 100th percentile ETE for midday scenarios is dictated by traffic congestion at the Gayley Rd/La Loma Ave/Hearst Ave intersection. The 100th percentile ETE during the weekend and nighttime is dictated by trip mobilization time.

When LBNL and UC Berkeley evacuate together, the 90th percentile ETE ranges from 1 hour and 15 minutes to 2 hours and 15 minutes. The 100th percentile ETE for LBNL and UC Berkeley combined mimics the ETE for UC Berkeley as the mobilization (and ultimately the evacuation) of UC Berkeley dictates the ETE of the UC Berkeley plus LBNL region.

An anomaly can be seen when inspecting Region R12 and R14 in Table 7-1. One might expect the 90th percentile ETE for UC Berkeley evacuating by itself (R12) to be shorter than the 90th percentile ETE for UC Berkeley and LBNL evacuating (R14). As shown in Table 7-1, there is one case where this is not true (Scenario 3). This is a result of the composition of vehicular demand within each of these evacuating regions. LBNL is purely made up of employees. UC Berkeley has employees, commuting students, and residents within its zones. When more quickly mobilizing vehicles (LBNL employees) are added in, the 90th percentile ETE can be reached more quickly, in the absence of traffic congestion from external traffic (during Scenario 3).

This anomaly, however, cannot be seen (and is not possible) at the 100th percentile. Figure 7-14 shows the ETE and trip generation time (mobilization time) for an LBNL evacuation, during fall, midweek, midday (Region R13 Scenario 4). The travel times experienced for different time periods are summarized below (the sum of these two times can be used to calculate the ETE):

- Mobilized 15 minutes after the Evacuation Order – Travel Time 15 minutes
- Mobilized 30 minutes after the Evacuation Order – Travel Time 50 minutes
- Mobilized 45 minutes after the Evacuation Order – Travel Time 80 minutes
- Mobilized 60 minutes after the Evacuation Order – Travel Time 75 minutes

7.4 ETE for Response Planning

Table 7-4 summarizes the ETE values recommended for use in response plans based on the analysis of this report.

Per US NRC recommendation, the table presents 90th percentile ETE, except when marked with an asterisk (*). Entries with an asterisk are 100th percentile ETE. In these cases, traffic congestion dictates ETE, meaning that the 100th percentile is more appropriate for planning purposes (see Section 7.3).

Rows marked "Urgent Mobilization" present ETEs expected when evacuees mobilize more quickly (30 minutes) than would be predicted from responses to the Demographic Survey (Appendix D). These times were identified through the Sensitivity Study for Evacuation Readiness, described in detail in Section 10.1. These times are associated with no-notice evacuations, such as active wildfires in close proximity to the city.

7.5 Guidance on Using ETE Tables

The user first determines the percentile of population for which the ETE is sought (federal guidance for nuclear emergencies calls for the 90th percentile). The applicable value of ETE within the chosen table may then be identified using the following procedure:

1. Identify the applicable **Scenario** (Table 6-4):
   - Season
     - Summer
     - Fall
   - Day of Week
     - Midweek
     - Weekend
   - Time of Day
     - Midday
     - Nighttime

While these Scenarios are designed, in aggregate, to represent conditions throughout the year, some further clarification is warranted:

- The seasons are defined as follows:
  - Summer assumes that public schools are not in session.
  - Fall considers that public schools are in session.
- Time of Day: Midday implies the time over which most commuters are at work or are travelling to/from work.

2. With the desired percentile ETE and Scenario identified, now identify the **Evacuation Region**:
   - Determine which Region is evacuating using Table 6-1:
3. Determine the **ETE Table** based on the **percentile** selected (Table 7-1 or Table 7-2**.** Then, for the **Scenario** identified in Step 1 and the **Region** identified in Step 2, proceed as follows:
   - The columns of Table 7-1 and Table 7-2 are labeled with the Scenario numbers. Identify

the proper column in the selected Table using the Scenario number defined in Step 1.

- Identify the row in this table that provides ETE values for the Region identified in Step 2.
- The unique data cell defined by the column and row so determined contains the desired value of ETE expressed in Hours:Minutes.

Example

To identify the ETE for the following conditions:

- Wednesday, October 14th at 12:00 PM.
- The hazard threatens the North Berkeley Hills.
- The desired ETE is that of an evacuation of 90 percent of the population from within the impacted Region.

Table 7-1 is applicable because the 90th percentile ETE is desired. Proceed as follows:

1. Identify the Scenario as fall, midweek, midday conditions. Entering Table 6-4 (or Table 7-1), it is seen that this combination of circumstances describes Scenario 4.
2. In Table 6-1, locate the Region that has North Berkeley Hills: Region R09.
3. In Table 7-1 (90th percentile ETE table), locate the data cell containing the value of ETE for Scenario 4 and Region R09. This data cell is in column (4) and in the row for Region R09; it contains the ETE value of 2 hours and 5 minutes.

Table 7-1. Time to Clear the Indicated Area of *90* Percent of the Affected Population

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Region	**Midday**	**Midday**	**Nighttime**	**Midday**	**Midday**	**Nighttime**
R01 - Citywide Evacuation	3:40	3:10	2:30	4:00	2:55	2:30
R02 - Fire 1923	2:25	1:50	1:45	2:55	1:50	1:45
R03 - Fire 1923 Phase a	2:05	1:40	1:40	2:45	1:35	2:10
R03 - Fire 1923 Phase b	2:15	2:00	2:15	2:45	2:10	2:30
R03 - Fire 1923 Phase c	4:10	4:20	4:30	4:00	4:25	4:35
R04 - Panoramic Hill Fire	1:40	1:35	1:40	1:45	1:35	1:40
R05 - Fire Zones 2 & 3 Combined	2:05	1:55	1:45	2:20	1:55	1:45
R06 - Tsunami - Phase 3	1:20	1:20	1:05	1:45	0:55	1:10
R07 - Tsunami - Max Phase	2:15	2:10	1:50	2:15	2:05	1:50
R08 - Berkeley Flats	2:55	2:35	2:10	3:10	2:25	2:05
R09 - North Berkeley Hills	2:10	2:00	1:50	2:05	1:50	1:45
R10 - South Berkeley Hills	1:35	1:30	1:35	2:15	1:35	1:35
R11 - West Berkeley	1:40	1:35	1:35	1:45	1:35	1:35
R12 - UC Berkeley	1:05	1:15	1:25	1:20	1:30	1:35
R13 - Lawrence Berkeley National Lab	1:15	0:45	0:45	2:00	0:45	0:45
R14 - UC Berkeley + Lawrence Berkeley National Lab	1:30	1:15	1:20	2:15	1:30	1:35

Table 7-2. Time to Clear the Indicated Area of *__100__* Percent of the Affected Population

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)
Region	**Midday**	**Midday**	**Nighttime**	**Midday**	**Midday**	**Nighttime**
R01 - Citywide Evacuation	5:10	4:25	3:25	5:35	4:00	3:25
R02 - Fire 1923	3:40	3:25	3:25	4:10	3:25	3:25
R03 - Fire 1923 Phase a	4:25	4:30	4:40	4:30	4:15	4:35
R03 - Fire 1923 Phase b	6:10	5:55	6:00	6:15	6:00	6:10
R03 - Fire 1923 Phase c	6:20	6:20	6:20	6:20	6:20	6:20
R04 - Panoramic Hill Fire	3:40	3:25	3:25	3:40	3:25	3:25
R05 - Fire Zones 2 & 3 Combined	3:40	3:25	3:25	3:40	3:25	3:25
R06 - Tsunami - Phase 3	3:40	3:25	3:25	3:40	3:25	3:25
R07 - Tsunami - Max Phase	3:40	3:25	3:25	3:40	3:25	3:25
R08 - Berkeley Flats	4:10	3:25	3:25	4:20	3:25	3:25
R09 - North Berkeley Hills	3:40	3:25	3:25	3:40	3:25	3:25
R10 - South Berkeley Hills	3:40	3:25	3:25	3:40	3:25	3:25
R11 - West Berkeley	3:40	3:25	3:25	3:40	3:25	3:25
R12 - UC Berkeley	3:40	3:25	3:25	3:40	3:25	3:25
R13 - Lawrence Berkeley National Lab	1:25	1:05	1:05	2:15	1:05	1:05
R14 - UC Berkeley + Lawrence Berkeley National Lab	3:40	3:25	3:25	3:40	3:25	3:25

Table 7-3. Time to Clear the Indicated Area of *__90__* Percent of the Affected Population for 1923 Fire Repeat

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)
Region	**Midday**	**Midday**	**Nighttime**	**Midday**	**Midday**	**Nighttime**
R02 Phase a	2:00	1:35	1:25	2:45	1:35	1:40
R03 Phase a	2:05	1:40	1:40	2:45	1:35	2:10
R02 Phase b	2:15	1:45	1:35	2:40	1:40	1:30
R03 Phase b	2:15	2:00	2:15	2:45	2:10	2:30
R02 Phase c	2:25	1:50	1:45	2:55	1:50	1:45
R03 Phase c	4:10	4:20	4:30	4:00	4:25	4:35

Table 7-4. Time to Clear the Indicated Area for Response Planning

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	**1**	**2**	**3**	**4**	**5**	**6**
Region	**Midday**	**Midday**	**Nighttime**	**Midday**	**Midday**	**Nighttime**
R01 - Citywide Evacuation	5:10*	4:25*	2:30	5:35*	4:00*	2:30
R02 - Fire 1923	2:25	1:50	1:45	4:10*	1:50	1:45
R02 - Fire 1923 Urgent Mobilization	*2:25*	*1:50*	*1:35*	*4:10**	*1:45*	*1:35*
R03 - Fire 1923 Phase a	4:25*	4:30*	1:40	4:30*	4:15*	2:10
R03 - Fire 1923 Phase a Urgent Mobilization	*2:30**	*2:10**	*1:25*	*3:30**	*2:10**	*1:35*
R03 - Fire 1923 Phase b	6:10*	5:55*	2:15	6:15*	6:00*	2:30
R03 - Fire 1923 Phase b Urgent Mobilization	*4:00**	*4:00**	*1:40*	*4:00**	*2:10**	*1:40*
R03 - Fire 1923 Phase c	4:10	4:20	4:30	4:00	4:25	4:35
R03 - Fire 1923 Phase c Urgent Mobilization	*3:35*	*3:45*	*1:40*	*3:50*	*1:30*	*1:40*
R04 - Panoramic Hill Fire	1:40	1:35	1:40	1:45	1:35	1:40
R04 - Panoramic Hill Fire Urgent Mobilization	*1:05*	*0:50*	*0:45*	*1:45*	*0:50*	*0:50*
R05 - Fire Zones 2 & 3 Combined	2:05	1:55	1:45	2:20	1:55	1:45
R06 - Tsunami - Phase 3	1:20	1:20	1:05	1:45	0:55	1:10
R07 - Tsunami - Max Phase	2:15	2:10	1:50	2:15	2:05	1:50
R08 - Berkeley Flats	4:10*	2:35	2:10	4:20*	2:25	2:05
R09 - North Berkeley Hills	2:10	2:00	1:50	2:05	1:50	1:45
R10 - South Berkeley Hills	1:35	1:30	1:35	2:15	1:35	1:35
R11 - West Berkeley	1:40	1:35	1:35	1:45	1:35	1:35
R12 - UC Berkeley	1:05	1:15	1:25	1:20	1:30	1:35
R13 - Lawrence Berkeley National Lab	1:25*	0:45	0:45	2:15*	0:45	0:45
R14 - UC Berkeley + Lawrence Berkeley National Lab	1:30	1:15	1:20	2:15	1:30	1:35

[*] Entries with an asterisk are 100th percentile ETE. All other ETE presented in Table 7-4 are the 90th percentile ETE.

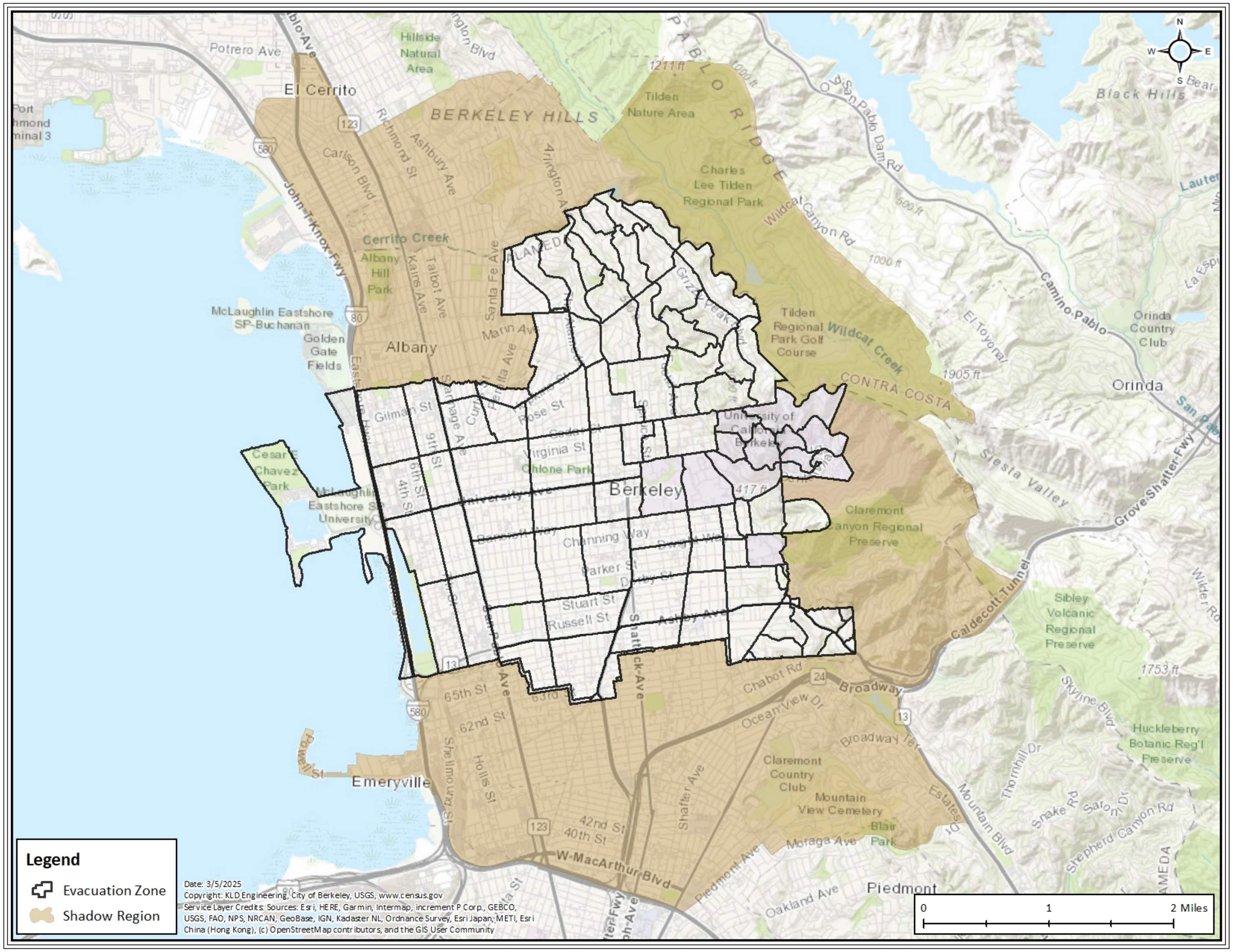


Figure 7-1. Study Area Shadow Region

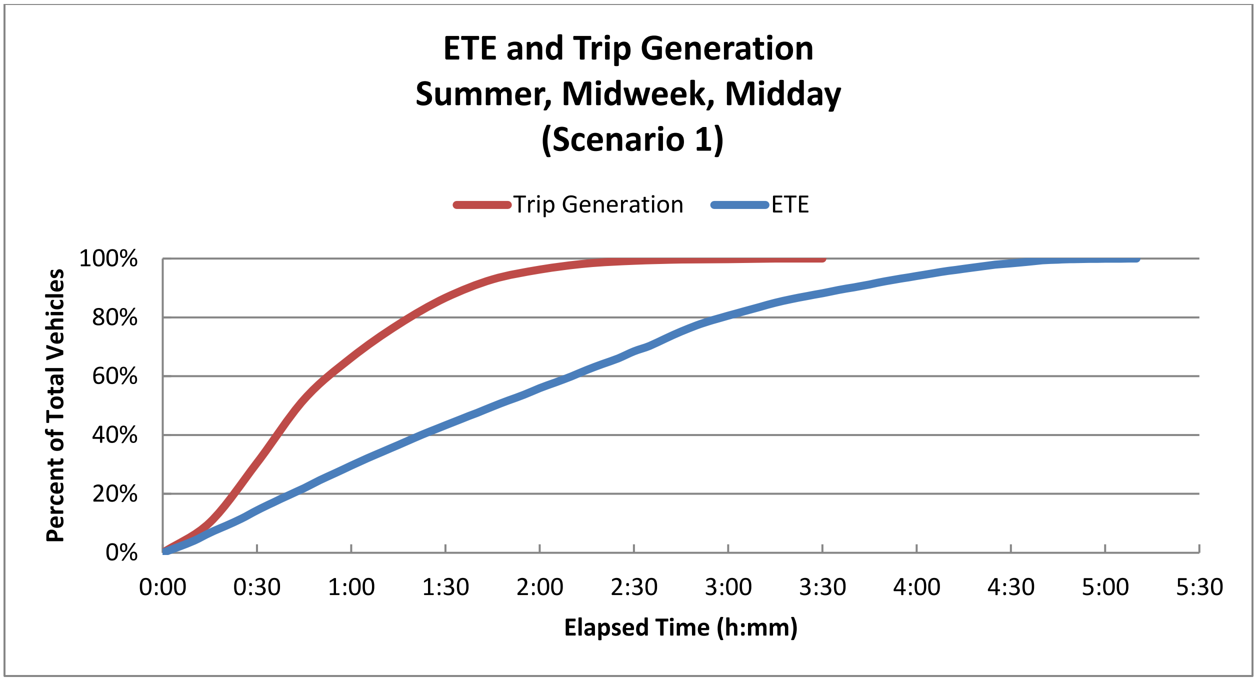


Figure 7-2. Evacuation Time Estimates - Scenario 1 for Region R01

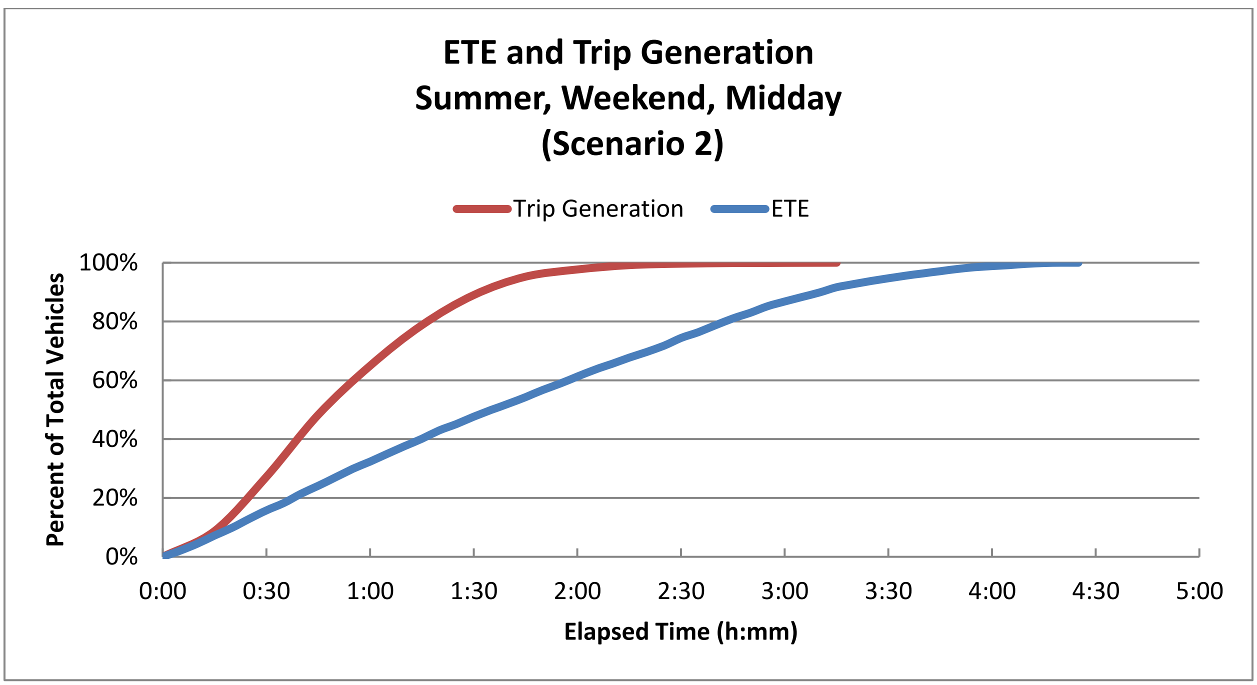


Figure 7-3. Evacuation Time Estimates - Scenario 2 for Region R01

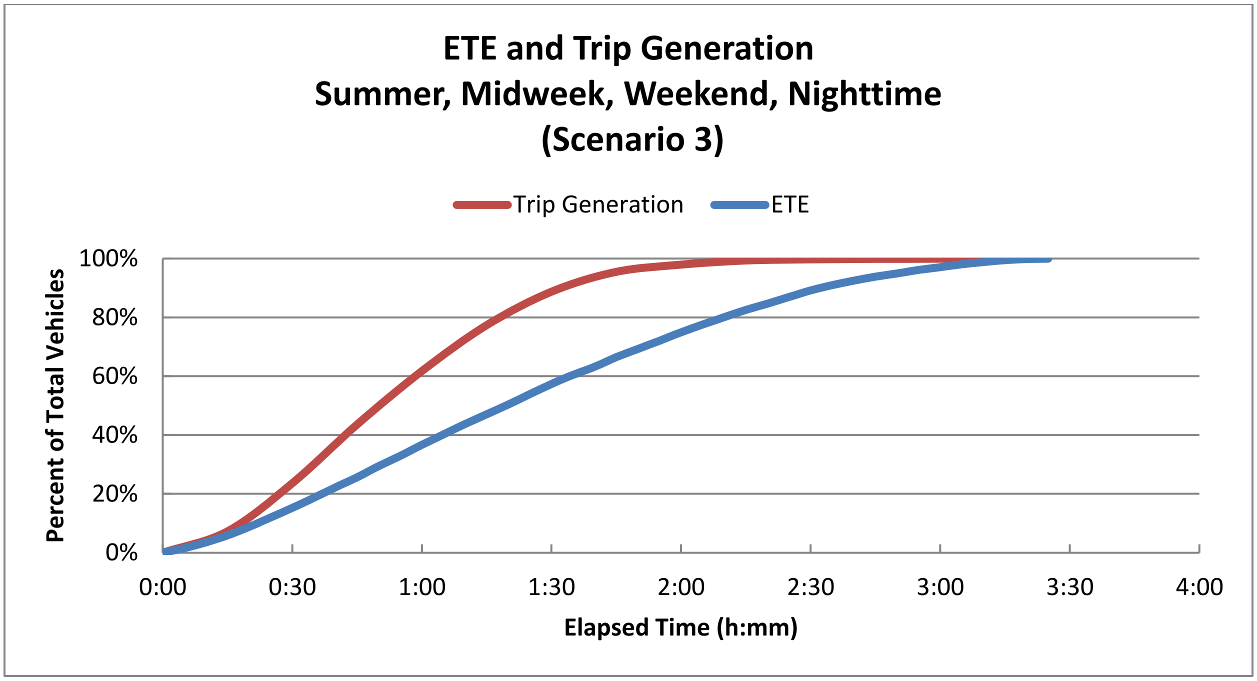


Figure 7-4. Evacuation Time Estimates - Scenario 3 for Region R01

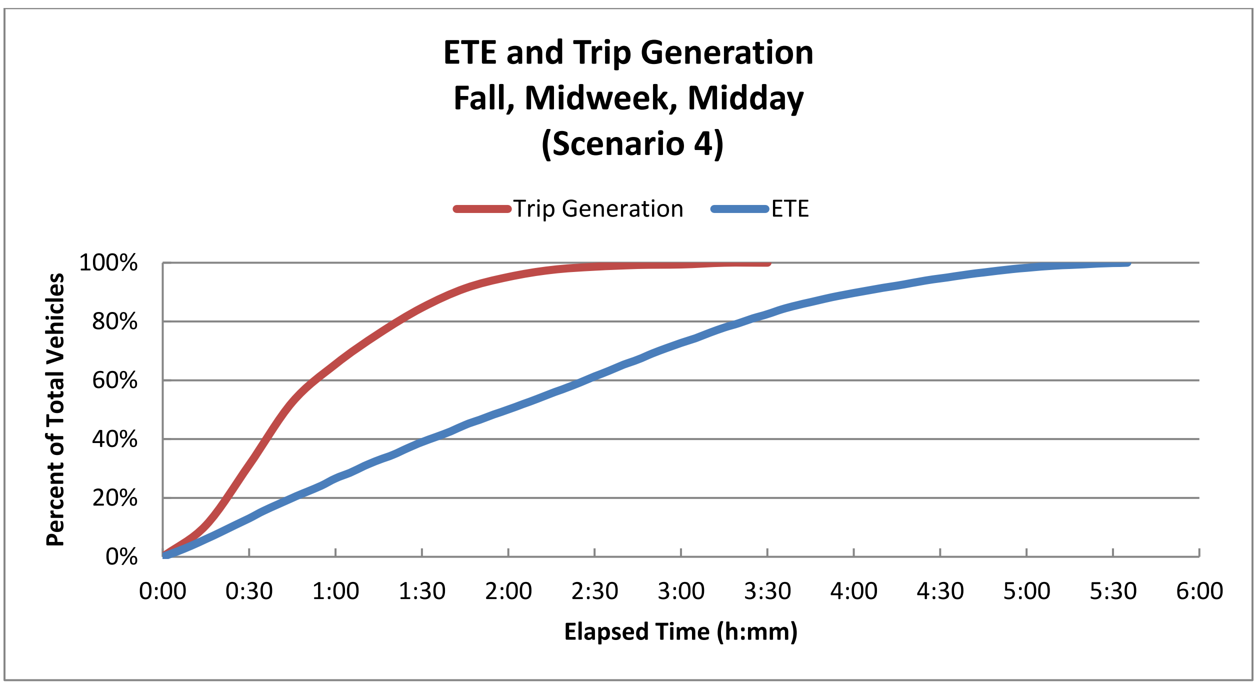


Figure 7-5. Evacuation Time Estimates - Scenario 4 for Region R01

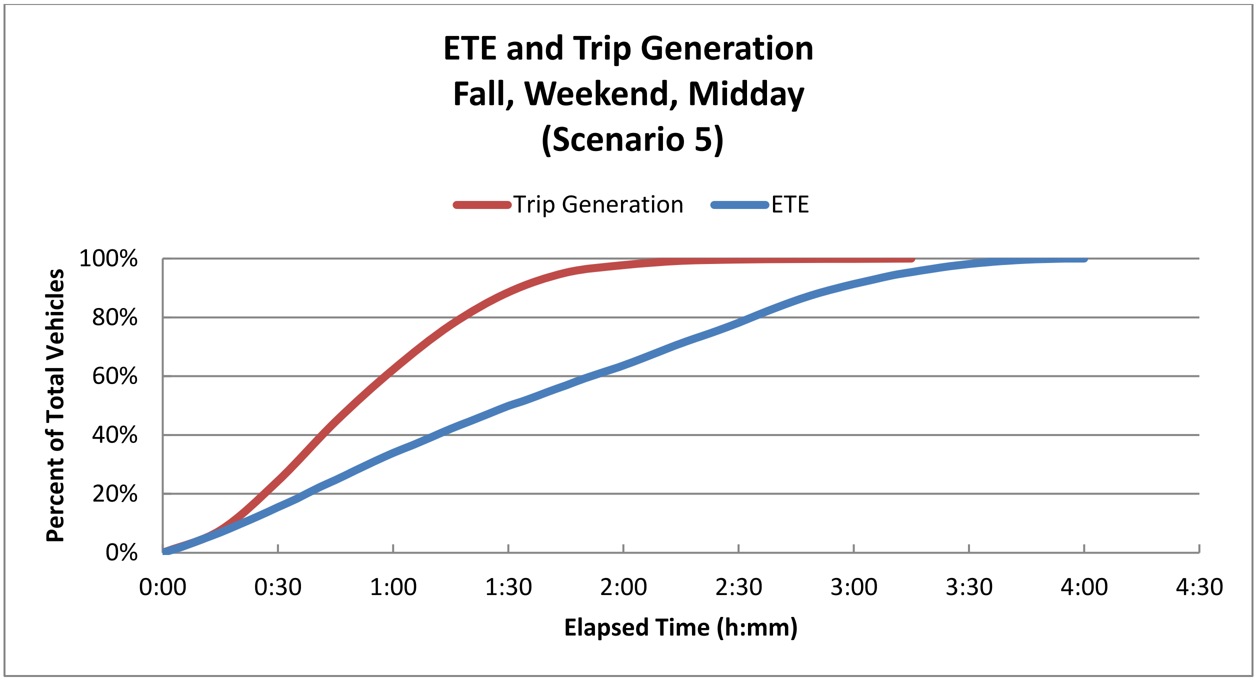


Figure 7-6. Evacuation Time Estimates - Scenario 5 for Region R01

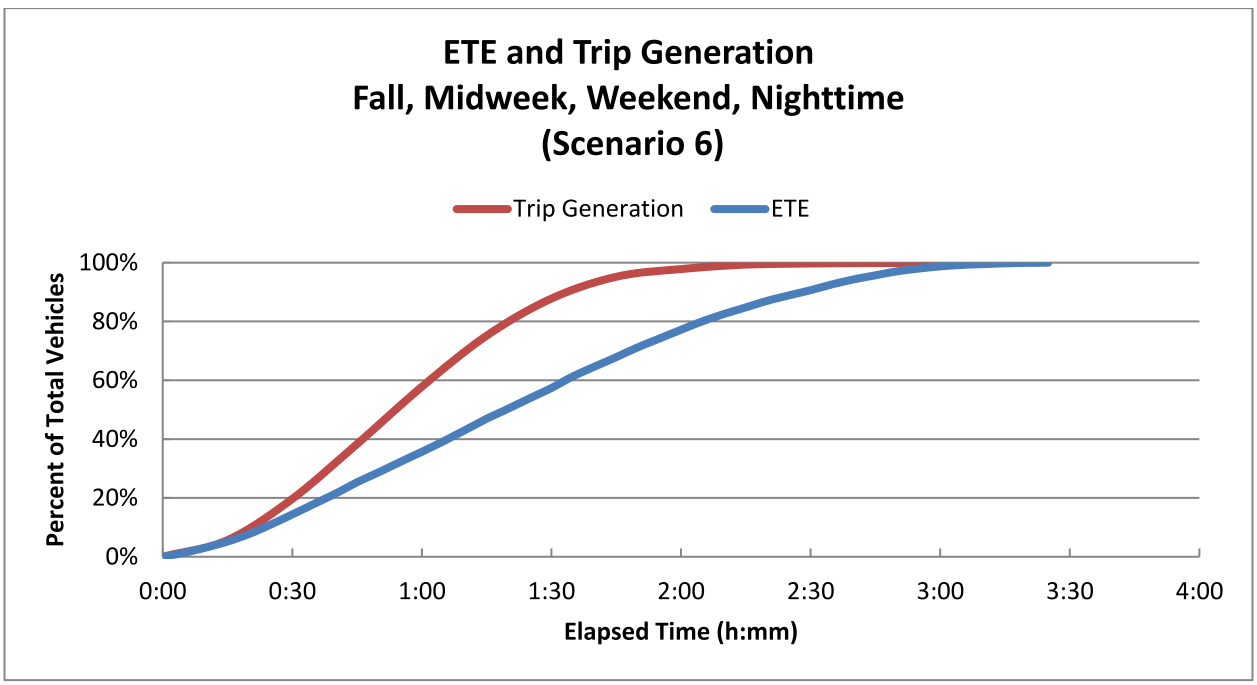


Figure 7-7. Evacuation Time Estimates - Scenario 6 for Region R01

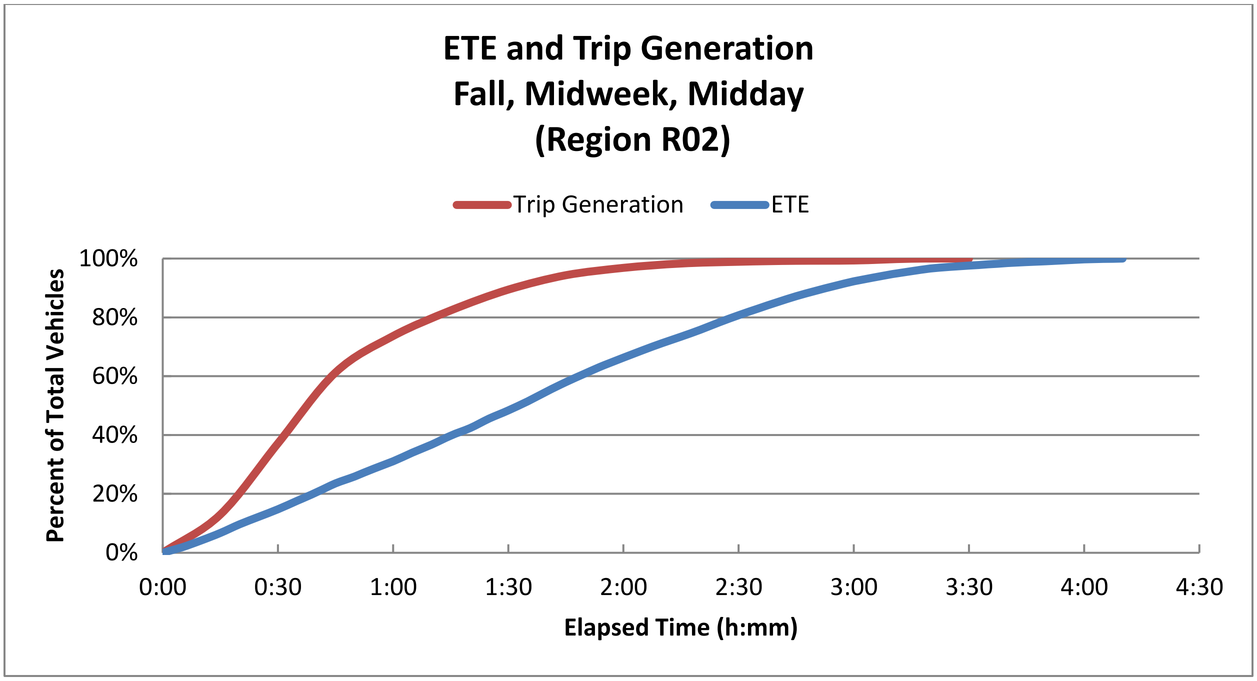


Figure 7-8. Evacuation Time Estimates - Scenario 4 for Region R02

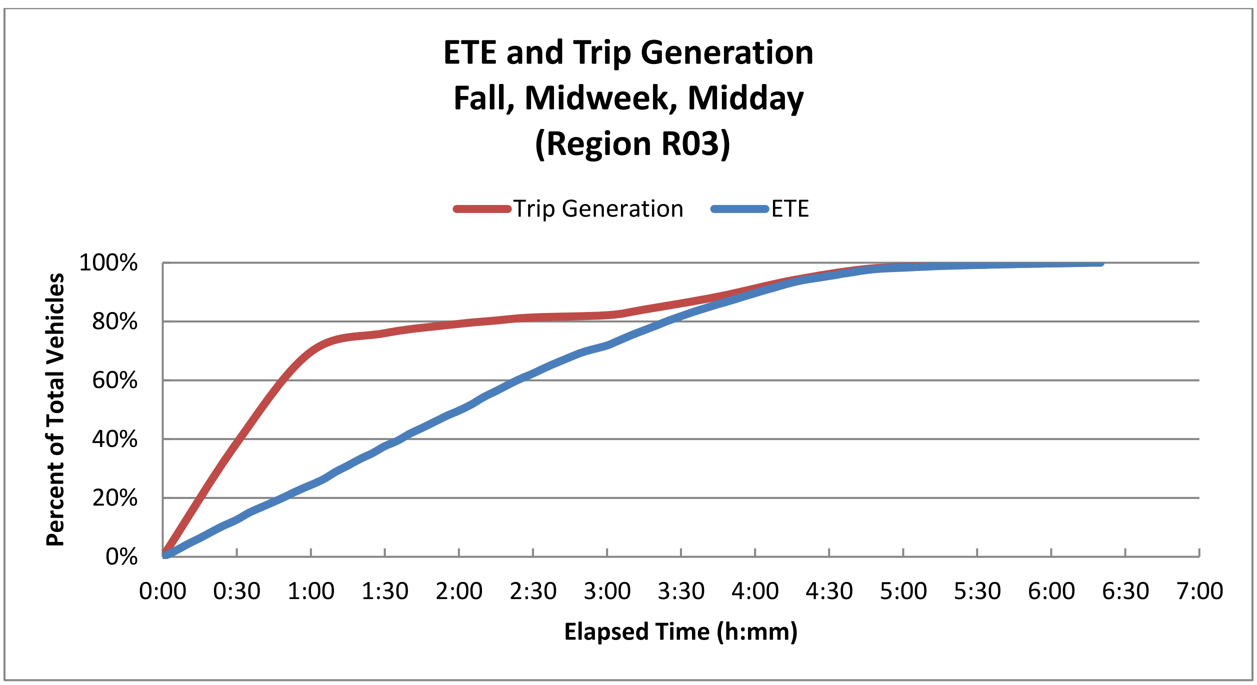


Figure 7-9. Evacuation Time Estimates - Scenario 4 for Region R03

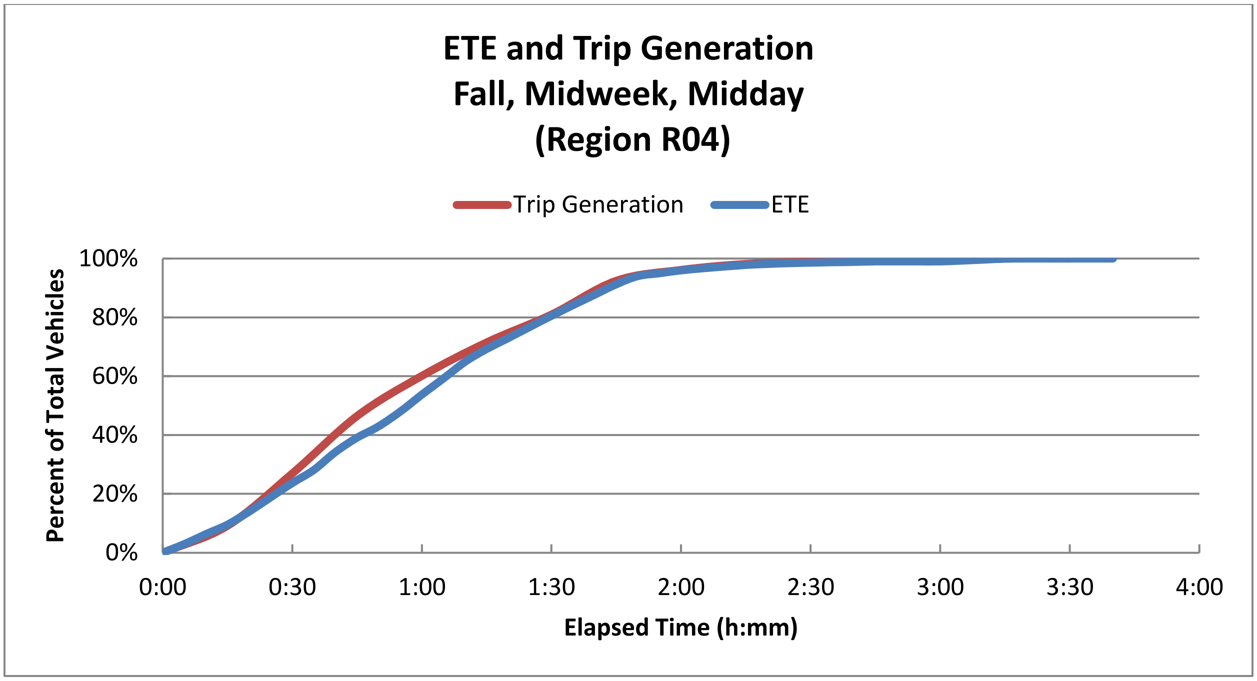


Figure 7-10. Evacuation Time Estimates - Scenario 4 for Region R04

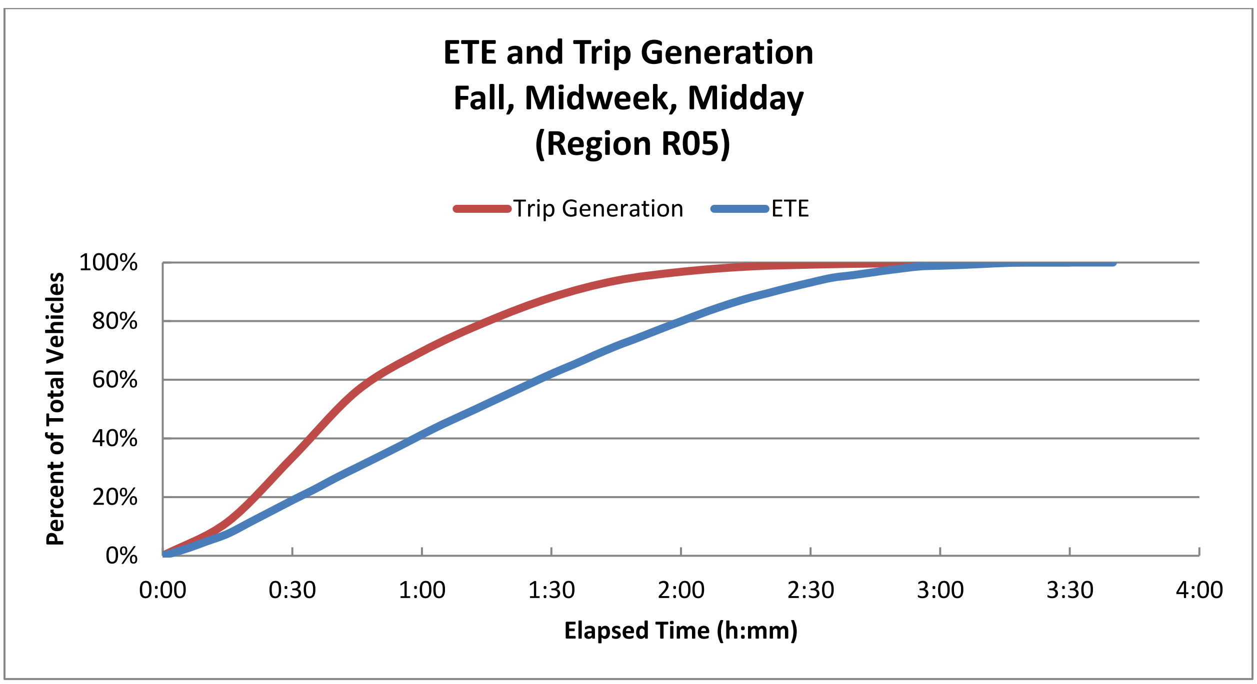


Figure 7-11. Evacuation Time Estimates - Scenario 4 for Region R05

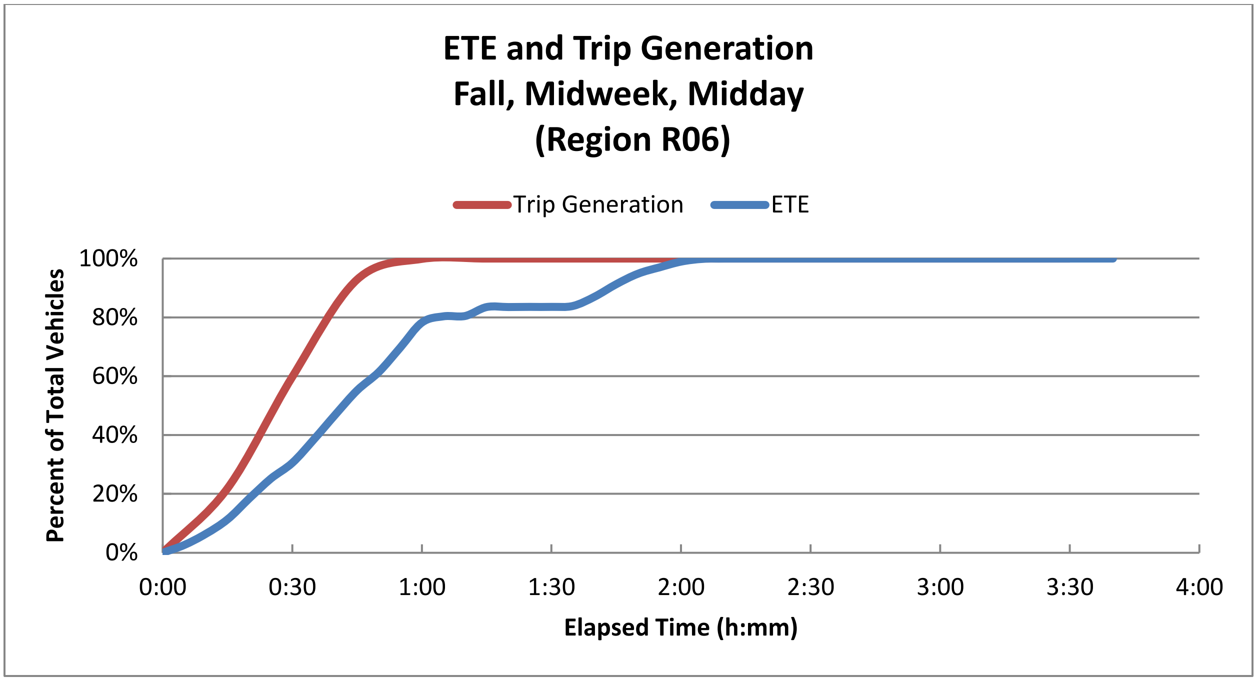


Figure 7-12. Evacuation Time Estimates - Scenario 4 for Region R06

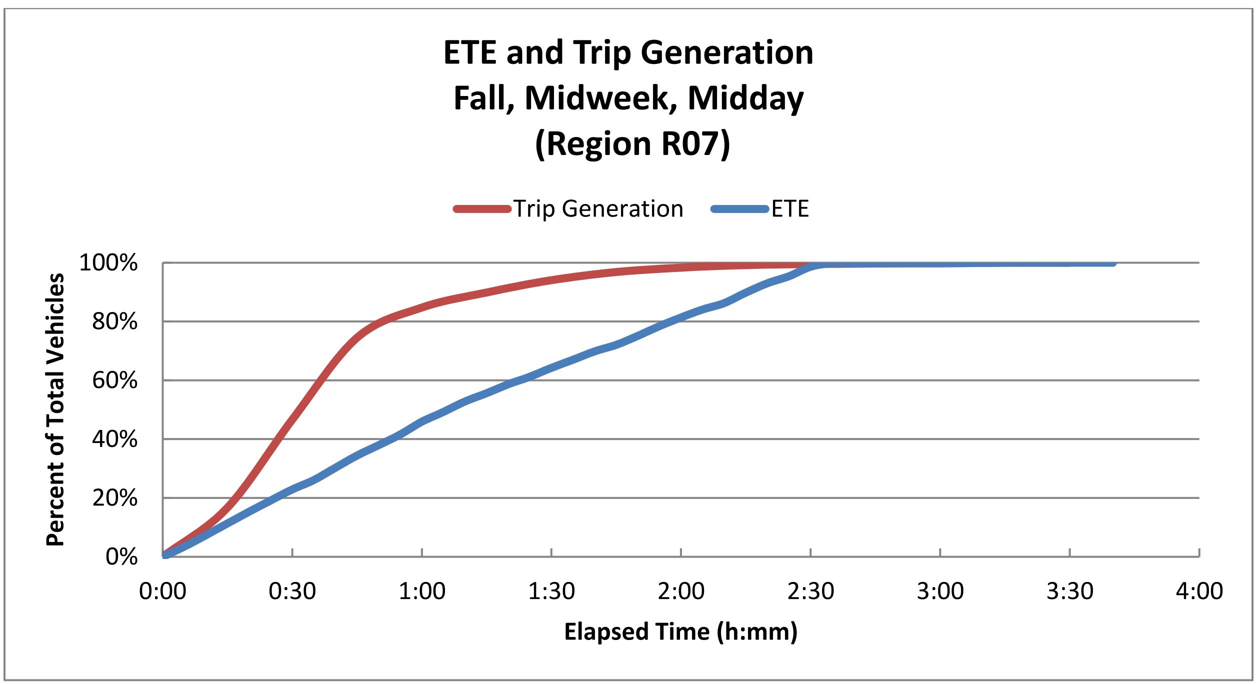


Figure 7-13. Evacuation Time Estimates - Scenario 4 for Region R07

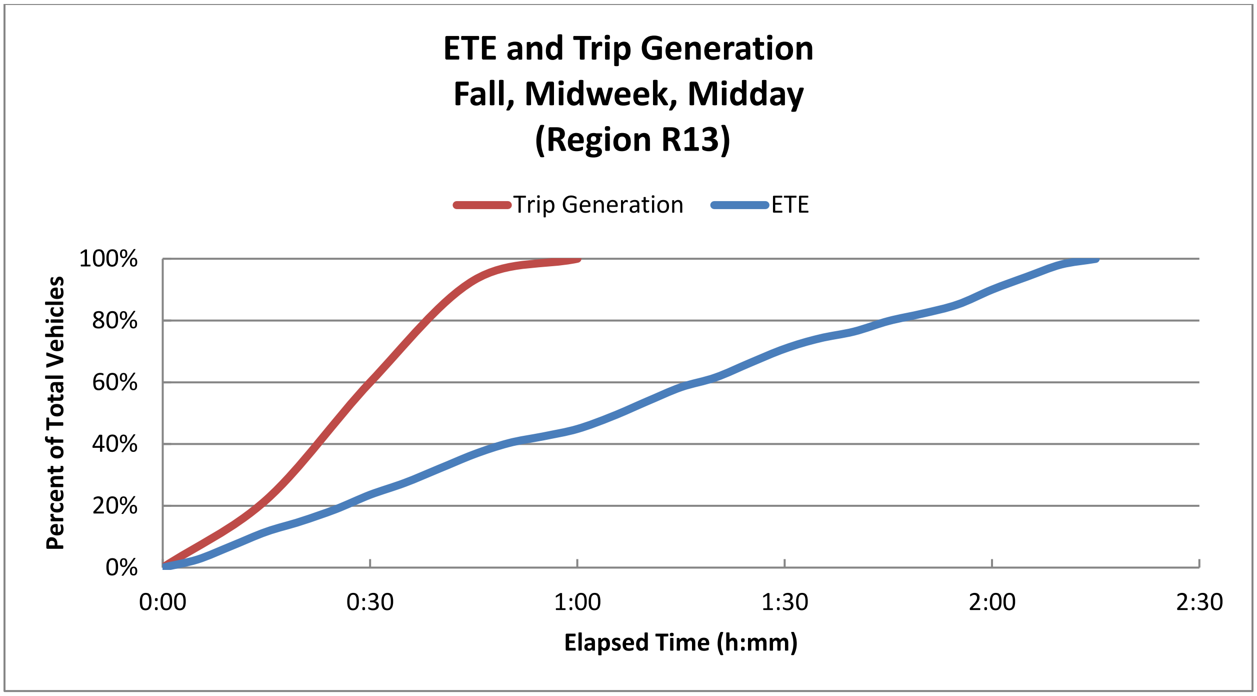


Figure 7-14. Evacuation Time Estimates - Scenario 4 for Region R13

8 TRANSIT-DEPENDENT AND SPECIAL FACILITY EVACUATION ACTIVITIES

This section details the analyses applied and the results obtained in the form of evacuation time estimates for transit vehicles. The demand for transit services reflects the needs of three population groups:

- residents with no vehicles available;
- residents of special facilities (i.e., schools, preschools/day care centers, colleges/universities, and medical facilities); and
- transit-dependent visitors and employees.

These transit vehicles mix with the general evacuation traffic that is comprised mostly of "passenger cars" (pc's). The presence of each transit vehicle in the evacuating traffic stream is represented within the modeling paradigm as equivalent to two pc's. This equivalence factor represents the longer size and more sluggish operating characteristics of a transit vehicle, relative to those of a pc.

Transit vehicles must be mobilized in preparation for their respective evacuation missions. Specifically:

- Drivers must be alerted
- They must travel to the depot
- They must be briefed there and assigned to a route or facility.

These activities consume time. In the absence of standards or studies, for the purposes of this analysis, it is assumed that bus mobilization time will average approximately 90 minutes extending from the evacuation order to the time when buses first arrive at schools/preschools/day care centers, colleges/universities, or medical facilities, and 180 minutes for the transit dependent population (see Section 2.4). It is noted that the bus mobilization time can expand or contract based on available resources and the situation regionally (for example, if regional resources are being requested by multiple jurisdictions).

During this mobilization period, other mobilization activities are taking place. One of these is the action taken by parents, neighbors, relatives and friends to pick up children from school prior to the arrival of buses, so that they may join their families. Virtually all studies of evacuations have concluded that this "bonding" process of uniting families is universally prevalent during emergencies and should be anticipated in the planning process. As discussed in Section 2, this study assumes that some children will likely be picked up by parents or guardians prior to an evacuation and that the time to perform this activity is included in the trip generation times discussed in Section 5. This report provides estimates of buses under the assumption 83% of children at schools and preschools/day care centers will be picked up by their parents based on the results of the demographic survey.

The procedure for computing transit dependent ETE is to:

- Estimate demand for transit service
- Estimate time to perform all transit functions
- Estimate route travel times out of the area at risk.

These procedures were done for Citywide Evacuation (Region R01), Fire 1923 (Regions R02 and R03), Panoramic Hill Fire (Region R04), Fire Zone 2 & 3 (Region R05), Tsunami Phase 3 (Region R06), and Tsunami Max Phase (Region R07). A fall midway midweek scenario was selected for this analysis as it represents the highest vehicular demand.

8.1 Analysis of Resource Needs for Each Evacuation Region

Table 8-1 summarizes the number of vehicles needed to evacuate schools, preschools/day care centers, colleges/universities, medical facilities, and the transit-dependent population[1] for different Regions. For an evacuation of the entire City, 10,683 people would utilize rail services, people would rely on 586 buses, 259 wheelchair accessible vehicles and 148 ambulances. For the other regions considered, approximately 40% or less of these resources are needed, the second highest demand being the 1923 Fire region (Region R02) and lowest being Tsunami Phase 3 region (Region R06).

The City can work to quantify likely resource shortfalls associated with the evacuation scenarios in this report through planning partnerships with transit providers serving Berkeley and the region, as well as emergency management and mutual aid partners at the Operational Area (County) and State. Section 8 identifies resource needs for transit-dependent evacuees. Planning partners can clarify regional and State capacity to provide support, as well as time estimates to mobilize those resources in localized and regional disaster scenarios.

8.2 Evacuation Activities for Transit Dependent Population Groups

Figure 8-1 presents the chronology of events relevant to transit operations. The elapsed time for each activity will now be discussed with reference to Figure 8-1.

<u>Activity: Mobilize Drivers (A→B→C)</u>

Mobilization is the elapsed time from the Evacuation Order until the time buses arrive at the facility to be evacuated or first bus stop along a pickup route. It is assumed that for a rapidly escalating emergency with no observable indication before the fact, drivers would likely require 90 minutes to be contacted, to travel to the depot, be briefed, and to travel to the route for the special facilities[2]. It is assumed this process takes 180 minutes for transit dependent individuals,

[1] It was conservatively assumed that all transit dependent residents would utilize buses to evacuate, rather than rapid transit. This assumption provides an upper bound of the number of vehicles that would be needed to evacuate this population. It also provides a more conservative evacuation time estimate for those with and without their own vehicles since it results in more evacuating vehicles on the roadway (rather than utilizing rapid transit vehicles that have their own dedicated railway). It was assumed that visitors who would need transit assistance would be split 50/50 between buses and rail to evacuate. It was assumed that employees who would need transit assistance would be split 58/42 between buses and rail to evacuate, based on results of the demographic survey (see Figure D-8).

[2] The special facilities considered within the study area are schools, preschools/day care centers, colleges/universities and medical facilities.

including residents, employees, and visitors to utilize public transit buses, see Assumption 4b in Section 2.4.

Activity: Board Passengers (C→D)

A loading time of 15 minutes is assumed for buses servicing schools, preschools/day care centers and colleges/university. Loading times of 1 minute, 5 minutes, and 30 minutes per patient are assumed for ambulatory patients, wheelchair using patients, and bedridden patients, respectively. A loading time of 1 minute per person is used for the general transit dependent population. Concurrent loading on multiple vehicles is assumed.

For multiple stops along a pick-up route (transit-dependent bus routes) estimation of travel time must allow for the delay associated with stopping and starting at each pick-up point. The time, t, required for a bus to decelerate at a rate, "a", expressed in ft/sec/sec, from a speed, "v", expressed in ft/sec, to a stop, is t = v/a. Assuming the same acceleration rate and final speed following the stop yields a total time, T, to service boarding passengers:

$$T = t + B + t = B + 2t = B + \frac{2v}{a},$$

Where B = Dwell time to service passengers. The total distance, "s" in feet, travelled during the deceleration and acceleration activities is: $s = v^2/a$. If the bus had not stopped to service passengers, but had continued to travel at speed, v, then its travel time over the distance, s, would be: s/v = v/a. Then the total delay (i.e. pickup time, P) to service passengers is:

$$P = T - \frac{v}{a} = B + \frac{v}{a}$$

Assigning reasonable estimates:

- B = 50 seconds: a generous value for a single passenger, carrying personal items, to board per stop
- v = 25 mph = 37 ft/sec
- a = 4 ft/sec/sec, a moderate average rate

Then, P ≈ 1 minute per stop. Allowing 30 minutes of pick-up time per bus run implies 30 stops per run.

Activity: Travel Time to Safety (D→E)

Mobilizing buses, wheelchair accessible vans and ambulances and loading them with transit dependent individuals take time. Unlike other population groups, transit dependent individuals need to wait for these two events to take place before they can start their evacuation trip. The total time to complete these events is as follows:

- Schools/Preschools/Colleges – 105 minutes (90 minutes to mobilize resources and 15 minutes of loading time)
- Transit-Dependent Population – 210 minutes (180 minutes to mobilize resources and 30 minutes of loading time)
- Medical Facilities:
  - Ambulatory Patients – 120 minutes (90 minutes to mobilize resources and 30

minutes max loading time per vehicle)
    - Wheelchair Bound Patients – 100 minutes (90 minutes to mobilize resources and 10 minutes max loading time per vehicle)
    - Bedridden Patients – 150 minutes (90 minutes to mobilize resources and 60 minutes max loading time per vehicle)
- Access and/or Functional Needs Population: The mobilization of buses for Access and/or Functional needs population is the same as transit-dependent population (180 minutes) but the loading time depends on the number of stops the resources need to make which vary for each Region.

As discussed in Section 7.3, the difference between the trip generation and ETE curves provides the average travel time for a specific departure time. Plots of trip generation versus ETE are indicative of the level of traffic congestion during evacuation. The travel time to safety activity can only start after the resources for the transit-dependent individuals leave the facility being evacuated and/or when buses complete all their stops for the transit-dependent population.

The trip generation versus ETE plots in Section 7 can be used to estimate the travel time for each transit dependent population group for specific Regions depending on when the transportation resources are mobilized, and passengers are loaded.

For example: Using Figure 7-8, the evacuation time out of the Fire 1923 region can be computed as the sum of time associated with Activities A→B→C, C→D, and D→E as follows:

- Schools/Preschools/Colleges – 90 + 15 + 80 = 190 minutes or 3:10 (Here, 80 minutes is the difference of the ETE curve and the trip generation curve at 105 minutes (1:45) into the evacuation. First find 1:45 on the x axis; follow a straight line up to when it hits the red curve; estimate the percentage of evacuating demand [about 94%]; follow a straight line to when the blue curve reaches 94% [3:10]; the travel time is the distance between these two curves = 3:10 – 1:45 = 80 minutes.)
- Transit-Dependent Population – 180 + 30 + 40 = 250 minutes or 4:10
- Medical Facilities:
    - Ambulatory Patients – 90 + 30 + 85 = 205 minutes or 3:25
    - Wheelchair Bound Patients – 90 + 10 + 80 = 180 minutes or 3:00
    - Bedridden Patients – 90 + 60 + 75 = 225 minutes or 3:45
- Access and/or Functional Needs:
    - Ambulatory People – 180 + 45 + 25 = 250 minutes or 4:10
    - Wheelchair Bound People – 180 + 45 + 25 = 250 minutes or 4:10
    - Bedridden People – 180 + 50 + 20 = 250 minutes or 4:10

This methodology could be applied to all the facilities and population groups shown in Appendix H for Region R02 for a more *facility-specific* ETE.

It should be noted that ETE for schools can vary slightly depending on the efficiency of parent pick-up procedures and the resulting traffic flow around school zones.

8.3 Public Transit Evacuation

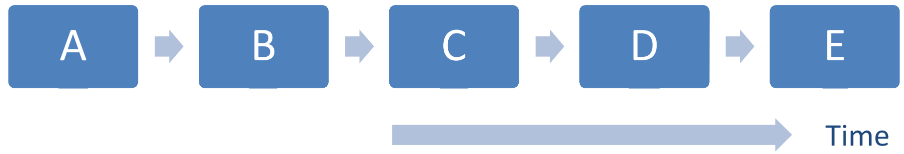
The demand that relies on public transit – both bus service and rail (Bay Area Rapid Transit or Amtrak) should be evaluated against those resources. The scope of this study is limited to vehicular evacuation and does not integrate evacuation time estimates for people evacuating on rapid transit (rail).

Table 8-1. Summary of Transportation Needs

Transportation Resource	Rail	Buses	Wheelchair Accessible Vans	Ambulances
Resources Needed (Citywide - Region R01)				
School and Preschool/Day Care Center Transportation Needs (Table 3-7):	0	112	0	0
College/University Transportation Needs (Table 3-8):	255 (people)	125	0	0
Medical Facility Transportation Needs (Table 3-6):	0	20	111	128
Specialized Transportation Assistance Needs (Section 3.8):	0	0	50	125
Transit-Dependent Transportation Needs (Section 3.7 and Table 3-9):	0	115	0	0
Employee Transportation Needs (Section 3.4 and Table 3-10):	3,799 (people)	88	0	0
Visitor Transportation Needs (Section 3.4 and Table 3-10):	6,629 (people)	111	0	0
TOTAL TRANSPORTATION NEEDS:	**10,683 (people)**	**571**	**161**	**253**
Resources Needed (1923 Fire Repeat - Region R02 and 1923 Fire Repeat Phased - Region R03)				
School and Preschool/Day Care Center Transportation Needs:	0	19	0	0
College/University Transportation Needs:	255 (people)	118	0	0
Medical Facility Transportation Needs:	0	3	32	27
Specialized Transportation Assistance Needs (Section 3.8):	0	0	16	39
Transit-Dependent Transportation Needs:	0	34	0	0
Employee Transportation Needs:	2,303 (people)	54	0	0
Visitor Transportation Needs:	2,002 (people)	34	0	0
TOTAL TRANSPORTATION NEEDS:	**4,560 (people)**	**262**	**48**	**66**
Resources Needed (Panoramic Hill Fire - Region R04)				
School and Preschool/Day Care Center Transportation Needs:	0	2	0	0
College/University Transportation Needs:	0	0	0	0
Medical Facility Transportation Needs:	0	3	25	21
Specialized Transportation Assistance Needs (Section 3.8):	0	0	3	6
Transit-Dependent Transportation Needs:	0	5	0	0
Employee Transportation Needs:	0	0	0	0
Visitor Transportation Needs:	163 (people)	3	0	0

Transportation Resource	Rail	Buses	Wheelchair Accessible Vans	Ambulances
TOTAL TRANSPORTATION NEEDS:	**163 (people)**	**13**	**28**	**27**
Resources Needed (Fire Zones 2 & 3 Combined - Region R05)				
School and Preschool/Day Care Center Transportation Needs:	0	11	0	0
College/University Transportation Needs:	0	0	0	0
Medical Facility Transportation Needs:	0	4	32	27
Specialized Transportation Assistance Needs (Section 3.8):	0	0	20	50
Transit-Dependent Transportation Needs:	0	38	0	0
Employee Transportation Needs:	26 (people)	1	0	0
Visitor Transportation Needs:	1,897 (people)	32	0	0
TOTAL TRANSPORTATION NEEDS:	**1,923 (people)**	**86**	**52**	**77**
Resources Needed (Tsunami Warning - Phase 3 - Region R06)				
School and Preschool/Day Care Center Transportation Needs:	0	0	0	0
College/University Transportation Needs:	0	0	0	0
Medical Facility Transportation Needs:	0	0	0	0
Specialized Transportation Assistance Needs (Section 3.8):	0	0	1	3
Transit-Dependent Transportation Needs:	0	3	0	0
Employee Transportation Needs:	19 (people)	1	0	0
Visitor Transportation Needs:	417 (people)	7	0	0
TOTAL TRANSPORTATION NEEDS:	**436 (people)**	**11**	**1**	**3**
Resources Needed (Tsunami Warning - Max Phase - Region R07)				
School and Preschool/Day Care Center Transportation Needs:	0	4	0	0
College/University Transportation Needs:	0	0	0	0
Medical Facility Transportation Needs:	0	0	0	0
Specialized Transportation Assistance Needs (Section 3.8):	0	0	4	8
Transit-Dependent Transportation Needs:	0	8	0	0
Employee Transportation Needs:	532 (people)	13	0	0
Visitor Transportation Needs:	874 (people)	15	0	0

Transportation Resource	Rail	Buses	Wheelchair Accessible Vans	Ambulances
TOTAL TRANSPORTATION NEEDS:	**1,406 (people)**	**40**	**4**	**8**



Event	
A	Evacuation Order
B	Bus Dispatched from Depot
C	Bus Arrives at Facility/Transit Bus Stop
D	Bus Departs Facility/ Transit Bus Stop
E	Bus Exits Evacuated Area
Activity	
A→B	Driver Mobilization
B→C	Travel to Facility or Transit Bus Stop
C→D	Passengers Board the Bus
D→E	Bus Travels Toward Boundary of the Evacuated Area

Figure 8-1. Chronology of Transit Evacuation Operations

9 HIGHEST CAPACITY ROUTES, EVACUATION SIGNAGE, AND PARKING RESTRICTIONS

This section documents main thoroughfares within the City of Berkeley that can serve the most vehicles in an evacuation. It discusses potential impacts to evacuation times and traffic flow from "red curbing." It also provides considerations on evacuation signage based on Berkeley's situation and current traffic engineering standards.

9.1 Highest Capacity Routes

In suburban and rural areas there may be relatively few routes that can lead evacuees out of a hazard area. In these situations, it is critical to designate these roadways as "Evacuation Routes" and to direct the community to those specific routes. Alternatively, in urban environments such as Berkeley, there will generally be multiple roadways that can transport vehicles out of hazard areas to safety.

Even Berkeley's highest-capacity roadways are not designed to handle a large volume of vehicles associated with a large-scale evacuation alone. It is important that evacuating vehicles are distributed across all available roadways to improve overall evacuation times. When multiple routes are available for evacuation, each with inadequate capacity alone, designating particular roadways as "Evacuation Routes" and directing community members to them will slow down overall evacuation times by not using all available roadway capacity.

As such, this study considers all roadways in Berkeley to potentially serve as evacuation routes, and identifies roadways with the highest capacity based on their characteristics. Emergency management personnel may use information from this analysis to prioritize available traffic management resources during evacuations. City leaders may also consider prioritizing preservation of vehicular capacity on these roadways when analyzing future roadway improvement projects.

Evacuees will select routes within the city in such a way as to minimize their risk exposure. This expectation is met by the DYNEV II model routing traffic away from the location of the wildfire, tsunami, or other hazard to the extent practicable. The DTRAD model[1] satisfies this behavior by routing traffic so as to balance traffic demand relative to the available highway capacity (the number of vehicles that can be processed in a given amount of time) to the extent possible.

[1] https://kldassociates.com/wp-content/uploads/2024/10/DTRAD-DYNEV.pdf

9.1.1 Highest Capacity Roadways

Although the city has numerous exit routes, the following roadways possess the greatest capacity for vehicular traffic. Thus, they are likely to carry the greatest number of vehicles in an evacuation:

- Interstate 580 (I-580)
- San Pablo Ave (SR 123)
- Sacramento St
- Martin Luther King Jr Way
- Adeline St/Shattuck Ave
- Telegraph Ave
- College Ave
- Arlington Ave
- Grizzly Peak Blvd
- Ashby Ave

The following roadways do not provide direct exits out of the city, but connect into those that do and are likely to also carry the greatest number of vehicles in an evacuation:

- Solano Ave
- Marin Ave
- Hopkins St
- Durant Ave
- Oxford St
- Spruce Street
- Bancroft Way
- Haste St
- Cedar St
- University Ave
- Dwight Way
- Euclid Ave

These roadways are highlighted in Figure 9-1. While numerous roadways exit the city, these are the roadways that can process the most vehicles. **These routes are not designated "Evacuation Routes" at the exclusion of other roadways. All available roadways should be considered evacuation routes.** These routes, along with others will be used by the general population evacuating in private vehicles. Because of their high capacity, these routes are preferable for use by transit-dependent population evacuating on buses. The general population may evacuate to some alternate destination (e.g., lodging facilities, relative's home, emergency shelter) outside the city or evacuated area. Transit-dependent evacuees will be routed to safety, outside of the evacuation area.

Figure 9-7 through Figure 9-9 display the public transit routes within the City of Berkeley, which were obtained from the California State Geoportal[2], which includes routes from all transit operators (including UC Berkeley Bear Transit and Alameda-Contra Costa Transit District, or AC Transit). It is assumed that transit-dependent people will gather at the transit stops along the routes shown to evacuate using a bus. This does not imply that these exact routes would be used in an emergency. It would also be prudent to send buses along routes serving major population centers to pick up transit-dependent individuals who do not live close to existing routes and/or bus stops.

For the purpose of this study, schools, preschools/day care centers, colleges/universities, medical facilities and juvenile homes were routed along the most likely path from the facility being evacuated to the boundary of the evacuation region, which may not have been along a high-capacity route. A single route was used for facilities that would use a similar path for evacuation.

[2] https://gis.data.ca.gov/datasets/dd7cb74665a14859a59b8c31d3bc5a3e_0/explore?location=37.865645%2C-122.267599%2C14.84

See Section 3.5, Section 3.6, and Section 3.7 for more information on Berkeley's transit dependent population and Section 8 for transit dependent resource needs.

9.2 Evacuation Signage

Evacuation signage can help people quickly and safely find their way to safety in an emergency. In a chaotic situation, evacuation route signage can help people stay calm and focused, and they can prevent people from getting lost or feeling trapped.

However, evacuees can generally head in a generic direction (north toward Albany, south toward Oakland, east toward the hills, west toward the water) to get to safety. For optimal throughput, evacuees should be distributed on all available roadways as equitably as possible. Furthermore, posting signage directing people to Berkeley's highest capacity roadways may actually increase overall evacuation times. There can be issues with evacuation signage, including:

- Evacuation routes and direction of travel change depending on the type of emergency (fire, flood, earthquake, etc.). A sign that's useful for one situation might be useless or even dangerous in another.
- Generic signs lack specificity. These signs often say, "Evacuation Route" and provide a general direction of travel, as shown in Figure 9-10. However, these signs don't tell people *where* to go. In a large-scale emergency, people may need directions to specific reception sites, which in large-scale emergencies may be outside the city limits.
- Generally, cities are full of signs. Adding more signs can create "sign pollution" and make it harder to spot the truly critical directions.
- Most city residents are already familiar with the major roads and thoroughfares. Adding evacuation signs might not provide much new information.
- Moving evacuees onto specific designated roadways does not increase the capacity of those roadways. As Evacuation Cases show (see Section 7), evacuees will experience traffic congestion. Human behavior dictates that drivers will re-route in order to avoid gridlock. This redistribution of traffic to include lower-capacity roadways can ultimately improve both individual and overall evacuation times.

This report does not specify the precise locations for evacuation signage. Chapter 2N of the 2023 MUTCD[3] presents guidelines for placing emergency management signs. The installation of evacuation route signage, however, must comply with the guidance provided in the MUTCD.

Whether or not evacuation signage is implemented, it is still crucial to have a comprehensive evacuation plan that includes:

- Emergency alerts to provide real-time instructions and updates.
- Trained personnel to guide people and manage the evacuation.
- Pre-identified priority routes to receive evacuation management resources. Adaptable strategies to respond to the specific needs of different emergencies.

[3] Manual on Uniform Traffic Control Devices for Streets and Highways, 2023 Edition, US Department of Transportation, Federal Highway Administration

Ultimately, effective evacuation relies on a multi-faceted approach that considers the strengths and limitations of evacuation signage, even in a well-organized grid system.

9.3 Parking Restrictions

Implementing parking restrictions (red curbing) in the Berkeley hills is unlikely to substantially improve evacuation flow. The principal limitations to vehicle movement are not primarily due to reduced roadway widths caused by parked cars. Instead, bottlenecks occur at intersections, which have a finite capacity to manage the merging of traffic from multiple directions. Widening lanes by prohibiting parking would likely cause vehicles to arrive at these already congested intersections more rapidly, potentially worsening the congestion. Moreover, the inherent geometric characteristics of Berkeley's hillside roadways, including their curvature and steepness, impose natural speed limitations, further reducing the impact of on-street parking on evacuation times. Additionally, during an evacuation, most privately owned vehicles currently parked along roadways will be in active use for egress, thereby diminishing the effect of side street parking on overall evacuation speed in the hills.

It's possible that parking restrictions could improve the ingress of emergency responders both in day-to-day response and during evacuations. The City could consider the strategic implementation of parking restrictions along arterial roadways in the hills, with a focus on those roadways predominantly utilized by emergency response vehicles for ingress during emergency response. This targeted approach would optimize maneuverability and reduce potential impedance for essential services without imposing broad restrictions that are unlikely to significantly improve overall evacuation egress flow.

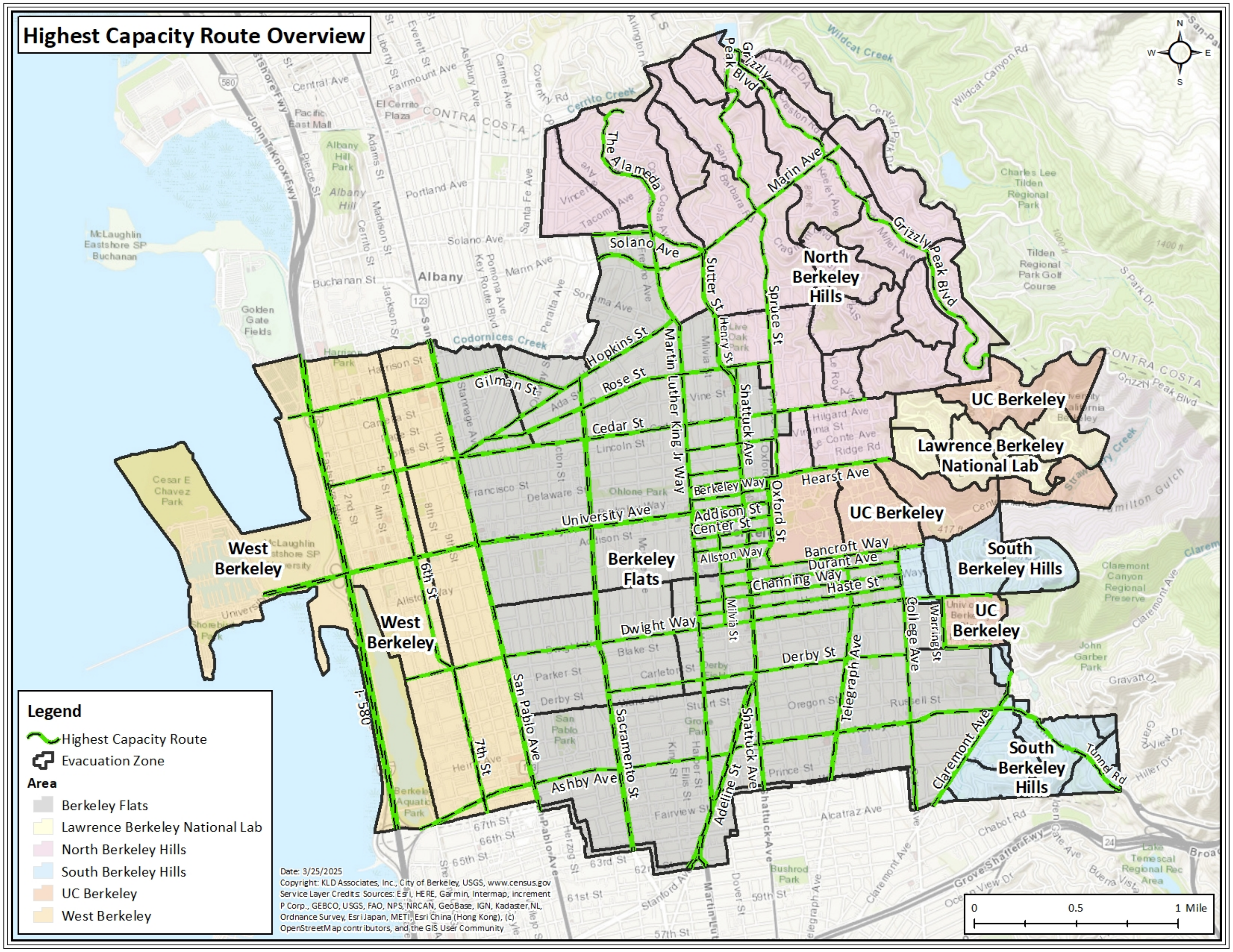


Figure 9-1. Highest Capacity Routes - Overview

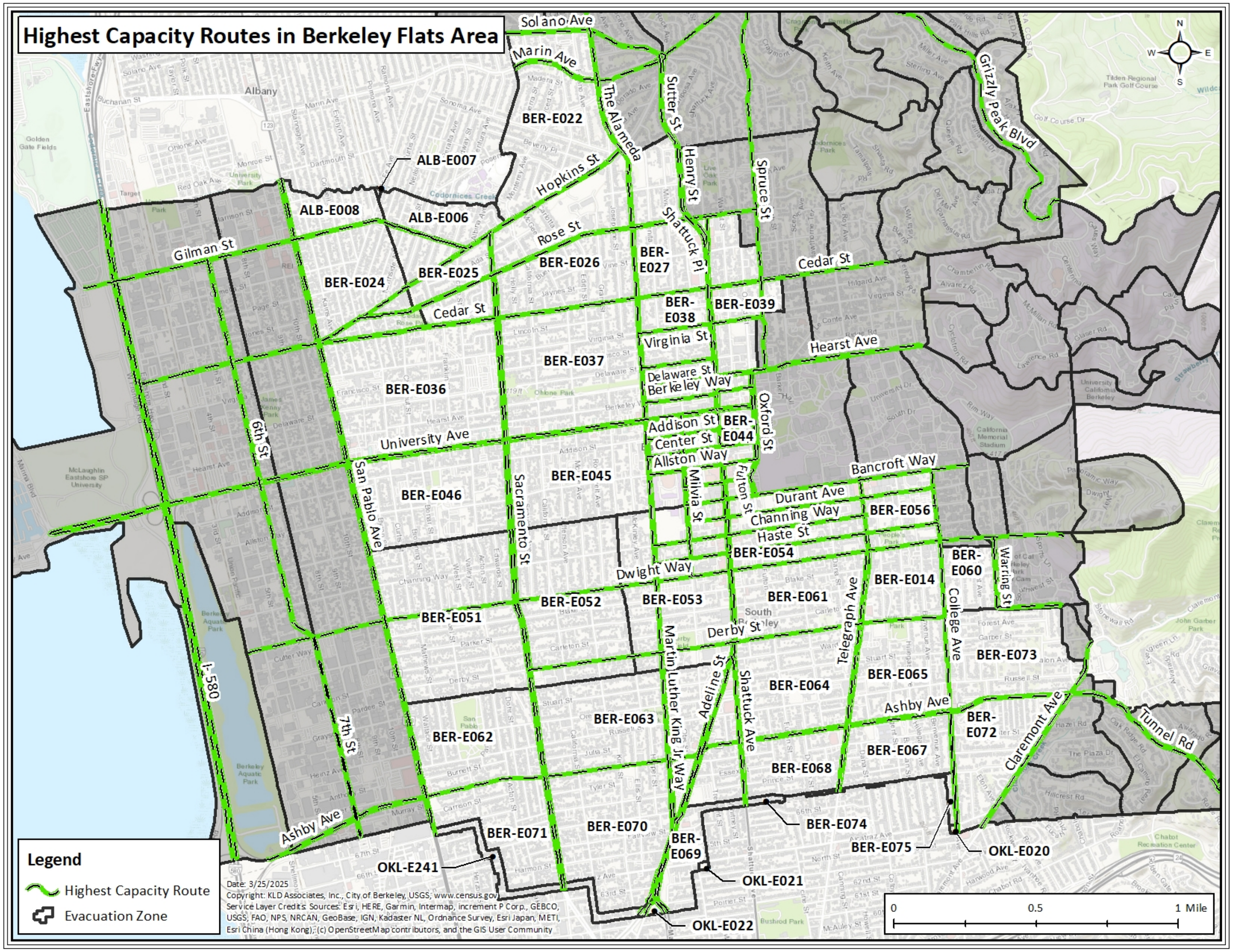


Figure 9-2. Highest Capacity Routes – Berkeley Flats

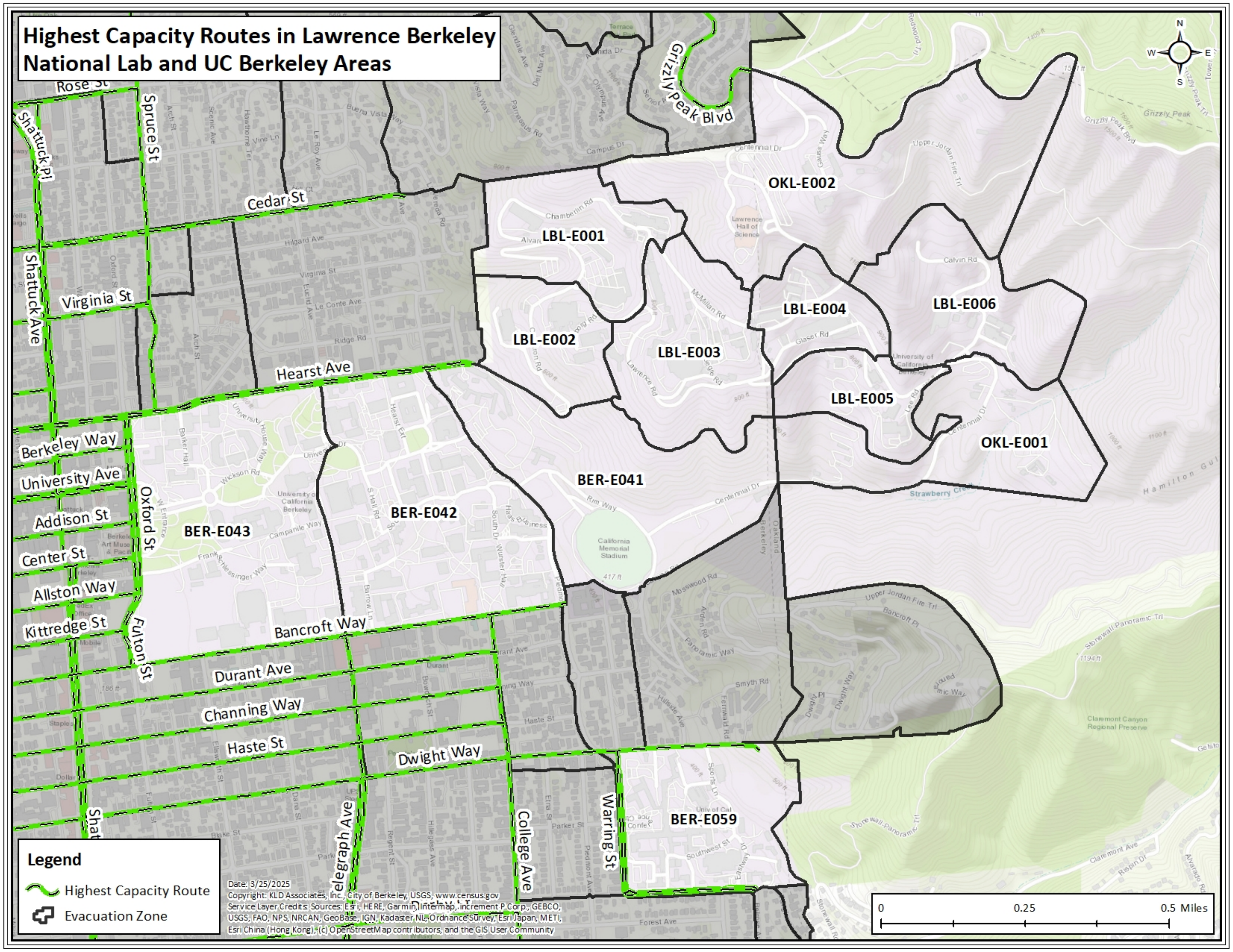


Figure 9-3. Highest Capacity Routes from Lawrence Berkeley National Lab and UC Berkeley

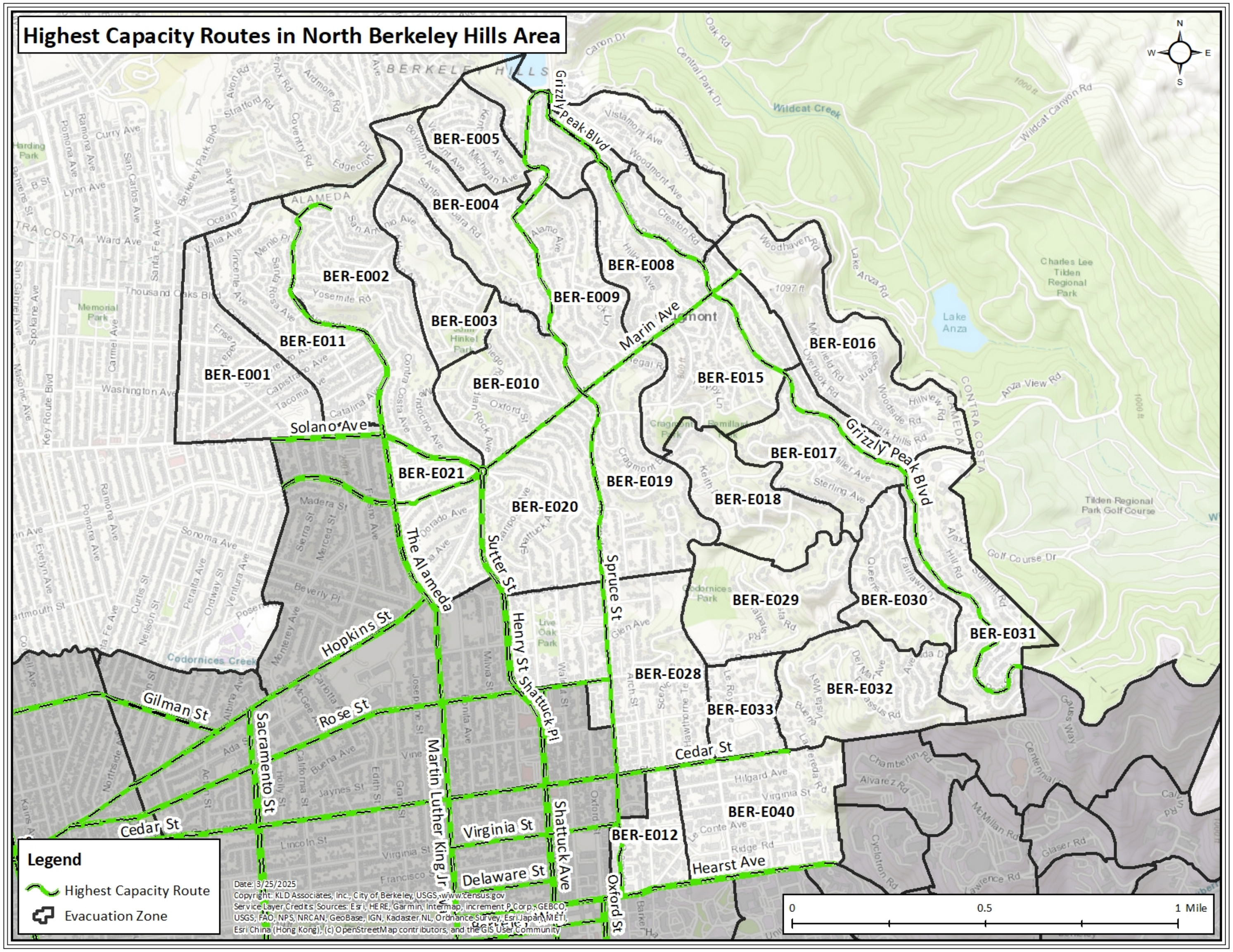


Figure 9-4. Highest Capacity Routes – North Berkeley Hills

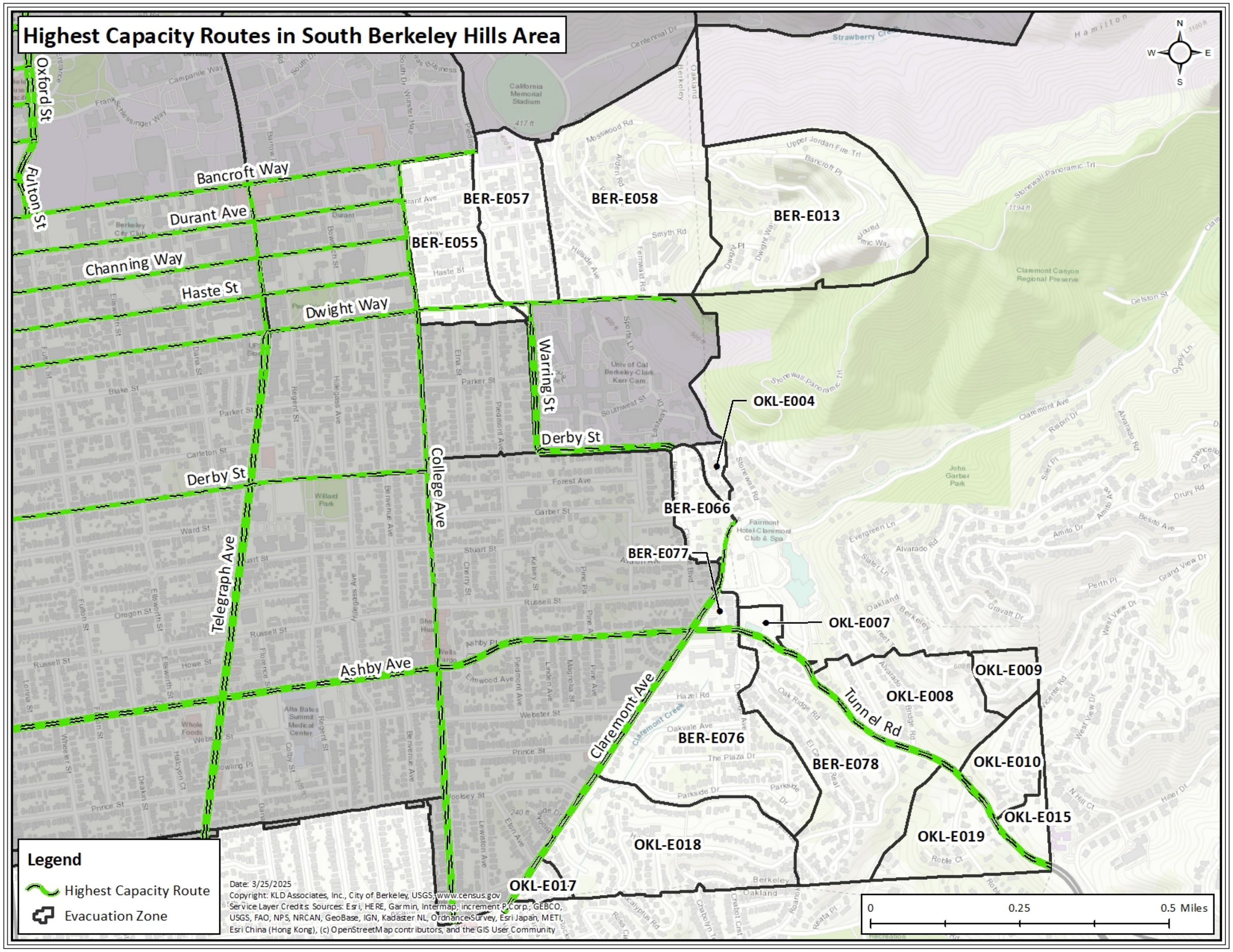


Figure 9-5. Highest Capacity Routes – South Berkeley Hills

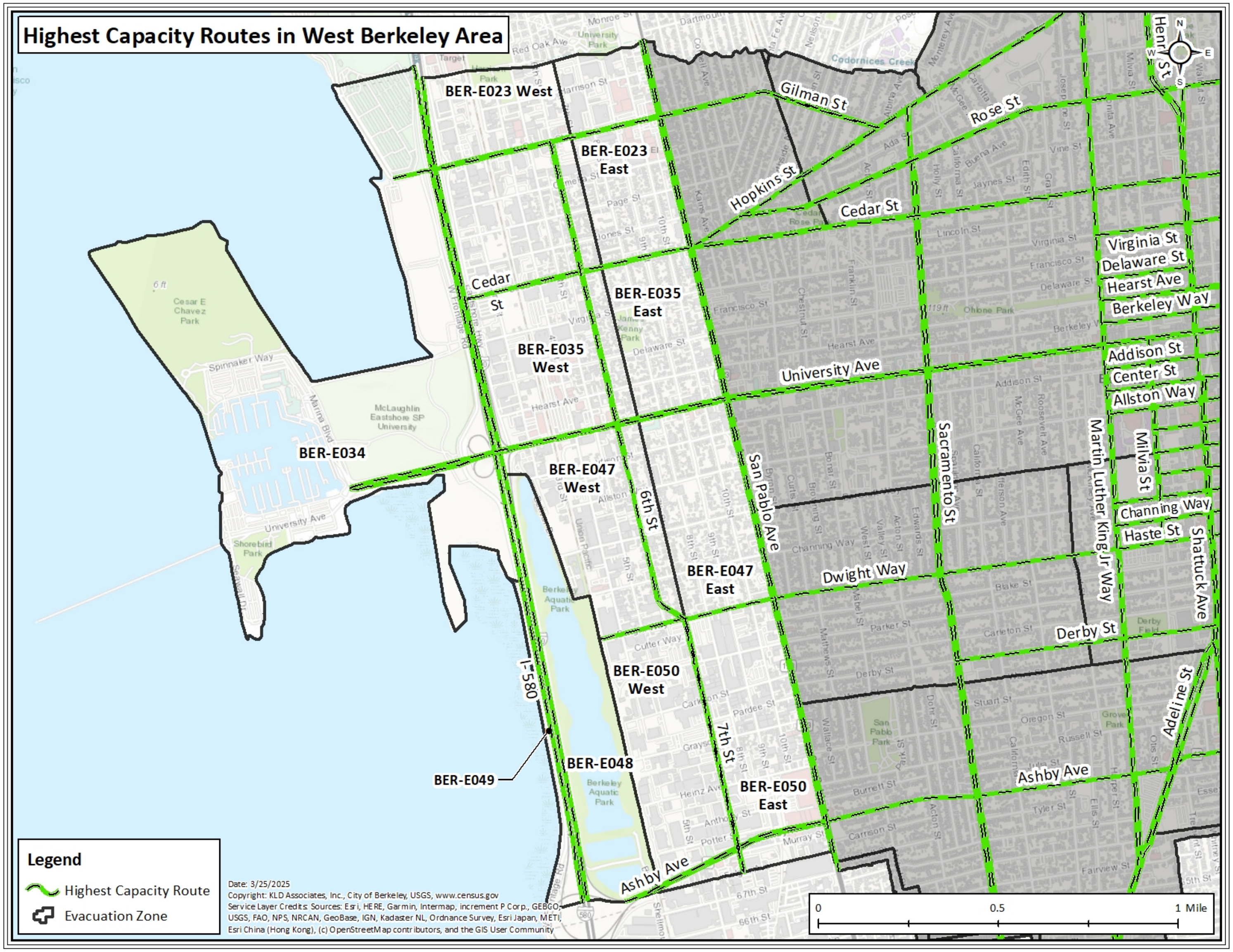


Figure 9-6. Highest Capacity Routes – West Berkeley

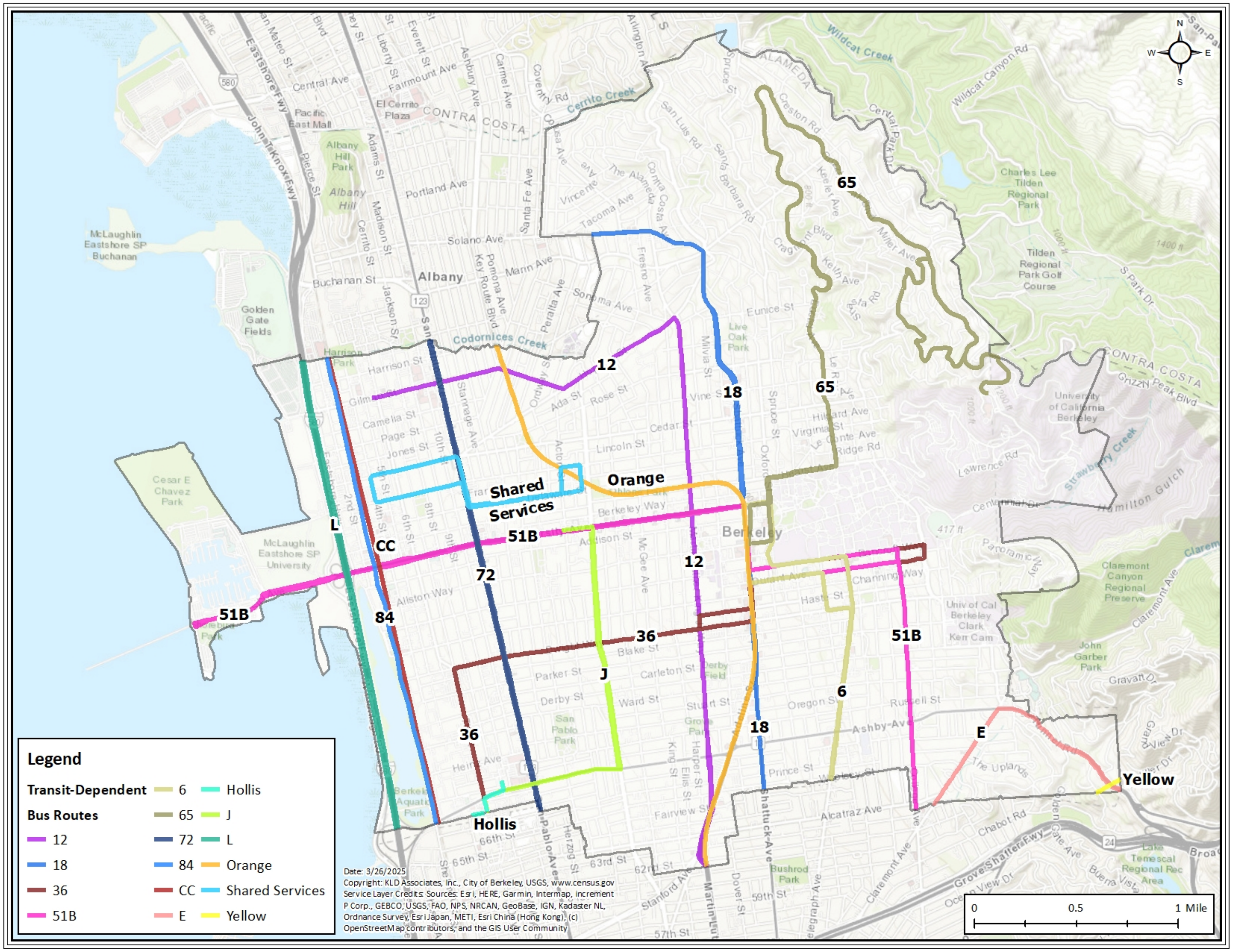


Figure 9-7. Transit-Dependent Bus Routes - 1

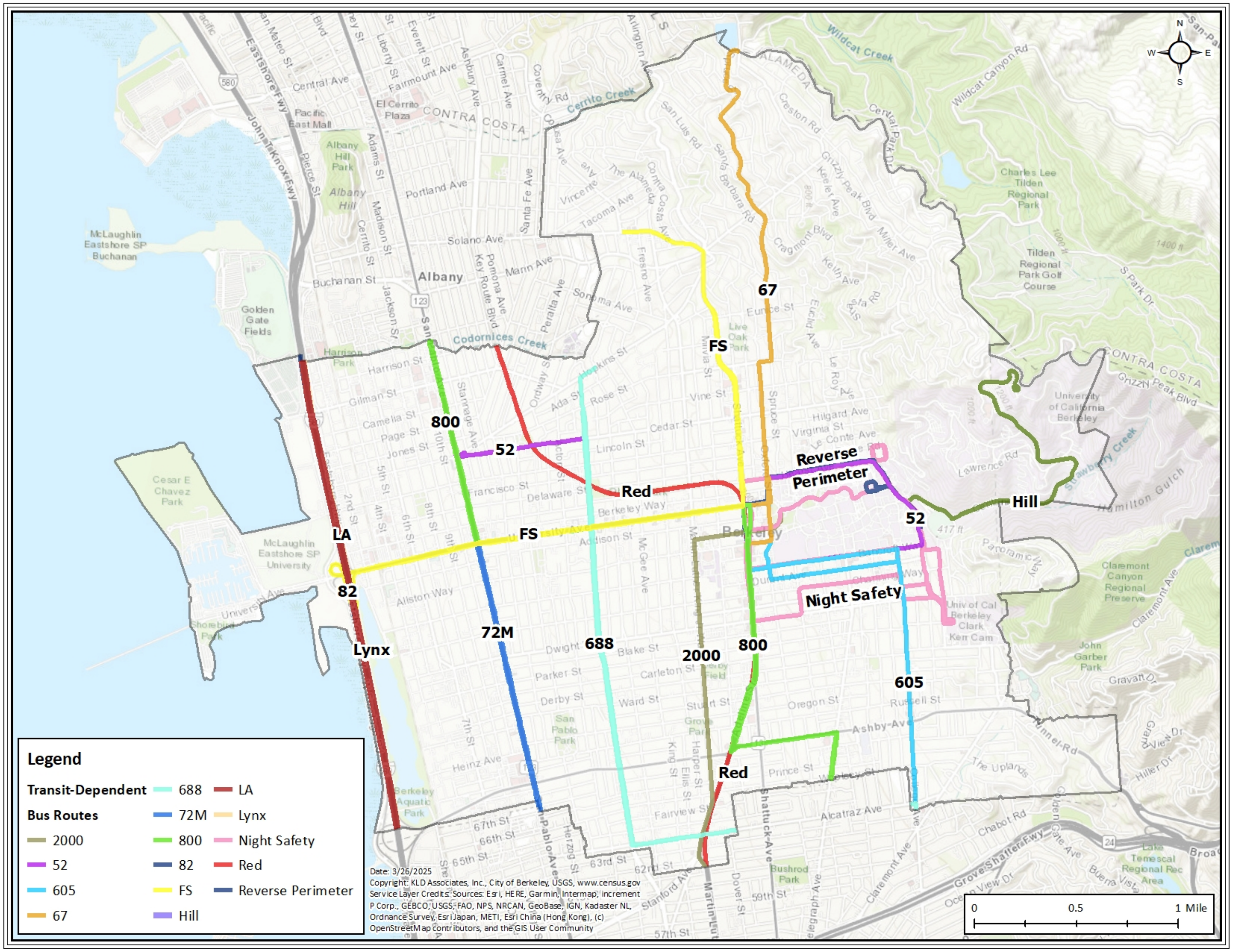


Figure 9-8. Transit-Dependent Bus Routes - 2

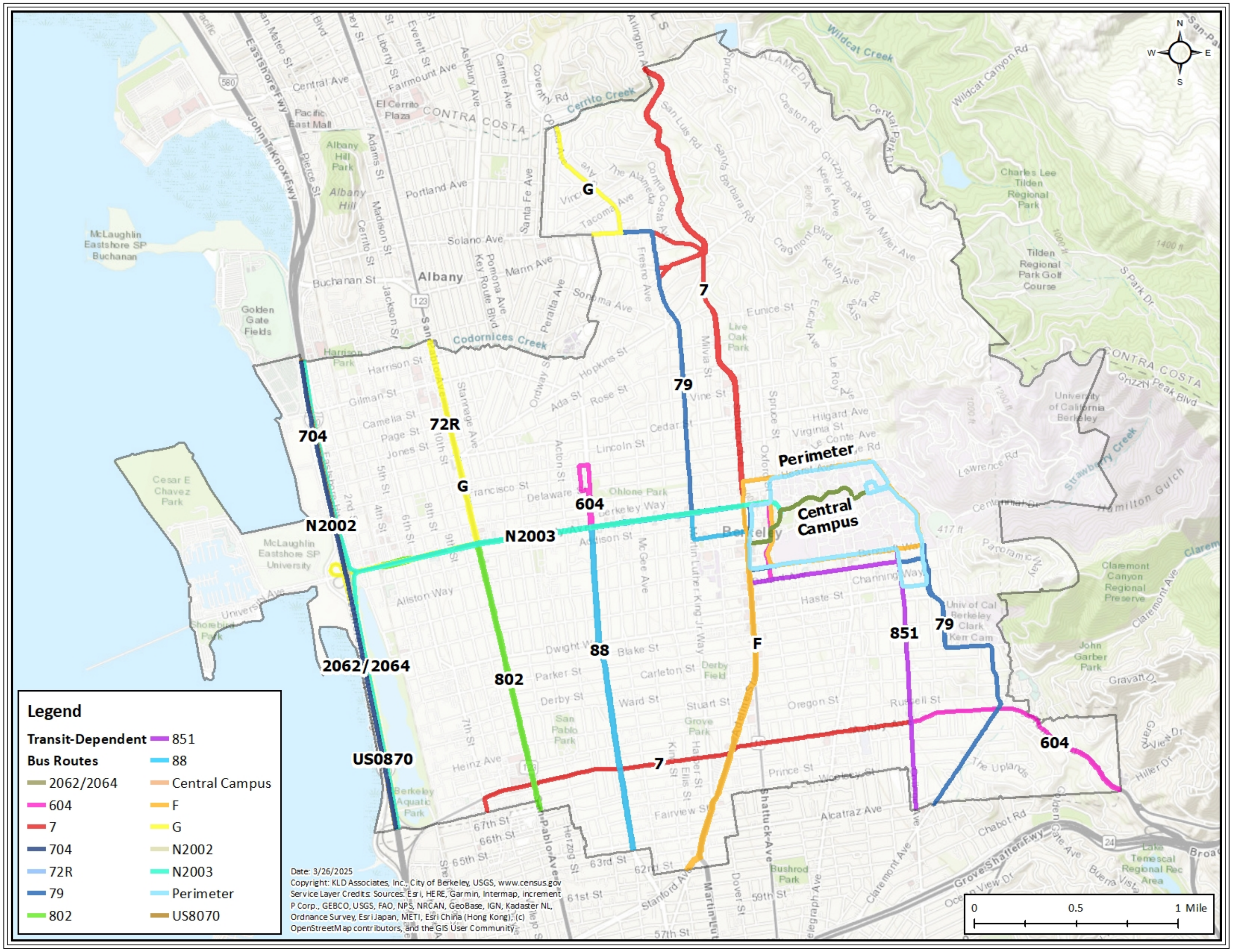


Figure 9-9. Transit-Dependent Bus Routes - 3

Figure 9-10. Evacuation Route Sign Example

10 EVACUATION SENSITIVITY STUDIES

This section presents the results of a series of sensitivity analyses, or "what-if" analyses. These analyses are designed to identify the sensitivity of the ETE to changes in some base evacuation conditions. The cases that were selected are based on special interests from City of Berkeley as well as KLD's expertise in evacuations.

10.1 Evacuation Readiness

A sensitivity study was performed to determine whether changes in the estimated trip generation (mobilization) time influence the ETE for an evacuation. Specifically, if the tail of the mobilization distribution were truncated (i.e., if those who responded most slowly to the Evacuation Order, could be persuaded to respond much more rapidly) how would the ETE be affected? Optimization of evacuation mobilization may be achieved through pre-emptive readiness protocols, facilitated by public education initiatives promoting 'go-bag' preparedness during periods of elevated wildfire risk. Furthermore, scenarios where urgent mobilization is necessary, and evacuees have little to no time to prepare to evacuate (no-notice evacuations) were also considered. All Scenarios for 1923 Fire (Region R02), 1923 Fire Phased (Region R03) and Panoramic Hill Fire (Region R04) were simulated for this sensitivity study. The results are tabulated in Table 10-1 and Table 10-2.

For the 1923 Fire case, a 1-hour reduction in mobilization time reduces the 90th percentile ETE by approximately 3%, as shown in Table 10-1. The 90th percentile ETE for this case is dictated by traffic congestion and a reduction in the time needed to perform pre-evacuation activities results in minimal change to the ETE. Furthermore, an urgent (30-minute mobilization time) mobilization can actually increase the ETE (specifically for the peak demand case) since the demand is now loaded onto the roadway network in a smaller time period, overwhelming the roadway system, resulting in more congestion and delay and, ultimately, longer ETE.

The 100th percentile ETE for the 1923 Fire case is reduced by approximately 9%[1] at most with a 1-hour reduction in mobilization for the 1923 Fire case, as shown in Table 10-2. When the mobilization time is reduced to 30 minutes, the ETE for the 1923 Fire is dictated by the time for transit vehicles to mobilize. In the base case, 100th percentile ETE for the fall midweek (Scenario 4) scenario increases due to the compression of the mobilization time overwhelming the roadway system.

When the 1923 Fire region is phased, the 90th percentile and 100th percentile ETE are reduced by at most 9% and 29%, respectively, when the mobilization time is reduced by 1-hour. However, when the mobilization time is reduced by 3 hours, there are at most 65% changes in both the 90th and 100th percentile ETE for the 1923 Fire phased region. The ETE decreases by over 4 hours (nighttime scenarios for certain phases).

[1] The mobilization time for transit-dependent population groups remains constant at 180 minutes following an evacuation order. Consequently, for scenarios where the ETE is governed by mobilization time, the 100th percentile ETE is 3 hours and 10 minutes.

For Panoramic Hill (Region R04), the 90th percentile ETE decreases by at most 5% and the 100th percentile ETE is reduced by 14% for all cases when the mobilization time is reduced by 1-hour (dictated by transit dependent mobilization time). However, when the mobilization time is reduced by 3 hours, the 90th percentile ETE is reduced by at most 55% at the 90th percentile ETE. When the mobilization time for Panoramic Hill is 30 minutes, the 90th percentile ETE is dictated by congestion and no longer the mobilization time of evacuees. The 100th percentile ETE becomes dictated by the time needed to mobilize transit vehicles. When buses can be more quickly mobilized to support evacuation of transit-dependent evacuees, the overall ETE can also be reduced.

10.2 Effect of Changes in the Number of People who Voluntarily Relocate

A sensitivity study was conducted to measure the effects on ETE due to changes in the percentage of people who decide to relocate from the Shadow Region (see Figure 7-1) and areas within the city not under Evacuation Order. The movement of people outside of the area being evacuated has the potential to impede vehicles from leaving areas that are ordered to evacuate. Refer to Sections 3.2 and 7.1 for additional information on Shadow and Voluntary Evacuation. A Citywide Evacuation (Region R01), 1923 Fire (Region R02), Panoramic Hill Fire (Region R04), Tsunami Phase 3 (Region R06) and Tsunami Max Phase (Region R07) were considered for this sensitivity study.

Table 10-3 and Table 10-4 present the ETE for the simulated scenarios. The results indicate that reducing the shadow population to 10% yields a 7% reduction on ETE across all regions, with the notable exception of Region R06, Tsunami – Phase 3. A Phase 3 tsunami represents a Warning-level tsunami that requires evacuation of the Berkeley Marina and Waterfront areas up to Interstate 80. In this specific region, a reduction in shadow and voluntary evacuation percentages results in 48% decrease in the 90th percentile ETE. Evacuees from Region R06 rely on Frontage Road and University Avenue as primary egress routes. As a result, this evacuation region is particularly sensitive to shadow and voluntary evacuee traffic that may utilize these roadways, which can impede Tsunami Phase 3 evacuation.

Furthermore, increasing the shadow population (to 60% or 100%, for example) for Region R06 results in 309% increase at the 90th percentile with a 100% shadow population participation.

For other regions, the 90th percentile ETE increases by 21% and 66%, on average, when the shadow percentage is increased to 60% and 100%, respectively. The most noticeable impacts to ETE are on weekdays during the day (Scenarios 1 and 4) as these cases have the highest number of evacuating vehicles.

The 100th percentile ETE exhibits minimal sensitivity to a reduction in shadow population to 10%, primarily due to the ETE being predominantly constrained by mobilization time. Conversely, increasing the shadow population to 60% and 100% results in 100th percentile ETE increases of as much as 17% and 68%, respectively.

The more people that voluntarily evacuate but are not ordered to do so, the less roadway capacity is available for evacuees. As such, specifically for the Berkeley area, voluntary evacuations by those not under evacuation warning or order contribute to traffic congestion, increasing evacuation times for those who are ordered to evacuate. Public information and public messaging as to who is at risk should be clear before and during an emergency so that community members who are not at risk are less likely to contribute to traffic congestion.

10.3 Leaving Early (Reduction in Evacuation Demand)

The relationship between supply and demand is very important in computing ETE. The evacuation travel supply is the ability of the roadway network to serve the traffic demand (number of evacuating vehicles) during an emergency. In this context, when the demand exceeds the supply (available capacity), congestion occurs, causing delay and prolonging the evacuation. The roadway capacity is often challenging to increase as it is expensive and difficult to widen existing infrastructure or build additional roadways. An effective way of reducing evacuation demand is to have people leave during high-risk fire weather, before a fire starts. To that end, the City of Berkeley recommends that residents of the Berkeley hills (Fire Zones 2 & 3) leave the hills during Extreme Fire Weather.

For the purposes of this sensitivity study, Fire Zones 2 & 3 were considered to be 'high-risk' and residents in these areas were assumed to leave early. Thus, the evacuation demand was reduced. To account for those who would leave early, the vehicular demand for Fire Zones 2 & 3 was reduced by 10%, 50% and 75%. Of these people that left early (during Extreme Fire Weather but before a fire ignited and evacuations were ordered), it was assumed that 50% would stay in the Berkeley Flats Area outside of the evacuated region and the remaining 50% would relocate outside of the city limits. As such, these people would, therefore, become part of the shadow and voluntary evacuating population when a fire ignites. All Scenarios for 1923 Fire (Region R02) and Panoramic Hill Fire (Region R04) were considered. Table 10-5 and Table 10-6 summarize the results of this sensitivity study.

There are approximately 27,830 vehicles evacuating from Region R02 (1923 Fire). But a significant portion of Region R02 is not in Fire Zones 2 and 3, so only 10,330 of those vehicles would belong to households subject to Berkeley's leave early recommendation. Scenarios involving 10%, 50%, and 75% early evacuation result in 1,033, 5,165, and 7,748 vehicles within Region R02, respectively, departing early (leaving 26,797, 22,665, and 20,082 evacuating vehicles, respectively, upon the order to evacuate). As such, the effective demand of the 1923 Fire region (Region R02) decreases by 3.7%, 19%, and 28%, respectively. Furthermore, of the vehicles that departed early, half of them were included within Berkeley Flats and will subsequently participate in voluntary evacuation following the issuance of an Evacuation Order. The other half were assumed to be out of the study area, increasing the voluntary and shadow demand.

All of the evacuated portions of Region R04 are located within Fire Zones 2 and 3. As such, a 10%, 50%, and 75% reduction in high-risk evacuees due to those leaving early reduces the effective demand of the region by 10%, 50%, and 75%, respectively.

As shown in Table 10-5 and Table 10-6, relative to the Base Case, the 90th percentile ETE exhibits a maximum reduction of 3%, 14%, and 14% for the 10%, 50%, and 75% leave early cases, respectively. The 100th percentile ETE demonstrates a maximum reduction of 4%, 10%, and 10% for the 10%, 50%, and 75% leave early cases, respectively.

The reduced demand reduces traffic congestion in the simulated cases. As a result, the 90th percentile ETE becomes dictated by trip generation time, rather than traffic congestion. The ETE only drops as low as the mobilization will allow and, as a result, the reduction in ETE due to the reduction in evacuation demand for those that leave early is limited and incremental.

As discussed in Section 10.1, reducing the mobilization time to 30 minutes can decrease ETE (except for an evacuation of the 1923 Fire region (Region R02) under a Fall, Midweek, Midday Scenario (Scenario 4) where congestion actually worsens an increases ETE). To analyze the impact of people leaving early with compressed mobilization (30-minutes), these cases were simulated and the results are presented in Table 10-7 and Table 10-8.

Comparing values within Table 10-7 and Table 10-8, it can be seen that under urgent mobilization (30 minutes) conditions, the 90th percentile ETE exhibits a maximum reduction of 20%, 23%, and 40% for the 10%, 50%, and 75% leave early cases, respectively. The 100th percentile ETE demonstrates a maximum reduction of 13% and 22% for the 50% and 75% leave early cases, respectively. There is no change at the 10% leave early level.

When comparing the combined leave early and compressed mobilization approaches (shown in Table 10-7 and Table 10-8 to the base cases simulated (first two rows of Table 10-5 and Table 10-6), it can be seen that compressing the mobilization and encouraging residents in Fire Zones 2 and 3 to leave early provides a benefit of up to 68% at the 90th percentile and up to 14% at the 100th percentile. Once again, it should be noted that compressing the mobilization (with a 10% reduction in ETE) still increases congestion and increases ETE for the 1923 Fire case (by up to 25 minutes at the 100% percentile) as discussed in Section 10.1. A reduction in demand of 10% is not enough to outweigh the increase in congestion caused by the compressed mobilization time for the Fall, midweek, midday scenario for the 1923 Fire case (Region R02).

10.4 Second Egress Out from Panoramic Hill

The steep, single-access, and curvilinear road network of Panoramic Hill, coupled with its proximity to the Claremont Canyon Regional Preserve, presents critical logistical constraints for emergency egress. The area's unique topography and natural setting pose substantial evacuation challenges for residents in the event of wildfire. This sensitivity analysis investigates the impact of a secondary egress point, connecting Dwight Way to Dwight Place, on the ETE for Panoramic Hill, which is currently served by a single egress route, Panoramic Way. All Scenarios for the 1923 Fire (Region R02) and Panoramic Hill Fire (Region R04) were considered. Even though Panoramic Hill is included inside both Regions R02 and R04, the ETE presented for this sensitivity study shows when vehicles have evacuated beyond either Panoramic Way or Dwight Way, rather than the final times when the entire evacuating Regions are clear. This focuses the analysis on the specific impact from an additional route out of Panoramic Hill.

As shown in Table 10-9 and Table 10-10, when mobilization times are not altered, the addition of a secondary egress point from Panoramic Hill does not alter the 90th or 100th percentile ETE (compare the “Two Ways out of Panoramic Hill” to “One Way out of Panoramic Hill (Base)”). The ETE in this case is dictated by the 3 hour and 30 minute-maximum mobilization period, rather than traffic congestion. Consequently, the introduction of a second egress point does not yield a reduction in ETE.

However, a fast-moving wildfire that threatens the Panoramic Hill area may not allow evacuees 3.5 hours to mobilize. To explore the impact of a secondary egress route on a fast-spreading fire, a combination of urgent mobilization was combined with a secondary egress route. When an urgent mobilization is ordered (mobilization time of 30 minutes for population groups with personal vehicles)[2] and there are two ways out of Panoramic Hill, the 90th percentile ETE reduces by at most 29% for the 1923 Fire and 33% for Panoramic Hill Fire (compared to the urgent mobilization case with one way out).

10.5 Accessory Dwelling Units and Middle Housing Developments

The purpose of this sensitivity study is to provide analysis of any public safety impacts resulting from the maximum potential amount of new residential development of accessory dwelling units (ADUs), junior accessory dwelling units (JADUs), and their associated vehicles in the Hillside Overlay, which encompasses the Very High Fire Hazard Severity Zones (VHFHSZ)[3], under the current interpretation of State law per the Department of Housing and Community Development (HCD), as well as a projection of likely development that could result from implementation of the "Middle Housing" zoning changes evaluated in the 2023-2031 Housing Element Update. The Middle Housing zoning changes would amend the Berkeley Municipal Code to allow for multi-unit development on individual parcels that are zoned for lower-density residential development. The zoning districts under consideration in the Hillside Overlay are:

- Single-family Residential (R-1),
- Limited Two-family Residential (R-1A),
- Restricted Two-family Residential (R-2), and
- Restricted Multiple-family Residential (R-2A).

The results of this study will inform the City's approach to regulating development of ADUs, JADUs, and Middle Housing in the Hillside Overlay, which encompasses the City's VHFHSZ.

To determine the public safety impact of the projected development resulting from ADUs, JADUs, and Middle Housing, this report considers: Region R01 – Citywide Evacuation, Region R02 – 1923 Fire, Region R04 – Panoramic Hill Fire, and Region R05 – Fire Zones 2 & 3 Combined. All temporal variations (Scenarios) were simulated.

The results for Accessory Dwelling Units and Middle Housing Developments are presented in Table 10-12 through Table 10-15. Table 10-14 and Table 10-15 illustrate the change in ETE between the 'Future Case' scenario and the proposed development cases. These tables utilize a

[2] It should be noted that these results do not account for transit-dependent populations within Panoramic Hill requiring bus transportation (walking down the hill to an AC Transit – or similar – stop). Despite the potential presence of such individuals, transit dependent bus routes were not modeled within Panoramic Hill as detailed in Section 9. Consequently, the 180-minute mobilization time associated with bus deployment does not influence the calculated ETE for Panoramic Hill.
[3] Since this analysis was performed, Fire Hazard Severity Zone boundaries have been updated. The Hillside Overlay encompasses both the old and updated Fire Hazard Severity Zone boundaries.

color gradient, ranging from white (minimal ETE difference) to blue (maximum ETE difference), to facilitate visual interpretation of the results.

10.5.1 Future Case: No Middle Housing or ADU/JADU

The Future Case represents the projected conditions without any Middle Housing or ADU/JADU developments. Based on the population projection assumptions used in the 2023-2031 Housing Element EIR, by 2031, the City of Berkeley is projected to have 18,205 additional units excluding any increases resulting from ADUs, JADUs, or Middle Housing. Based on the average household size and vehicle evacuation rates established in the base ETE study (Section 3) from the results of the demographic survey, these number of units equate to 43,146 additional people and 20,754 additional evacuating vehicles (Table 10-11) for the Future Case.

As shown in Table 10-14 and Table 10-15, analysis of the Future Case indicates that this increased vehicle volume results in a maximum increase in ETE of 40% at the 90th percentile (Region R01, Scenario 3) and 39% at the 100th percentile (Region R01, Scenario 3). Given the absence of planned roadway infrastructure improvements (e.g. increasing capacity by converting a stop-controlled intersection to a signalized intersection to help facilitate or improve traffic flow) to accommodate an increase in projected demand, the additional vehicle volume contributes to increased congestion and a corresponding rise in ETE for most cases, specifically at the 90th percentile.

10.5.2 Future Build Case - Accessory Dwelling Units and Junior Accessory Dwelling Units Only

This case considers the 2031 population increase plus the maximum theoretical development of new ADUs and JADUs only (no Middle Housing considered). According to the data provided, there are approximately 9,020 parcels located in the Hillside Overlay that are eligible for ADUs and JADUs. The Hillside Overlay is located within North and South Berkeley Hills. Each parcel can accommodate at maximum 2 ADUs and 1 JADU, consistent with the current interpretation of State law per HCD. Taking into account existing ADUs and JADUs based on permit data, this totals 27,060 total units (Table 10-11). Using the average household size and vehicle evacuation rates established as part of this study, this case considers an additional 107,278 people (64,132 people from ADU/JADU and 43,146[4] people from future population growth) and 51,602 evacuating vehicles (30,848 vehicles from ADU/JADU and 20,754 from future growth) in the Hillside Overlay when compared to the base cases considered.

Compared to the Future Case, development of the maximum possible number of ADUs & JADUs in the Hillside Overlay results in 25% or more increases in ETE, as detailed in Table 10-15 and Table 10-14. Specifically, the 90th percentile ETE for a citywide evacuation (Region R01) increases by approximately 54% on average, for the 1923 Fire (Region R02) by 102% on average, for Panoramic Hill Fire (Region R04) by 52% on average, and for Fire Zones 2 & 3 Combined (Region

[4] It is important to note that the 2031 future growth data encompass the entire city, whereas the analysis of new ADU, JADU, Middle Housing developments is specifically focused on the Hillside Overlay. Consequently, the 18,205 new units projected for 2031 represent the city as a whole, and only a subset of these units will be located within the Hillside Overlay. Of these 18,205 new units, it is estimated that 4,238 of them would be within the Hillside Overlay.

R05) by about 154% on average. Similarly, at the 100th percentile, ETE increases by approximately 114% on average for Region R01 and Region R05 and 121% for Region R02. Region R04 experiences minimal impact at the 100th percentile, as its 100th percentile ETE remains primarily determined by trip mobilization time rather than congestion. Improvements to roadway capacity would need to be made in order to offset these increases. To mitigate these projected increases, significant roadway network modifications and/or changes in the vicinity of these ADU/JADU developments would be necessary, as the current infrastructure capacity is insufficient to accommodate the anticipated additional demand.

10.5.3 Future Build Case - Middle Housing Developments Only

This case considers the 2031 population increase plus the projected likely development under the proposed Middle Housing zoning changes only (no ADUs or JADUs considered). There are approximately 6,440 parcels within the Hillside Overlay (generally the North and South Berkeley Hills) and of those parcels, only 4.5% of them are likely to develop by 2031, resulting in 290 (6,440 x 0.045 = 289.8) available parcels that are eligible for Middle Housing developments. Each hillside parcel can accommodate a maximum of 3 units, totaling 870 potential new Middle Housing units within the Hillside Overlay, for a total of 19,075[4] units citywide, 45,208 people (2,062 people from Middle Housing and 43,146 people from future population growth), and 21,746 evacuating vehicles (992 vehicles from Middle Housing and 20,754 from future growth) more than the amount considered under the base cases (Table 10-11).

As shown in Table 10-14 and Table 10-15, implementation of new housing under the Middle Housing zoning changes results in increases of up to 8% at the 90th [Region R05, Scenario 3] and 100th percentile [Region R01, Scenario 5] to the ETE compared to the Future Case. Specifically, the additional 992 vehicles associated with Middle Housing could add between 5 and 10 minutes overall to ETEs for a repeat of the 1923 Fire (R02). This suggests that the Middle Housing developments should be further assessed in the context of fire spread scenarios. By overlaying fire spread data with evacuation time estimates, the City can better understand potential impacts to public health and safety from Middle Housing zoning changes.

10.5.4 Future Build Case - Accessory Dwelling Units, Junior Accessory Dwelling Units, & Middle Housing Developments

The combined implementation of development with the maximum possible amount of ADU/JADU units and likely Middle Housing units projects a total of 27,930 new housing units in the Hillside Overlay. This results in an additional 46,135 units[4], 109,340 residents and 52,594 evacuating vehicles by 2031 citywide. Increases in ETE are observed at both the 90th and 100th percentiles. Specifically, the 90th percentile ETE increases by about 61% on average for a Citywide Evacuation (Region R01), 105% on average for a 1923 Fire (Region R02), 166% on average for Fire Zones 2 & 3 Combined (Region R05), and about 54% on average for Panoramic Hill Fire (Region R04), as shown in Table 10-14 and Table 10-15. At the 100th percentile, ETE increases by 102% for Region R01, 126% for Region R02 and 147% for Region R05. Region R04 shows at most 2% increase at the 100th percentile, with its 100th percentile ETE remaining primarily influenced by trip mobilization time. To address these substantial increases, comprehensive roadway network improvements in the vicinity of these developments are essential, as the current infrastructure is inadequate to handle the projected demand.

10.5.5 Future Build Case - Accessory Dwelling Units and Junior Accessory Dwelling Units Only including Public Transit Parking Standard Exemption

In accordance with State law, JADUs are not required to provide off-street parking spaces, and ADUs are only required to provide off-street parking spaces if the parcel is located more than 1/2 mile walking distance of public transit, which is defined as “a location, including, but not limited to, a bus stop or train station, where the public may access buses, trains, subways, and other forms of transportation that charge set fares, run on fixed routes, and are available to the public.” This case assumes that any ADU or JADU resident living on a parcel that is not required to have off-street parking would not have a personal vehicle and would instead rely on public transit to evacuate. Of the total 9,020 ADU/JADU parcels, 4,434 of them fall within the transit exemption zone. It was conservatively assumed that people living on these 4,434 parcels would utilize a public transit bus to leave the area during an emergency. Using the standard assumptions of household size and vehicle occupancies in this study, a total of 13,302 units (4,434 x 3 = 13,302), which would house 31,526 people, would require buses to evacuate. Using an assumption of 30 people per bus, an additional 1,051 buses are estimated to be needed to evacuate the new ADU/JADU residents that do not have a personal vehicle above the base cases. The remaining 4,586 parcels would evacuate in personal vehicles. In total for this case, there are an additional 15,681 personal vehicles and 1,051 buses when compared to the Future Case.

Even with the estimation that approximately half of the eligible parcels will utilize public transportation for evacuation instead of a personal vehicle, the 90th and 100th percentile ETE exhibit increases compared to the Future Case, as shown in Table 10-14 and Table 10-15. Specifically, the 90th percentile ETE increases by about 28% on average for Citywide Evacuation (Region R01), 65% on average for the 1923 Fire (Region R02), 70% on average for Panoramic Hill Fire (Region R04) and 129% on average for Fire Zones 2 & 3 Combined (Region R05). Compared to the 'Future Build - ADU/JADU Only' case without the parking exemption, the 100th percentile ETE demonstrates a decrease of approximately 9% on average for Regions R01, R02 and R05. This reduction is attributed to the presence of 1,051 buses (2,102 personal car equivalents) and a decrease of 15,167 vehicles on the road.

10.5.6 Future Build Case - Accessory Dwelling Units, Junior Accessory Dwelling Units, & Middle Housing including Public Exemption

This case represents a similar scenario discussed in Section 10.5.5 with the Middle Housing units. Unlike State law governing the development of ADUs and JADUs, development under the proposed Middle Housing zoning changes does not include a parking exemption within transit-rich areas. For this reason, it is assumed that all Middle Housing developments are evacuated in personal vehicles. As shown in Table 10-11, there are approximately 16,673 additional evacuating vehicles and 1,051 buses for this case compared to the Future Case.

When compared to the Future Case, the 90th percentile ETE increases by 29% on average for Citywide Evacuation (Region R01), 68% on average for the 1923 Fire (Region R02), 69% on average for Panoramic Hill Fire (Region R04) and 135% on average for Fire Zones 2 & 3 Combined (Region R05). Compared to the 'Future Build - ADU/JADU and Middle Housing' case without the parking exemption, the 100th percentile ETE demonstrates a decrease of approximately 11% on average for Regions R01, R02 and R05. This reduction is attributed to the presence of 1,051 buses and a decrease of 16,673 vehicles on the road.

10.6 Optimized Signals

As discussed in Section 7 and Appendix F, there are some pre-timed signals within the city. Pre-timed signals utilize a fixed timing plan, rather than allowing the signal to optimize the splits between directions based on the demand at each approach. Actuated signals allow the signal to choose the appropriate timing plan based on the demand on each approach, with some limits to minimum and maximum green time. A sensitivity study was conducted to determine the impact to ETE if the pre-timed signals in the city were changed to actuated signals. The two fire cases (Fire 1923 non-phased [R02] and Panoramic Hill [R04]) were simulated for urgent mobilization (since many cases are dictated by trip generation time and the results of this sensitivity analysis would likely show no impact on the regular mobilization cases). All scenarios were considered. The results are presented in Table 10-16 and Table 10-17 at the 90th and 100th percentile, respectively.

When compared to Table 10-1 and Table 10-2, respectively, it can be seen that converting the pre-timed signals to actuated signals can improve evacuation times by up to 13% at the 90th percentile and up to 4% at the 100th percentile. In most cases, the 100th percentile ETE remains dictated by the time needed to mobilize transit vehicles. When buses can be more quickly mobilized to support evacuation of transit-dependent evacuees, the 100th percentile ETE can also be reduced.

Table 10-1. 90th Percentile Evacuation Time Estimates for Evacuation Readiness Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Region	**Midday**	**Midday**	**Nighttime**	**Midday**	**Midday**	**Nighttime**
30 Minute Mobilization Time						
R02	2:25	1:50	1:35	3:20	1:45	1:35
R03 Phase a	2:05	1:40	1:25	2:45	1:25	1:35
R03 Phase b	2:10	1:50	1:40	2:40	1:30	1:40
R03 Phase c	3:35	3:45	1:40	3:50	1:30	1:40
R04	1:05	0:50	0:45	1:45	0:50	0:50
2 Hour and 30 Minute Mobilization Time						
R02	2:20	1:50	1:45	2:55	1:50	1:45
R03 Phase a	2:05	1:40	1:40	2:30	1:35	2:10
R03 Phase b	2:10	2:00	2:15	2:45	2:10	2:25
R03 Phase c	4:05	4:15	4:25	4:00	4:20	4:30
R04	1:35	1:30	1:35	1:40	1:35	1:35
3 Hour and 30 Minute Mobilization Time (Base)						
R02	2:25	1:50	1:45	2:55	1:50	1:45
R03 Phase a	2:05	1:40	1:40	2:45	1:35	2:10
R03 Phase b	2:15	2:00	2:15	2:45	2:10	2:30
R03 Phase c	4:10	4:20	4:30	4:00	4:25	4:35
R04	1:40	1:35	1:40	1:45	1:35	1:40

Table 10-2. 100th Percentile Evacuation Time Estimates for Evacuation Readiness Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Region	**Midday**	**Midday**	**Nighttime**	**Midday**	**Midday**	**Nighttime**
30 Minute Mobilization Time						
R02	3:25	3:10	3:10	4:35	3:10	3:10
R03 Phase a	2:30	2:10	2:05	3:30	2:10	2:10
R03 Phase b	4:00	4:00	2:05	4:00	2:10	2:10
R03 Phase c	4:30	4:25	2:15	4:45	2:10	2:10
R04	3:10	3:10	3:10	3:10	3:10	3:10
2 Hour and 30 Minute Mobilization Time						
R02	3:20	3:10	3:10	4:10	3:10	3:10
R03 Phase a	3:20	3:20	3:20	3:20	3:20	3:20
R03 Phase b	5:15	5:15	5:20	5:20	5:15	5:10
R03 Phase c	5:20	5:20	5:20	5:20	5:20	5:20
R04	3:10	3:10	3:10	3:10	3:10	3:10
3 Hour and 30 Minute Mobilization Time (Base)						
R02	3:40	3:25	3:25	4:10	3:25	3:25
R03 Phase a	4:25	4:30	4:40	4:30	4:15	4:35
R03 Phase b	6:10	5:55	6:00	6:15	6:00	6:10
R03 Phase c	6:20	6:20	6:20	6:20	6:20	6:20
R04	3:40	3:25	3:25	3:40	3:25	3:25

Table 10-3. 90th Evacuation Time Estimates for Voluntary Evacuation Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Region	**Midday**	**Midday**	**Evening**	**Midday**	**Midday**	**Evening**
10 Percent Shadow (Demographic Survey)						
R01	3:30	3:05	2:30	4:00	2:50	2:25
R02	2:20	1:50	1:45	2:55	1:50	1:45
R04	1:40	1:35	1:35	1:40	1:35	1:40
R06	1:15	1:20	0:50	0:55	0:55	0:50
R07	2:05	2:00	1:50	2:05	2:00	1:50
20 Percent Shadow (Base)						
R01	3:40	3:10	2:30	4:00	2:55	2:30
R02	2:25	1:50	1:45	2:55	1:50	1:45
R04	1:40	1:35	1:40	1:45	1:35	1:40
R06	1:20	1:20	1:05	1:45	0:55	1:10
R07	2:15	2:10	1:50	2:15	2:05	1:50
60 Percent Shadow						
R01	4:00	3:30	2:55	4:30	3:20	2:45
R02	3:10	2:30	2:05	3:35	2:20	2:00
R04	2:00	1:40	1:45	2:50	1:45	1:45
R06	3:10	3:05	2:15	3:15	3:00	2:15
R07	3:05	2:50	2:05	3:10	2:45	2:10
100 Percent Shadow						
R01	4:25	3:55	3:15	4:55	3:45	3:05
R02	4:20	3:30	2:55	4:40	3:20	2:40
R04	3:35	3:00	2:20	4:40	2:35	2:15
R06	4:15	3:55	3:05	4:25	3:45	3:15
R07	4:15	3:55	3:20	4:25	3:45	3:15

Table 10-4. 100th Evacuation Time Estimates for Voluntary Evacuation Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)
Region	Midday	Midday	Nighttime	Midday	Midday	Nighttime
10 Percent Shadow (Demographic Survey)						
R01	5:10	4:15	3:25	5:35	3:45	3:25
R02	3:40	3:25	3:25	4:10	3:25	3:25
R04	3:40	3:25	3:25	3:40	3:25	3:25
R06	3:40	3:25	3:25	3:40	3:25	3:25
R07	3:40	3:25	3:25	3:40	3:25	3:25
20 Percent Shadow (Base)						
R01	5:10	4:25	3:25	5:35	4:00	3:25
R02	3:40	3:25	3:25	4:10	3:25	3:25
R04	3:40	3:25	3:25	3:40	3:25	3:25
R06	3:40	3:25	3:25	3:40	3:25	3:25
R07	3:40	3:25	3:25	3:40	3:25	3:25
60 Percent Shadow						
R01	5:45	5:05	3:55	6:10	4:40	3:50
R02	4:15	3:25	3:25	4:35	3:25	3:25
R04	3:40	3:25	3:25	3:40	3:25	3:25
R06	3:40	3:40	3:25	3:45	3:25	3:25
R07	3:55	3:55	3:25	4:00	3:25	3:25
100 Percent Shadow						
R01	7:20	5:55	4:35	7:35	5:40	4:30
R02	6:10	5:00	3:55	6:45	4:35	3:30
R04	3:40	3:40	3:25	5:25	3:25	3:25
R06	5:25	4:55	4:00	6:05	4:40	4:00
R07	5:45	5:15	4:15	6:10	5:05	4:10

Table 10-5. 90th Evacuation Time Estimates for Leaving Early Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)
Region	Midday	Midday	Nighttime	Midday	Midday	Nighttime
No One Leaves Early (Base)						
R02	2:25	1:50	1:45	2:55	1:50	1:45
R04	1:40	1:35	1:40	1:45	1:35	1:40
10% Leave Early						
R02	2:20	1:50	1:45	2:50	1:50	1:45
R04	1:40	1:35	1:40	1:40	1:35	1:40
50% Leave Early						
R02	2:10	1:35	1:35	2:45	1:40	1:35
R04	1:40	1:35	1:40	1:35	1:35	1:40
75% Leave Early						
R02	2:05	1:35	1:35	2:40	1:35	1:35
R04	1:35	1:35	1:40	1:35	1:35	1:40

Table 10-6. 100th Evacuation Time Estimates for Leaving Early Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)
Region	Midday	Midday	Nighttime	Midday	Midday	Nighttime
No One Leaves Early (Base)						
R02	3:40	3:25	3:25	4:10	3:25	3:25
R04	3:40	3:25	3:25	3:40	3:25	3:25
10% Leave Early						
R02	3:40	3:25	3:25	4:00	3:25	3:25
R04	3:40	3:25	3:25	3:40	3:25	3:25
50% Leave Early						
R02	3:40	3:25	3:25	3:45	3:25	3:25
R04	3:40	3:25	3:25	3:40	3:25	3:25
75% Leave Early						
R02	3:40	3:25	3:25	3:45	3:25	3:25
R04	3:40	3:25	3:25	3:40	3:25	3:25

Table 10-7. 90th Evacuation Time Estimates for Leaving Early & Urgent Mobilization Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)
Region	Midday	Midday	Nighttime	Midday	Midday	Nighttime
No One Leaves Early (Urgent Mobilization)						
R02	2:25	1:50	1:35	3:20	1:45	1:35
R04	1:05	0:50	0:45	1:45	0:50	0:50
10% Leave Early						
R02	2:25	1:50	1:35	3:10	1:40	1:25
R04	0:55	0:50	0:45	1:45	0:50	0:40
50% Leave Early						
R02	2:15	1:35	1:25	2:55	1:30	1:20
R04	0:50	0:45	0:40	1:40	0:40	0:40
75% Leave Early						
R02	2:05	1:30	1:15	2:45	1:25	1:15
R04	0:50	0:40	0:35	1:35	0:30	0:40

Table 10-8. 100th Evacuation Time Estimates for Leaving Early & Urgent Mobilization Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)
Region	Midday	Midday	Nighttime	Midday	Midday	Nighttime
No One Leaves Early (Urgent Mobilization)						
R02	3:25	3:10	3:10	4:10	3:10	3:10
R04	3:10	3:10	3:10	3:10	3:10	3:10
10% Leave Early						
R02	3:25	3:10	3:10	4:10	3:10	3:10
R04	3:10	3:10	3:10	3:10	3:10	3:10
50% Leave Early						
R02	3:25	3:10	3:10	4:00	3:10	3:10
R04	3:10	3:10	3:10	3:10	3:10	3:10
75% Leave Early						
R02	3:25	3:10	3:10	3:35	3:10	3:10
R04	3:10	3:10	3:10	3:10	3:10	3:10

Table 10-9. 90th Evacuation Time Estimates for Panoramic Hill Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)
Region	Midday	Midday	Nighttime	Midday	Midday	Nighttime
Two Ways Out of Panoramic Hill (Urgent Mobilization)						
R02	0:50	0:50	0:35	1:00	0:40	0:30
R04	0:45	0:50	0:35	0:40	0:35	0:30
Two Ways Out of Panoramic Hill						
R02	1:20	1:15	1:20	1:30	1:20	1:30
R04	1:20	1:15	1:20	1:30	1:20	1:30
One Way Out of Panoramic Hill (Urgent Mobilization)						
R02	1:05	1:10	0:45	1:25	0:55	0:35
R04	1:00	1:00	0:40	1:00	0:45	0:30
One Way Out of Panoramic Hill (Base)						
R02	1:20	1:15	1:20	1:30	1:20	1:30
R04	1:20	1:15	1:20	1:30	1:20	1:30

Table 10-10. 100th Evacuation Time Estimates for Panoramic Hill Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)
Region	Midday	Midday	Nighttime	Midday	Midday	Nighttime
Two Ways Out of Panoramic Hill (Urgent Mobilization)						
R02	1:00	1:00	0:45	1:15	0:45	0:40
R04	0:55	1:00	0:40	0:50	0:40	0:40
Two Ways Out of Panoramic Hill						
R02	3:40	3:25	3:25	3:40	3:25	3:25
R04	3:40	3:25	3:25	3:40	3:25	3:25
One Way Out of Panoramic Hill (Urgent Mobilization)						
R02	1:10	1:20	0:55	1:35	1:00	0:45
R04	1:05	1:05	0:45	1:10	0:50	0:40
One Way Out of Panoramic Hill (Base)						
R02	3:40	3:25	3:25	3:40	3:25	3:25
R04	3:40	3:25	3:25	3:40	3:25	3:25

Table 10-11. ADU/JADU/Middle Housing Units, People and Number of Evacuation Vehicles

Case	Number of Units	Number of People	Number of Vehicles	Number of Buses[5]
Future Case (City Wide)	18,205	43,146	20,754	0
Future Case (Hillside)	4,238	10,044	4,831	0
Future Build – ADU/JADUs Only	27,060	64,132	30,848	0
Future Build - Middle Housing Only	870	2,062	992	0
Future Build – ADUs/JADUs and Middle Housing	27,930	66,194	31,840	0
Future Build – ADUs/JADUs only with Transit Exemption	27,060	64,132	15,681	1,051
Future Build – ADU/JADUs and Middle Housing with Transit Exemption	27,930	66,194	16,673	1,051

Notes

Future Case (City Wide):	**Includes housing units that are projected to be built by the year 2031 for the City of Berkeley. Excludes any future ADU/JADU and Middle Housing developments.**
Future Case (Hillside):	**Includes the estimated number of housing units to be built in the Hillside Overlay by the year 2031. Excludes any future ADU/JADU and Middle Housing developments.**
Future Build – ADU/JADUs Only:	**The maximum number of ADU/JADUs that can be built within the Hillside Overlay.**
Future Build – Middle Housing Only:	**The estimated number of Middle Housing units that will be built in the Hillside Overlay.**
Future Build – ADUs/JADUs and Middle Housing:	**Combined number of ADU/JADUs and Middle Housing units in the Hillside Overlay.**
Future Build – ADUs/JADUs only with Transit Exemption:	**Residents living on an ADU/JADU parcel that is not required to have off-street parking would not have a personal vehicle and would instead rely on public transit to evacuate.**
Future Build – ADU/JADUs and Middle Housing with Transit Exemption:	**Same as "Future Build – ADUs/JADUs only with Transit Exemption" case with the addition of Middle Housing units.**

[5] Represented as 2 pce's in the simulations.

Table 10-12. 90th Evacuation Time Estimates for ADU/JADU/Middle Housing Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)
Region	Midday	Midday	Nighttime	Midday	Midday	Nighttime
Base						
R01	3:40	3:10	2:30	4:00	2:55	2:30
R02	2:25	1:50	1:45	2:55	1:50	1:45
R04	1:40	1:35	1:40	1:45	1:35	1:40
R05	2:05	1:55	1:45	2:20	1:55	1:45
Future Case						
R01	4:30	4:00	3:30	4:55	4:00	3:25
R02	2:55	2:30	2:10	3:20	2:20	2:10
R04	1:50	1:45	1:45	2:00	1:45	1:45
R05	2:30	2:30	2:10	2:45	2:15	2:10
Future ADUs and JADUs						
R01	6:40	6:15	5:55	6:25	6:05	5:45
R02	5:40	5:10	4:50	5:15	5:00	4:40
R04	2:55	2:55	2:40	2:30	2:45	2:40
R05	6:20	6:05	6:00	5:25	6:10	6:05
Future Middle Housing						
R01	4:40	4:10	3:35	5:00	4:05	3:30
R02	3:05	2:30	2:15	3:30	2:20	2:15
R04	1:50	1:45	1:45	2:00	1:45	1:45
R05	2:40	2:30	2:20	2:50	2:25	2:10
Future Combined						
R01	6:55	6:30	6:15	6:40	6:20	6:05
R02	5:40	5:10	5:00	5:20	5:05	4:45
R04	2:50	2:55	2:45	2:35	2:50	2:45
R05	6:35	6:50	6:10	5:35	6:20	6:20
Future ADU with Transit Exemption Zones						
R01	5:40	5:10	4:45	5:50	4:50	4:40
R02	4:25	4:15	4:00	4:20	4:05	3:50
R04	3:00	3:05	3:05	3:00	3:05	3:05
R05	5:55	5:40	5:30	4:30	5:50	5:05
Future Combined with Transit Exemption Zones						
R01	5:45	5:10	4:50	5:45	5:05	4:35
R02	4:30	4:20	4:05	4:30	4:10	3:50
R04	3:00	3:00	3:05	3:00	3:05	3:05
R05	5:50	5:45	5:35	5:00	5:50	5:25

Table 10-13. 100th Evacuation Time Estimates for ADU/JADU/Middle Housing Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)
Region	Midday	Midday	Nighttime	Midday	Midday	Nighttime
Base						
R01	5:10	4:25	3:25	5:35	4:00	3:25
R02	3:40	3:25	3:25	4:10	3:25	3:25
R04	3:40	3:25	3:25	3:40	3:25	3:25
R05	3:40	3:25	3:25	3:40	3:25	3:25
Future Case						
R01	6:10	5:35	4:45	7:05	5:15	4:35
R02	4:05	3:25	3:25	4:35	3:25	3:25
R04	3:40	3:25	3:25	3:40	3:25	3:25
R05	4:00	4:05	3:30	4:15	3:30	3:25
Future ADUs and JADUs						
R01	11:25	11:15	9:50	10:10	11:05	9:35
R02	8:35	8:25	8:05	7:45	8:15	7:40
R04	3:40	3:25	3:25	3:40	3:25	3:25
R05	8:55	9:15	9:15	7:55	9:30	8:20
Future Middle Housing						
R01	6:25	5:40	5:05	7:15	5:40	4:35
R02	4:10	3:40	3:25	4:40	3:25	3:25
R04	3:40	3:25	3:25	3:40	3:25	3:25
R05	4:00	4:10	3:45	4:20	3:40	3:25
Future Combined						
R01	11:30	11:15	10:15	10:30	11:05	11:20
R02	8:50	8:30	8:10	7:50	8:25	8:00
R04	3:40	3:30	3:25	3:40	3:25	3:25
R05	9:20	9:45	10:15	7:55	9:35	8:50
Future ADU with Transit Exemption Zones						
R01	10:35	9:50	9:10	9:30	9:50	9:00
R02	8:10	7:40	7:10	7:05	7:25	6:50
R04	3:40	3:25	3:25	3:40	3:25	3:25
R05	8:10	8:30	8:10	6:50	8:15	8:05
Future Combined with Transit Exemption Zones						
R01	10:45	10:05	9:50	9:40	9:50	9:05
R02	8:10	7:40	7:15	7:20	7:35	7:00
R04	3:40	3:30	3:25	3:40	3:25	3:25
R05	8:10	8:30	8:35	6:55	8:25	8:05

Table 10-14. 90th Evacuation Time Estimates Differences Between Build and Future Cases

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Region	**Midday**	**Midday**	**Nighttime**	**Midday**	**Midday**	**Nighttime**
ADUs and JADUs Compared to Future Case						
R01	2:10	2:15	2:25	1:30	2:05	2:20
R02	2:45	2:40	2:40	1:55	2:40	2:30
R04	1:05	1:10	0:55	0:30	1:00	0:55
R05	3:50	3:35	3:50	2:40	3:55	3:55
Middle Housing Compared to Future Case						
R01	0:10	0:10	0:05	0:05	0:05	0:05
R02	0:10	0:00	0:05	0:10	0:00	0:05
R04	0:00	0:00	0:00	0:00	0:00	0:00
R05	0:10	0:00	0:10	0:05	0:10	0:00
Combined Compared to Future Case						
R01	2:25	2:30	2:45	1:45	2:20	2:40
R02	2:45	2:40	2:50	2:00	2:45	2:35
R04	1:00	1:10	1:00	0:35	1:05	1:00
R05	4:05	4:20	4:00	2:50	4:05	4:10
ADU with Transit Exemption Zones Compared to Future Case						
R01	1:10	1:10	1:15	0:55	0:50	1:15
R02	1:30	1:45	1:50	1:00	1:45	1:40
R04	1:10	1:20	1:20	1:00	1:20	1:20
R05	3:25	3:10	3:20	1:45	3:35	2:55
Combined with Transit Exemption Zones Compared to Future Case						
R01	1:15	1:10	1:20	0:50	1:05	1:10
R02	1:35	1:50	1:55	1:10	1:50	1:40
R04	1:10	1:15	1:20	1:00	1:20	1:20
R05	3:20	3:15	3:25	2:15	3:35	3:15

Table 10-15. 100th Evacuation Time Estimates Differences Between Build and No Build Cases

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Region	**Midday**	**Midday**	**Nighttime**	**Midday**	**Midday**	**Nighttime**
ADUs and JADUs Compared to Future Case						
R01	5:15	5:40	5:05	3:05	5:50	5:00
R02	4:30	5:00	4:40	3:10	4:50	4:15
R04	0:00	0:00	0:00	0:00	0:00	0:00
R05	4:55	5:10	5:45	3:40	6:00	4:55
Middle Housing Compared to Future Case						
R01	0:15	0:05	0:20	0:10	0:25	0:00
R02	0:05	0:15	0:00	0:05	0:00	0:00
R04	0:00	0:00	0:00	0:00	0:00	0:00
R05	0:00	0:05	0:15	0:05	0:10	0:00
Combined Compared to Future Case						
R01	5:20	5:40	5:30	3:25	5:50	6:45
R02	4:45	5:05	4:45	3:15	5:00	4:35
R04	0:00	0:05	0:00	0:00	0:00	0:00
R05	5:20	5:40	6:45	3:40	6:05	5:25
ADU with Transit Exemption Zones Compared to Future Case						
R01	4:25	4:15	4:25	2:25	4:35	4:25
R02	4:05	4:15	3:45	2:30	4:00	3:25
R04	0:00	0:00	0:00	0:00	0:00	0:00
R05	4:10	4:25	4:40	2:35	4:45	4:40
Combined with Transit Exemption Zones Compared to Future Case						
R01	4:35	4:30	5:05	2:35	4:35	4:30
R02	4:05	4:15	3:50	2:45	4:10	3:35
R04	0:00	0:05	0:00	0:00	0:00	0:00
R05	4:10	4:25	5:05	2:40	4:55	4:40

Table 10-16. 90th Evacuation Time Estimates for Signal Optimization (Urgent Mobilization) Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)
Region	Midday	Midday	Evening	Midday	Midday	Evening
City of Berkeley						
R02	2:25	1:50	1:35	3:05	1:45	1:30
R04	1:05	0:50	0:40	1:45	0:45	0:45

Table 10-17. 100th Evacuation Time Estimates for Signal Optimization (Urgent Mobilization) Sensitivity Study

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)
Region	Midday	Midday	Evening	Midday	Midday	Evening
City of Berkeley						
R02	3:20	3:10	3:10	4:25	3:10	3:10
R04	3:10	3:10	3:10	3:10	3:10	3:10

11 RECOMMENDATIONS

This evacuation study explores how Berkeley's alerting systems, anticipated evacuee behaviors, estimated transportation resource needs, and roadway capacity and design will interact in large-scale emergencies. The results of this report can help inform Berkeley's disaster response planning, transportation and roadway planning, housing and land use development policies, and the individual evacuation plans of Berkeley households. This section uses the findings of this report to highlight recommendations for consideration by City officials.

Recommendations are summarized in Table 11-1.

11.1 Integrate Evacuation Study Concepts into City Policies and Response Planning

11.1.1 Emergency Response Strategies

It is recommended that the City consider integrating concepts from this Evacuation Study into emergency response plans and strategy development as described below.

The City can further contextualize evacuation time estimates in this report by overlaying evacuation time estimates with hazard-specific data (such as fire spread rates for fire regions, and tsunami arrival times on tsunami warning regions.) This integration of ETE and hazard data will help clarify the risk to the community from hazard events requiring large-scale evacuation.

The City can work to quantify likely resource shortfalls associated with the evacuation scenarios in this report through planning partnerships with transit providers serving Berkeley and the region, as well as emergency management and mutual aid partners at the Operational Area (County) and State. Section 8 identifies resource needs for transit-dependent evacuees. Planning partners can clarify regional and State capacity to provide support, as well as time estimates to mobilize those resources in localized and regional disaster scenarios.

The City can use congestion diagrams from this study (see Appendix F) to prioritize specific locations for Traffic Control Points (staff intersections and help improve traffic flow) during evacuations. Among the numerous competing life-safety needs associated with large-scale evacuations, responders can prioritize these locations for available traffic management resources to improve traffic flow and/or to reduce evacuation times. External traffic or pass-through traffic are vehicles with origins and destinations outside of the area being evacuated that pass through the area being evacuated during their trip. This traffic consumes the available roadway and transit capacity, reducing the available capacity to those most at risk, increasing congestion and prolonging ETE. During emergency evacuations, City responders can coordinate with partners to reduce or eliminate external/pass-through traffic. This can include use of electronic roadside signage, closure of off-ramps into Berkeley, and/or diversion of through traffic to other routes.

The City can encourage schools to develop and communicate site evacuation plans that enable parents and guardians to pick up their children at sites outside the evacuation zone. Making provisions for parents to pick up children outside the evacuation zone will reduce traffic congestion around schools in evacuation zones and will improve families' mobilization times.

11.1.2 Extreme Fire Weather Leave Early Policy

The Berkeley Fire Department should maintain its Leave Early Policy for extreme fire weather. Study results indicate population-level improvements such as the leave early policy could improve evacuation times by as much as 68% (Section 10.3). On the household level, Berkeley's Leave Early approach provides a targeted way for wildfire-exposed households to avoid fire evacuations. In a wildfire evacuation, fire may be present along the evacuation route, producing scorching radiant heat and oxygen-displacing gases. All evacuations involve potential for injury or death, if only from collisions and crashes.

In addition, the Fire Department may consider how the results of this study could be used to target Leave Early outreach efforts to residents who are most likely to have extended evacuation times. The policy is currently applied to all residents in Berkeley Fire Zones 2 & 3; staff may consider focusing on households at relatively greater risk due to extended mobilization times and/or on neighborhoods with extended driving times due to severe congestion.

11.1.3 Housing Development Policies

The City used this study to better understand how potential development in the Berkeley Hills could impact evacuation times (see Section 10.5). It is noted that these studies assessed impacts from the maximum potential levels of new residential development from ADUs/JADUs. These analyses therefore illustrate an upper bound of potential long-term impacts from ADU/JADU development in the Hillside Overlay. Based on the results of the study, it is recommended that the City institute separate, more restrictive ADU/JADU development provisions in the Hillside Overlay.

In addition, these studies identified impacts to evacuation times from a projection of likely development that could result from implementation of "Middle Housing" zoning changes. The results of this study indicated that in a repeat of the 1923 Fire (R02), Middle Housing could add between 5 and 10 minutes overall to ETEs. It is recommended that the City examine these increases in the context of fire spread scenarios. By overlaying fire spread data with evacuation time estimates, the City can better contextualize potential impacts to public health and safety from Middle Housing zoning changes.

Studies in Section 10.5 illustrate how increasing population density in an area, even when the added people do not own vehicles, can increase emergency evacuation times and create public safety impacts. More broadly, the City should consider impacts to evacuation when implementing zoning changes that could result in an increase in demand on roadways used by wildfire or tsunami evacuees. Simulation modeling could be employed to assess the impact of proposed development policies on evacuation times and congestion levels under emergency scenarios. This proactive approach can ensure that policymakers are able to consider emergency evacuation as part of the decision-making process.

11.2 Community Education and Household Evacuation Planning

Evacuation times, both for households and general populations at risk, are influenced by how quickly community members are alerted to an Evacuation Warning or Order, how quickly they can mobilize to begin their evacuation trips, and how quickly they can navigate the roadways to escape the hazard area. Reducing time in any of these three areas will speed individual and overall evacuation times and improve community safety in hazard events.

11.2.1 Community Alerting

The City of Berkeley maintains multiple emergency alerting systems for coordinated use in emergency evacuations, as described in Section 5.

It is recommended that the City consider conducting community education about Berkeley's evacuation zones, as well as the emergency alerting systems that will provide evacuation orders/warnings, and how community members can register for/opt-in to those systems. If the public is ready to receive emergency alerts, they can more quickly move into mobilization.

Additionally, the City should consider education to encourage potential evacuees to monitor evolving conditions and advisory announcements as well as maintain ongoing contact and communications with neighbors, friends, family members, support teams, and social media networks. These social connections will improve the distribution of the City's emergency alert information within the affected population. These social connections may also reduce mobilization time by connecting an evacuee to help with packing, carpooling, or ensuring they have an evacuation location ready with friends or family.

During an emergency evacuation, people outside the hazard area, who are not under evacuation order or warning, may still voluntarily evacuate. These voluntary evacuations reduce the available roadway capacity and contribute to traffic congestion. This increases evacuation times for people trying to escape the hazard area.[1] Public information and public messaging about who is at risk should be clear before and during an emergency so that community members who are not at risk are less likely to contribute to traffic congestion. The City may also consider including explicit instructions for people outside the hazard area to shelter in place, in order to reduce demand on roadways.

11.2.2 Improving Household Mobilization and Evacuation Travel Times

Mobilization is how quickly evacuees prepare to leave and enter the roadway system. Berkeley community members could take as long as 3.5 hours to mobilize. Higher mobilization times are associated with particular household decisions, such as waiting for commuters to return home, picking up children at school, or returning to the evacuation zone for any reason.

Evacuation travel time, or how long a vehicle is on the road, is increased with roadway

[1] Voluntary evacuation during an active wildfire is distinct from Berkeley Hills residents following Fire Department recommendations to leave early due to extreme fire weather, before a fire starts.

congestion. Reductions in vehicular traffic during emergency evacuations will help reduce congestion and speed evacuation travel times.

11.2.2.1 Community Education

The City should consider the results of this study when designing community education about household-level evacuation readiness. Community education may include the following concepts:

- Evacuees with vehicles should carpool (i.e., evacuate as a household in a single vehicle) to the extent possible to reduce the number of vehicles on the road, which will lessen traffic congestion and could reduce evacuation time. Evacuees with vehicle access should also be encouraged to include transit-dependent neighbors in their evacuation plans. Similarly, transit-dependent evacuees should be encouraged to improve their mobilization times by connecting with neighbors and making plans to carpool in an emergency evacuation.
- Evacuees should understand and practice using primary, secondary, and tertiary evacuation routes. An ability to react to changing conditions will improve a household's evacuation travel time and will contribute to a reduction in overall evacuation times by distributing traffic on available roadways (see Section 9).
- Parents and guardians should engage with their children's schools regarding evacuation plans, with the goal of reducing trips to pick up children from schools within an evacuation zone. Making provisions for parents to pick up children outside the evacuation zone will reduce traffic congestion around schools in evacuation zones and will improve families' mobilization times.
- Households should plan for commuters to remain outside of the evacuation zone and reunite with other household members outside the hazard area, instead of returning to the evacuation zone. This will reduce the household mobilization time.

11.2.3 Evacuating on Bicycle and Foot

The analysis in this document focuses on simulating and measuring vehicular traffic: 96.6% of Berkeley community members report that they plan to use a vehicle to evacuate. This high percentage is unsurprising, as many people will want to bring their valuable and sentimental items with them in an evacuation, and many people are not physically able and/or equipped to quickly leave on bike or foot.

However, some Berkeley community members plan to use bicycles or to walk during an evacuation. According to the demographic survey, citywide 2.2% of Berkeley residents, employees, and college students plan to evacuate on foot and 1.4% of people plan to evacuate on bicycle. In the hills specifically, these numbers decrease to 1.5% on foot and 0.5% on bicycle. This distinction could reflect the characteristics of the road network, which is winding, narrow, with significant elevation changes, versus relatively flat, wide, and gridded in the flats.

In addition to location, community members might be opting to walk or bike out for different reasons. Some households use bicycles and walking as their primary means of transportation. Others may not own or have access to a vehicle (which was the case for 7.5% of survey respondents Citywide). Still others may believe they will be able to evacuate more quickly on a bike or on foot than they could a vehicle. Past experience from the 1991 Oakland-Berkeley Hills Fire, as well as the analysis in this document, demonstrate the likelihood of significant traffic congestion in a fire, leading to the possibility that a fire could move faster than evacuating vehicles and overtake them.

From an individual evacuee perspective, the key issues to weigh in a cycling or pedestrian evacuation are speed and safety. The risks of driving out of an evacuating area are well-understood: collisions and traffic congestion can impede the evacuee's ability to escape the hazard area, creating the potential for exposure to the hazard while evacuating. Stated simply, there is an understood possibility that evacuees in vehicles could be stuck in traffic and overtaken by fire.

The assumption is that evacuating on foot or bike might be faster than evacuating in a vehicle. This analysis was not in the scope of this project.

The second key issue relates to evacuee safety. The risks present for people evacuating in vehicles (collisions and exposure to the hazard) are present for cyclists and pedestrians, and because of the lack of basic protections provided by the metal frame of a vehicle, they are heightened. Collisions are likely during evacuations, considering the high volume of people sharing the roadway under highly stressful conditions. The same collision may cause minor injuries/damage for a driver in a vehicle while a cyclist or pedestrian experiences serious injury or death. In addition, a significant injury would also divert critical emergency resources away from firefighting to attend to and transport patient(s) to the emergency room.

Secondly, exposure to the hazard at hand is also heightened for the cyclist or pedestrian. For instance, in a wildfire evacuation, fire may be present along the evacuation route, producing radiant heat and gases. Evacuees in vehicles have some protection from surrounding environmental conditions, reducing the initial impact of proximal wildfire. Evacuees on foot or bicycle will be exposed to scorching radiant heat and oxygen-displacing gases that are likely to significantly impact their ability to successfully evacuate an impacted area.

Berkeley's public safety officials recommend that biking and walking be considered as part of a household evacuation plan for a tsunami. This analysis does not assess the relative speeds of walking/biking compared to driving. Berkeley's public safety officials recommend that in some cases, for some individuals, walking or biking will provide a faster means of egress than driving. However, the circumstances under which walking or biking should be considered a primary means of egress are very specific and very limited.

<u>Tsunami</u>

In a tsunami, the potential area of impact has distinct geographic boundaries. If an evacuee can get outside of the inundation zone, they can reasonably assume that they will have made it to safety. In a tsunami, the arrival time and predicted location of the danger can be pre-defined.

These are advantages when evacuating on a bike or on foot – as long as the tsunami has not arrived, the fastest mode of travel that works for the individual will be the best option.

Depending on a tsunami's origin, an evacuee may be notified multiple hours in advance of its arrival onshore, allowing time with which they can safely navigate Berkeley's roadways on bike or on foot before a tsunami arrives. This means that a pedestrian or bicycling evacuation could be integrated as a primary option for a household or business tsunami evacuation plan. People who plan to bike or walk as their primary means of egress should evacuate at the earliest possible opportunity.

Wildfire

Wildfire presents a very different set of challenges from tsunami. The area of potential wildfire impact is not clearly defined and is highly dynamic due to the nature of wildfire spread. In a wildfire, the potential ignition locations are endless. A wildfire may start far away from Berkeley and grow before it impacts the community. Alternately, it may start within Berkeley. The speed of fire spread is variable depending on topography, fuel, and weather conditions. Ember cast can also ignite spot fires in advance of the main flame front.

Berkeley's public safety officials do not currently recommend biking or walking as a primary evacuation plan for wildfire. While, under some circumstances for some people, pedestrian or bicycle evacuation could potentially provide a faster means of egress than using a car, there are significant safety risks associated with this approach.

Ultimately, the decisions about when and how to evacuate belong to individuals, who will decide based on their own risk tolerance. All evacuations involve potential for injury or death, if only from collisions and crashes. The lowest-risk option is to pre-emptively leave the Berkeley Hills on days when the Berkeley Fire Department has declared extreme fire weather.

Cycling and walking: Impacts to overall evacuation times

This study does not specifically explore how overall roadway evacuation times change with a multimodal evacuation because of the 3.6% of evacuees citywide who plan to bike or walk instead of using a vehicle.

It could be posited that fewer cars on the roadway reduce vehicular congestion and could increase driving speeds. But it is beyond the scope of the study to identify how the interactions among cars, cyclists, and pedestrians leaving together sharing a roadway would change with additional cyclists/pedestrians and fewer vehicles. It is unknown whether a significant increase in people opting to evacuate via bicycle or on foot will significantly change overall evacuation times.

If it were assumed that cyclists and pedestrians could be considered removed from the roadways based on their chosen mode of egress, the sensitivity study examining the impacts to evacuation times from community members leaving the Berkeley hills early during extreme fire weather could serve as a proxy to define what kind of impacts on vehicular evacuation times would be created from more people opting to evacuate on foot or bike. (See Section 10.3 for details.)

While community members' evacuation plans may differ, it is critical that each household has a plan that all members understand, that they practice the plan together, and that each person is able to perform their role under significant stress.

11.3 Increasing Roadway Capacity and Connectivity

These recommendations focus on how the roadway capacity (number of vehicles that can be processed in a given amount of time) and connectivity (route choice for evacuating vehicles) can be increased. The higher the roadway capacity and connectivity, the lower the evacuation time (with the same evacuating demand).

11.3.1 Traffic Calming Devices

This analysis indicates that the Traffic Calming Devices (TCDs) throughout the city are performing as designed, effectively reducing vehicular speeds and thus reducing the risk of severe injury and/or fatality traffic crashes. However, this intended function conflicts with the goal of evacuation, which is to expedite the egress of individuals from the affected area.

Appendix F identifies patterns of traffic congestion during evacuation and Appendix G highlights particular roadway constraints and traffic calming devices with notable impacts across various evacuation regions studied. It is strongly recommended that the City of Berkeley consider the following actions:

- Existing Infrastructure: Develop a citywide connectivity and evacuation capacity improvement strategy, integrating approaches such as actuated or adaptive signal timing and replacing TCDs with removable/retractable options, and other evolving technologies.
- Future infrastructure: Develop and implement a methodology to evaluate and consider evacuation efficiency and roadway capacity during the planning and implementation phases of future roadway infrastructure development, including TCD installations.
- First Responder response times: Develop and implement a methodology to assess impacts from TCDs to first responder response times in daily traffic environments.

11.3.2 Traffic Signal Improvements

Traffic signals are essential to the safe and efficient functioning of the roadway network and play a critical role during emergency evacuations. Their effectiveness in such scenarios is greatly enhanced when they remain operational during power outages and feature signal timing plans that are both optimized and adaptable to real-time traffic conditions. These capabilities help minimize the need for emergency personnel to manually direct traffic, allowing those resources to be deployed to more urgent, lifesaving duties.

To improve the resilience, coordination, and functionality of the City's traffic signal infrastructure, the following actions are recommended:

- Optimize Signal Timing Plans: Evaluate and implement improved signal timing strategies, including actuated and/or adaptive systems, to better manage traffic flow day-to-day and during emergencies. (See Section 10.6.) Many existing signals in the city are pre-timed and lack flexibility. Adaptive signal control is particularly valuable during evacuations, as it can automatically adjust signal timings in response to real-time traffic conditions, helping to move large volumes of vehicles more efficiently and reduce congestion along key evacuation corridors.

- Install Battery Backup Systems: Upgrade all traffic signal cabinets to include battery backup systems that can operate for a minimum of 6-8 hours, ensuring continued signal operation during power outages and maintaining safe and coordinated traffic movement during evacuations.
- Enhance Emergency Vehicle Pre-emption: Evaluate potential improvements to traffic signal system to have the latest pre-emption equipment and capabilities. Pre-emption for Fire and Police Department vehicles is essential during day-to-day emergencies and evacuation events, as it allows responders to override normal signal operations, receive immediate green lights, and avoid delays. This capability ensures faster responder access to hazardous areas, supports evacuation logistics, and improves overall public safety and emergency response times.
- Strengthen Communications Infrastructure: Install a robust fiber-optic network to improve the reliability and speed of traffic signal communications. A strong communications backbone enables real-time monitoring and coordination, even if parts of the system experience disruptions.
- Deploy Smart Traffic Cameras: Install smart traffic cameras at key intersections and corridors to provide real-time detection, monitoring, and traffic data collection. These technologies support situational awareness, enable quicker response to traffic conditions, and facilitate adaptive signal control during emergencies.
- Implement Transit Signal Priority (TSP): Upgrade traffic signal system along Berkeley's highest capacity routes to ensure that public transit vehicles can move efficiently through congested corridors, reducing delays, and maximizing their ability to transport large numbers of people during day-to-day operations as well as evacuations.
- Coordinate Regionally: Work closely with surrounding jurisdictions to ensure interoperability and synchronization of traffic signal systems during emergency evacuations. Coordinated regional signal operations will help maintain consistent traffic flow, reduce delays at jurisdictional boundaries, and support broader evacuation strategies.
- Traffic Signal Software for Centralized Control: Assess the need for traffic signal software upgrades to enable full communication with external systems and centralized command through the City's envisioned Traffic Management Center (TMC). This ensures operators can remotely monitor and adjust traffic signals citywide during emergencies.

11.4 Parking Restrictions

Although temporary and permanent parking restrictions (such as red curbing) are unlikely to substantially improve evacuation flow (see Section 9), the City could consider the strategic implementation of parking restrictions along arterial roadways in the Berkeley Hills, with a focus on those roadways predominantly utilized by emergency response vehicles for ingress during emergency response. This targeted approach would optimize maneuverability and reduce potential impedance for essential services without imposing broad restrictions that are unlikely to significantly improve overall evacuation egress flow.

The City may also evaluate and determine if temporary parking restrictions implemented on certain roadway segments only during hazardous conditions (e.g., fire weather) could improve responder ingress times during evacuation.

Table 11-1. Summary of Recommendations for Consideration by the City of Berkeley

Recommendation		Reasoning
1	**Emergency Response Strategies**	
1.1	Overlay evacuation time estimates with hazard-specific data (such as fire spread rates for fire regions, and tsunami arrival times on tsunami warning regions.)	This integration of ETE and hazard data will help clarify the risk to the community from hazard events requiring large-scale evacuation.
1.2	Develop regional/State planning partnerships to quantify resource shortfalls for transit-dependent evacuees.	Understanding resource shortfalls will inform approaches to address evacuation needs for transit-dependent evacuees.
1.3	Use study results to prioritize specific locations for Traffic Control Points (staffed intersections that help improve traffic flow) during evacuations.	Reduce congestion and improve traffic flow in evacuations.
1.4	During evacuations, reduce or eliminate external/pass-through traffic. This can include use of electronic roadside signage, closure of I-80 and CA-24 off-ramps into Berkeley, and/or diversion of through traffic to other routes.	Reduce roadway demand to reduce congestion and improve traffic flow in evacuations.
1.5	Encourage schools to develop and communicate site evacuation plans that enable parents and guardians to pick up their children at sites outside the evacuation zone.	Reduce traffic congestion around schools in evacuation zones and improve families' mobilization times.
2	**Extreme Fire Weather Leave Early Policy**	
2.1	Maintain Berkeley Fire Department Leave Early Policy for extreme fire weather. Focus on households at relatively greater risk due to extended mobilization times and/or on neighborhoods with extended driving times due to severe congestion.	Improve population-level evacuation times by reducing roadway demand. Reduce hazard exposure to evacuees by avoiding emergency evacuation altogether. Focus on populations most likely to have poor evacuation outcomes.

3	**Housing Development Policies**	
3.1	Institute separate, more restrictive ADU/JADU development provisions in the Hillside Overlay.	Mitigate potential impacts to evacuation times from ADU/JADU development in Berkeley's Hillside Overlay.
3.2	Examine ETE increases from Middle Housing zoning changes in the Hillside Overlay in the context of fire spread scenarios.	Contextualize potential impacts to public health and safety from Middle Housing zoning changes in order to mitigate potential impacts to evacuation times from Middle Housing development in Berkeley's Hillside Overlay.
3.3	Consider impacts to evacuation when implementing zoning changes that could result in an increase in demand on roadways used by wildfire or tsunami evacuees.	Provide data measuring public safety impacts from increased population density to decisionmakers. Update response plans to account for changes to evacuation time estimates.
4	**Community Alerting**	
4.1	Conduct community education about Berkeley's evacuation zones, the emergency alerting systems that will provide evacuation orders/warnings, and how community members can register for/opt-in to those systems.	If the public is ready to receive emergency alerts, they can more quickly move into mobilization.
4.2	Conduct community education to encourage potential evacuees to monitor evolving conditions and stay in contact with social networks.	Improve distribution of the City's emergency alert information within the affected population. Connecting potential evacuees to people who can help with evacuation preparedness to reduce mobilization times.
4.3	Clearly define areas at risk as well as areas not at risk in public alerts. Include explicit instructions for people outside the hazard area to shelter in place.	Reduce roadway demand.

5 Improving Household Mobilization and Evacuation Travel Times	
5.1 Encourage carpooling.	Lessen traffic congestion and reduce evacuation times. Reduce mobilization times for transit-dependent populations.
5.2 Encourage familiarity with primary, secondary, and tertiary evacuation routes.	Improve household evacuation time. Help reduce overall evacuation times by distributing traffic on available roadways.
5.3 Parents should make provisions with schools to pick up children outside the evacuation zone.	Reduce traffic congestion around schools in evacuation zones. Improve families' mobilization times.
5.4 Commuters should plan to remain outside of the evacuation zone and reunite with other household members outside the hazard area, instead of returning to the evacuation zone.	Reduce household mobilization times.
6 Evacuating on Bicycle and Foot	
6.1 Encourage community members to explore walking or cycling for household/business tsunami evacuation plans.	Walking or cycling may provide a faster escape from the tsunami inundation zone than vehicular evacuation. Tsunami areas of impact/locations of danger are clearly defined. Tsunami arrival times can be anticipated, often with multiple hours of advanced notice.
7 Traffic Calming Devices	

7.1 Existing Infrastructure: Develop a citywide connectivity and evacuation capacity improvement strategy, integrating approaches such as actuated or adaptive signal timing and replacing TCDs with removable/retractable options, and other evolving technologies.	Improve traffic flow and reduce congestion during evacuations while retaining pedestrian and cyclist protections for day-to-day use.
7.2 Future infrastructure: Develop and implement a methodology to evaluate and consider evacuation efficiency and roadway capacity during the planning and implementation phases of future roadway infrastructure development, including TCD installations.	Improve traffic flow and reduce congestion during evacuations while retaining pedestrian and cyclist protections for day-to-day use.
7.3 First Responder response times: Develop and implement a methodology to assess impacts from TCDs to first responder response times in daily traffic environments.	Provide data on public safety impacts of TCDs to decisionmakers.
8 Traffic Signal Improvements	
8.1 Optimize Signal Timing Plans: Evaluate and implement improved signal timing strategies, including actuated and adaptive systems.	Better manage traffic flow day-to-day and during emergencies.
8.2 Install Battery Backup Systems: Upgrade all traffic signal cabinets to include battery backup systems that can operate for a minimum of 6-8 hours.	Ensure continued signal operation during power outages and maintain safe and coordinated traffic movement during evacuations.
8.3 Enhance Emergency Vehicle Pre-emption: Evaluate potential improvements to traffic signal system to have the latest pre-emption equipment and capabilities.	Ensures faster emergency response times in both day-to-day and evacuation scenarios.

8.4	Strengthen Communications Infrastructure: Install a robust fiber-optic network to improve the reliability and speed of traffic signal communications.	Enable real-time monitoring and coordination, even if parts of the system experience disruptions.
8.5	Deploy Smart Traffic Cameras: Install smart traffic cameras at key intersections and corridors to provide real-time detection, monitoring, and traffic data collection.	Support situational awareness, enable quicker response to traffic conditions, and facilitate adaptive signal control during emergencies.
8.6	Implement Transit Signal Priority (TSP) for public transit vehicles: Upgrade traffic signal system along Berkeley's highest capacity routes.	Ensure that public transit vehicles can move efficiently through congested corridors, reducing delays, and maximizing their ability to transport large numbers of people during day-to-day operations as well as evacuations.
8.7	Coordinate Regionally: Work closely with surrounding jurisdictions to ensure interoperability and synchronization of traffic signal systems during emergency evacuations.	Help maintain consistent traffic flow, reduce delays at jurisdictional boundaries, and support broader evacuation strategies.
8.8	Traffic Signal Software for Centralized Control: Assess the need for traffic signal software upgrades to enable full communication with external systems and centralized command through the City's envisioned Traffic Management Center (TMC).	Ensure operators can remotely monitor and adjust traffic signals citywide during emergencies.
9	**Parking Restrictions**	
9.1	Explore parking restrictions along arterial roadways in the Berkeley Hills utilized by emergency response vehicles for ingress during emergency response.	Improve emergency responder ingress times during evacuations.

9.2	Explore temporary parking restrictions implemented on certain roadway segments only during hazardous conditions (e.g., fire weather).	Improve emergency responder ingress times during evacuations.

APPENDIX A

Glossary of Traffic Engineering Terms

A. GLOSSARY OF TRAFFIC ENGINEERING TERMS

This appendix provides a glossary of traffic engineering terms that are used throughout this report.

Table A-1. Glossary of Traffic Engineering Terms

Term	Definition
Analysis Network	A graphical representation of the geometric topology of a physical roadway system, which is comprised of directional links and nodes.
Link	A network link represents a specific, one-directional section of roadway. A link has both physical (length, number of lanes, topology, etc.) and operational (turn movement percentages, service rate, free-flow speed) characteristics.
Measures of Effectiveness	Statistics describing traffic operations on a roadway network.
Node	A network node generally represents an intersection of network links. A node has control characteristics, i.e., the allocation of service time to each approach link.
Origin	A location attached to a network link, within the city or Shadow Region, where trips are generated at a specified rate in vehicles per hour (vph). These trips enter the roadway system to travel to their respective destinations.
Prevailing Roadway and Traffic Conditions	Relates to the physical features of the roadway, the nature (e.g., composition) of traffic on the roadway and the ambient conditions (weather, visibility, pavement conditions, etc.).
Service Rate	Maximum rate at which vehicles, executing a specific turn maneuver, can be discharged from a section of roadway at the prevailing conditions, expressed in vehicles per second (vps) or vph.
Service Volume	Maximum number of vehicles which can pass over a section of roadway in one direction during a specified time period with operating conditions at a specified Level of Service (The Service Volume at the upper bound of Level of Service, E, equals Capacity). Service Volume is usually expressed as vph.
Signal Cycle Length	The total elapsed time to display all signal indications, in sequence. The cycle length is expressed in seconds.

Term	Definition
Signal Interval	A single combination of signal indications. The interval duration is expressed in seconds. A signal phase is comprised of a sequence of signal intervals, usually green, yellow, red.
Signal Phase	A set of signal indications (and intervals) which services a particular combination of traffic movements on selected approaches to the intersection. The phase duration is expressed in seconds.
Traffic (Trip) Assignment	A process of assigning traffic to paths of travel in such a way as to satisfy all trip objectives (i.e., the desire of each vehicle to travel from a specified origin in the network to a specified destination) and to optimize some stated objective or combination of objectives. In general, the objective is stated in terms of minimizing a generalized "cost". For example, "cost" may be expressed in terms of travel time.
Traffic Density	The number of vehicles that occupy one lane of a roadway section of specified length at a point in time, expressed as vehicles per mile (vpm).
Traffic (Trip) Distribution	A process for determining the destinations of all traffic generated at the origins. The result often takes the form of a Trip Table, which is a matrix of origin-destination traffic volumes.
Traffic Simulation	A computer model designed to replicate the real-world operation of vehicles on a roadway network, so as to provide statistics describing traffic performance. These statistics are called Measures of Effectiveness (MOE).
Traffic Volume	The number of vehicles that pass over a section of roadway in one direction, expressed in vph. Where applicable, traffic volume may be stratified by turn movement.
Travel Mode	Distinguishes between private auto, bus, rail, pedestrian and air travel modes.
Trip Table or Origin-Destination Matrix	A rectangular matrix or table, whose entries contain the number of trips generated at each specified origin, during a specified time period, that are attracted to (and travel toward) each of its specified destinations. These values are expressed in vph or in vehicles.
Turning Capacity	The capacity associated with that component of the traffic stream which executes a specified turn maneuver from an approach at an intersection.

APPENDIX B

Detailed Description of Study Procedure

B. DETAILED DESCRIPTION OF STUDY PROCEDURE

This appendix describes the activities that were performed to compute the Evacuation Time Estimates. The individual steps of this effort are represented as a flow diagram in Figure B-1. Each numbered step in the description that follows corresponds to the numbered element in the flow diagram.

Step 1

The first activity was to obtain Evacuation Zone information and create a geographic information system (GIS) base map. The study area is bounded by I-580, Piedmont Avenue, Moraga Avenue, State Route 13 and State Route 24 to the south and southeast, by the boundary of Tilden Park to the east, by Moeser Lane, San Pablo Avenue, Potrero Avenue, S 55th Street, and Bayview Avenue to the North, and by San Francisco Bay and I-580 to the West. The area that is outside of the city limits but within the study area boundary is called the Shadow Region. The base map incorporates the local roadway topology, a suitable topographic background and the Evacuation Zone boundaries.

Step 2

2020 Census block population and Census population growth (using 2023[1] population estimates published by the US Census) information was obtained in GIS format. This information was used to project the permanent resident population within the Evacuation Zones and Shadow Region to the year 2024 and to define the spatial distribution and demographic characteristics of the population within the study area.

Employee data were provided by the city and supplemented by the U.S. Census Longitudinal Employer-Household Dynamics from the OnTheMap Census analysis tool[2].

Visitor information is based on parking lot capacities within the city and the average annual tourists that visit the City of Berkeley.

Schools, medical facilities and juvenile homes data were provided by the City of Berkeley supplemented with internet searches.

Step 3

A kickoff meeting was conducted with major stakeholders. The purpose of the kickoff meeting was to present an overview of the work effort, identify key agency personnel, and indicate the data requirements for the study. Specific requests for information were presented to the city. Unique features of the study area were discussed to identify the local concerns that should be addressed by the ETE study.

[1] The annual population estimates prepared by the Census Bureau for the entire U.S. involves an extensive data gathering process. As such, population estimates are a year behind – 2024 data will be released in 2025. Thus, this 2024 update uses the 2023 census population estimates. The schedule for release of Census data is provided on the Census website: https://www.census.gov/programs-surveys/popest/about/schedule.html

[2] https://onthemap.ces.census.gov/

Step 4

Next, a physical survey of the roadway system in the study area was conducted to determine the geometric properties of the roadway sections, the channelization of lanes on each section of roadway, whether there are any turn restrictions or special treatment of traffic at intersections, the type and location of traffic calming devices, the type and functioning of traffic control devices, gathering signal timings for pre-timed traffic signals, and to make the necessary observations needed to estimate realistic values of roadway capacity.

Step 5

A demographic survey of households within the City of Berkeley was conducted to identify household dynamics, trip generation characteristics, and evacuation-related demographic information of the city population. This information was used to determine important study factors including the average number of evacuating vehicles used by each household, and the time required to perform pre-evacuation mobilization activities.

Step 6

A computerized representation of the physical roadway system, called a link-node analysis network, was developed using the UNITES software developed by KLD (See Section 1.3). Once the geometry of the network was completed, the network was calibrated using the information gathered during the road survey (Step 4). Estimates of roadway capacity for each link and other link-specific characteristics were introduced to the network description. Traffic signal timings were input accordingly. The link-node analysis network was imported into a GIS map. Census data was overlaid in the map, and origin centroids where trips would be generated during the evacuation process were assigned to appropriate links.

Step 7

The study area includes 106 Evacuation Zones. Regions (groupings of Evacuation Zones) that may be ordered to evacuate, were developed.

The need for evacuation can occur over a range of times, or variations of time-of-day, day-of-week, and season. Scenarios were developed to capture the variation in evacuation demand, roadway capacity and mobilization time, for different times of day, days of the week, and times of year.

Step 8

The input stream for the DYNEV II model, which integrates the dynamic traffic assignment and distribution model, DTRAD, with the evacuation simulation model, was created for a prototype evacuation case – the evacuation of all Evacuation Zones for a representative scenario.

Step 9

After creating this input stream, the DYNEV II System was executed on the prototype evacuation case to compute evacuating traffic routing patterns. DYNEV II contains an extensive suite of data diagnostics which check the completeness and consistency of the input data specified. The analyst reviews all warning and error messages produced by the model and then corrects the database to create an input stream that properly executes to completion.

The model assigns destinations to all origin centroids consistent with a (general) outbound evacuation of the Evacuation Zones and Shadow Region, away from the hazard. The analyst may optionally supplement and/or replace these model-assigned destinations, based on professional judgment, after studying the topology of the analysis roadway network. The model produces link and network-wide measures of effectiveness as well as estimates of evacuation time.

Step 10

The results generated by the prototype evacuation case are critically examined. The examination includes observing the animated graphics (using the Evacuation Animator (EVAN) software which operates on data produced by DYNEV II) and reviewing the statistics output by the model. This is a labor-intensive activity, requiring the direct participation of skilled engineers who possess the necessary practical experience to interpret the results and to determine the causes of any problems reflected in the results.

Essentially, the approach is to identify those bottlenecks in the network that represent locations where congested conditions are pronounced and to identify the cause of this congestion. This cause can take many forms, either as excess demand due to high rates of trip generation, improper routing, a shortfall of capacity (as in a traffic calming device), or as a quantitative flaw in the way the physical system was represented in the input stream. This examination leads to one of two conclusions:

- The results are satisfactory; or
- The input stream must be modified accordingly.

This decision requires, of course, the application of the user's judgment and experience based upon the results obtained in previous applications of the model and a comparison of the results of the latest prototype evacuation case iteration with the previous ones. If the results are satisfactory in the opinion of the user, then the process continues with Step 13. Otherwise, proceed to Step 11.

Step 11

There are many "treatments" available to the user in resolving apparent problems. These treatments range from decisions to reroute the traffic by assigning additional evacuation destinations for one or more sources, imposing turn restrictions where they can produce significant improvements in capacity, changing the control treatment at critical intersections so as to provide improved service for one or more movements, or in prescribing specific treatments for channelizing the flow so as to expedite the movement of traffic along major roadway systems. Such "treatments" take the form of modifications to the original prototype evacuation case input stream. All treatments are designed to improve the representation of evacuation behavior.

Step 12

As noted above, the changes to the input stream must be implemented to reflect the modifications undertaken in Step 11. At the completion of this activity, the process returns to Step 9 where the DYNEV II System is again executed.

Step 13

The prototype evacuation case was used as the basis for generating all region and scenario-specific evacuation cases to be simulated. This process was automated through the UNITES user interface. For each specific case, the population to be evacuated, the trip generation distributions, the roadway capacity and speeds, and other factors are adjusted to produce a customized case-specific data set.

Step 14

All evacuation cases are executed using the DYNEV II System to compute ETE. Once results were available, quality control procedures were used to assure the results were consistent, dynamic routing was reasonable, and traffic congestion/bottlenecks were addressed properly.

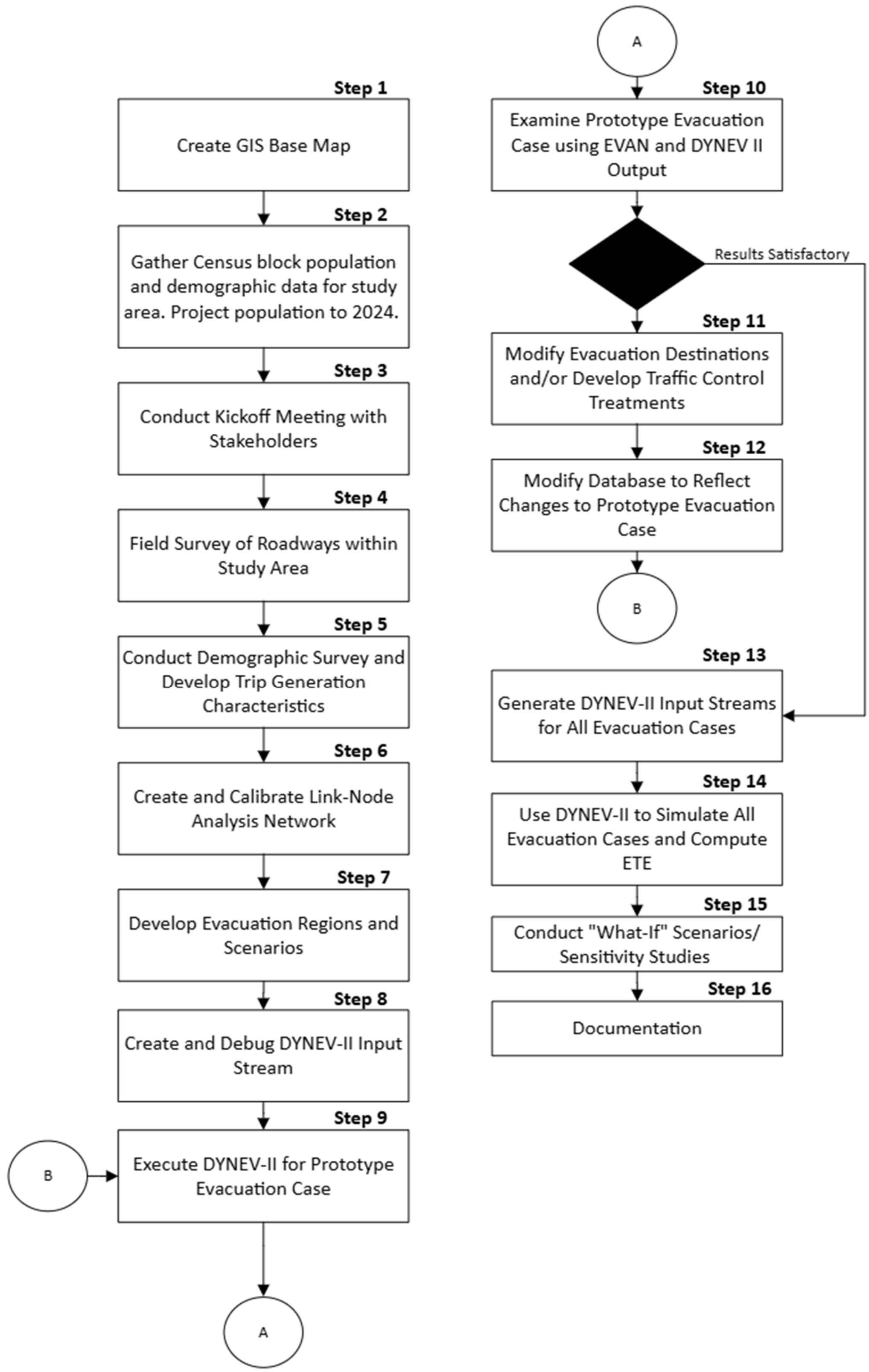
Step 15

Several ETE sensitivity studies were conducted to consider the impact on ETE based on "what if" scenarios. These scenarios were then compared to the baseline ETE (if possible) to test if certain tactics could be used to reduce evacuation time or to see the impact of changes in evacuating demand or roadway supply.

Step 16

The simulation results are analyzed, tabulated and graphed. The results were then documented.

Figure B-1. Flow Diagram of Activities



APPENDIX C

Facility Data

C. FACILITY DATA

This appendix lists population information, as of December 2024, for special facilities that were used in this study. Special facilities are defined as schools, preschools/day care centers, medical facilities, and juvenile homes. Maps of each school, preschool/day care center, medical facility, and juvenile home are provided. The estimates of tourist and employee population (see Section 3, Sub-sections 3.3 and 3.4, respectively) are summarized in the tables below.

Table C-1. K-12 Schools and Higher Education Sites within the City of Berkeley

Area(s)	Evacuation Zone	School Name	Street Address	Municipality	Enroll-ment
Berkeley Flats	BER-E014	Berkeley Rose Waldorf School	2515 Hillegass Ave	Berkeley	97
Berkeley Flats	BER-E014	Berkeley School of Theology	2606 Dwight Way	Berkeley	65
Berkeley Flats	BER-E025	Ruth Acty Elementary School	1400 Ada St	Berkeley	433
Berkeley Flats	BER-E025	The Crowden School	1475 Rose St	Berkeley	75
Berkeley Flats	BER-E026	Martin Luther King Middle School	1781 Rose St	Berkeley	1,007
Berkeley Flats	BER-E027	School of the Madeleine	1225 Milvia St	Berkeley	337
Berkeley Flats	BER-E038	Bayhill High School	1940 Virginia St	Berkeley	73
Berkeley Flats	BER-E038	Berkeley Arts Magnet at Whittier School	1645 Milvia St	Berkeley	407
Berkeley Flats	BER-E044	Berkeley City College	2050 Center St	Berkeley	6,519
Berkeley Flats	BER-E044	Berkeley High School	1980 Allston Way	Berkeley	3,427
Berkeley Flats	BER-E044	California Jazz Conservatory	2087 Addison St	Berkeley	88
Berkeley Flats	BER-E044	Pacific Boychoir Academy	215 Ridgeway Ave	Berkeley	30
Berkeley Flats	BER-E045	Berkwood Hedge School	1809 Bancroft Way	Berkeley	128
Berkeley Flats	BER-E046	Oxford Elementary at West Campus	1222 Univ Ave	Berkeley	256
Berkeley Flats	BER-E046	The Berkeley School	1310 University Ave	Berkeley	236
Berkeley Flats	BER-E052	Longfellow Arts and Technology Middle School	1500 Derby St	Berkeley	504
Berkeley Flats	BER-E053	Acupuncture and Integrative Medicine College-Berkeley	2550 Shattuck Ave	Berkeley	153
Berkeley Flats	BER-E053	Berkeley Technology Academy	2701 Mlk Jr. Way	Berkeley	36
Berkeley Flats	BER-E053	Walden Center & School	2446 Mckinley Ave	Berkeley	84
Berkeley Flats	BER-E053	Washington Elementary School	2300 Mlk Jr. Way	Berkeley	416
Berkeley Flats	BER-E054	East Bay School for Boys	2340 Durant Ave	Berkeley	105
Berkeley Flats	BER-E054	Institute of Buddhist Studies	2140 Durant Ave	Berkeley	53
Berkeley Flats	BER-E064	Sylvia Mendez Elementary School	2840 Ellsworth St	Berkeley	409
Berkeley Flats	BER-E065	The Elmwood Academy	2722 Benvenue Ave	Berkeley	100
Berkeley Flats	BER-E065	Willard Middle School	2425 Stuart St	Berkeley	669
Berkeley Flats	BER-E070	Malcolm X Elementary School	1731 Prince St	Berkeley	552

Area(s)	Evacuation Zone	School Name	Street Address	Municipality	Enroll-ment
Berkeley Flats	BER-E071	Escuela Bilingue Internacional School	410 Alcatraz Ave	Berkeley	324
Berkeley Flats	BER-E073	Emerson Elementary School	2800 Forest Ave	Berkeley	323
Berkeley Flats	BER-E073	Maybeck High School	2727 College Ave	Berkeley	121
North Berkeley Hills	BER-E001	Thousand Oaks Elementary School	840 Colusa Ave	Berkeley	382
North Berkeley Hills	BER-E009	Cragmont Elementary School	830 Regal Rd	Berkeley	331
North Berkeley Hills	BER-E016	Pacific Lutheran Theological Seminary	2770 Marin Ave	Berkeley	50
North Berkeley Hills	BER-E028	Dominican School of Philosophy & Theology	2301 Vine St	Berkeley	100
North Berkeley Hills	BER-E040	Church Divinity School of the Pacific	2451 Ridge Rd	Berkeley	122
North Berkeley Hills	BER-E040	Graduate Theological Union	2400 Ridge Rd	Berkeley	275
North Berkeley Hills	BER-E040	Jesuit School of Theology	1735 LeRoy Ave	Berkeley	112
North Berkeley Hills	BER-E040	Pacific School of Religion	1798 Scenic Ave	Berkeley	139
North Berkeley Hills	BER-E040	Zaytuna College	1712 Euclid Ave	Berkeley	43
South Berkeley Hills	BER-E055	The Wright Institute	2728 Durant Ave	Berkeley	638
South Berkeley Hills	BER-E076	John Muir Elementary School	2955 Claremont Ave	Berkeley	306
UC Berkeley	BER-E042	University of California - Berkeley	Oxford St	Berkeley	44,075
West Berkeley	BER-E047 East	Black Pine Circle School	2027 7th St	Berkeley	347
West Berkeley	BER-E047 East	Rosa Parks Environmental Science School	920 Allston Way	Berkeley	442
West Berkeley	BER-E047 West	VIA Center	2126 6th St	Berkeley	20
				TOTAL:	**64,409**

Table C-2. Preschools and Day Care Centers within the City of Berkeley

Area(s)	Evacuation Zone	Facility Name	Street Address	Municipality	Enroll-ment
Berkeley Flats	BER-E014	Berkeley Rose Waldorf School	2515 Hillegass Ave	Berkeley	24
Berkeley Flats	BER-E014	Hearts Leap Beginnings	2640 College Ave	Berkeley	40
Berkeley Flats	BER-E014	Hearts Leap ICRI Preschool	2638 College Ave	Berkeley	70
Berkeley Flats	BER-E022	Berkeley Little School	1611 Hopkins St	Berkeley	42
Berkeley Flats	BER-E024	Ala Costa Center for the Developmentally Disabled	1300 Rose St	Berkeley	58
Berkeley Flats	BER-E026	BUSD - Hopkins Street	1810 Hopkins St	Berkeley	140
Berkeley Flats	BER-E026	Mustard Seed Preschool	1640 Hopkins St	Berkeley	66
Berkeley Flats	BER-E027	Jewish Community Ctr of The East Bay-Berkeley	1414 Walnut St	Berkeley	75
Berkeley Flats	BER-E036	Cedar Creek Montessori School	1600 Sacramento St	Berkeley	40
Berkeley Flats	BER-E036	Woolly Mammoth Childcare & Preschool	1333 University Ave	Berkeley	69
Berkeley Flats	BER-E038	Berkeley Montessori School	2030 Francisco St	Berkeley	119
Berkeley Flats	BER-E038	The New School of Berkeley	1606 Bonita	Berkeley	48
Berkeley Flats	BER-E038	The New School of Berkeley-Schoolage	1924 Cedar St	Berkeley	45
Berkeley Flats	BER-E039	Hearts Leap North	2220 Cedar St	Berkeley	45
Berkeley Flats	BER-E045	Berkeley Special Education Preschool	2134 Mlk Jr. Way	Berkeley	90
Berkeley Flats	BER-E045	Berkeley YMCA EHS - Vera Casey	2246 Martin Luther King Jr Way	Berkeley	26
Berkeley Flats	BER-E045	Congregation Beth Israel-Gan Shalom	2230-32 Jefferson St	Berkeley	32
Berkeley Flats	BER-E045	Little Elephant Montessori, Inc.	2008 McGee Ave	Berkeley	24
Berkeley Flats	BER-E045	Shu Ren International School	2125 Jefferson Ave	Berkeley	179
Berkeley Flats	BER-E046	Berkeley International Montessori School	1227 Bancroft Way	Berkeley	21
Berkeley Flats	BER-E046	Child Education Center	2112 Browning St	Berkeley	107
Berkeley Flats	BER-E046	Congregation Netivot Shalom	1316 University Ave	Berkeley	30
Berkeley Flats	BER-E046	Little Beans Preschool	2117 Acton St	Berkeley	40
Berkeley Flats	BER-E046	Rosemarie's Motivational Preschool	1141 Bancroft Way	Berkeley	22
Berkeley Flats	BER-E053	BUSD - King Child Development Center	1939 Ward St	Berkeley	108
Berkeley Flats	BER-E054	Cornerstone Children's Center	2407 Dana St	Berkeley	112

Area(s)	Evacuation Zone	Facility Name	Street Address	Municipality	Enroll-ment
Berkeley Flats	BER-E054	UCB - Dwight Way Center	2427 Dwight Way	Berkeley	42
Berkeley Flats	BER-E054	UCB - Harold E. Jones Child Study Ctr/Childcare	2425 Atherton St	Berkeley	56
Berkeley Flats	BER-E054	UCB - Haste Street Child Development Center	2339 Haste St	Berkeley	92
Berkeley Flats	BER-E063	Berkeley YMCA Head Start - South YMCA	2901 California St	Berkeley	94
Berkeley Flats	BER-E068	Model School Comprehensive Humanistic Learning Ctr	2330 Prince St	Berkeley	63
Berkeley Flats	BER-E068	Through the Looking Glass Early Head Start	3075 Adeline Ave	Berkeley	24
Berkeley Flats	BER-E069	American International Montessori School	3339 Martin Luther King Jr Way	Berkeley	117
Berkeley Flats	BER-E069	Ephesian Children's Center	1907 Harmon Ave	Berkeley	36
Berkeley Flats	BER-E069	Mi Mundo Preschool	1866 Alcatraz Ave	Berkeley	29
Berkeley Flats	BER-E070	VIA Nova Children's School	3032 Martin Luther King Jr Way	Berkeley	45
Berkeley Flats	BER-E073	The Monteverde School	2727 College	Berkeley	30
Berkeley Flats	BER-E073	St. John's Child Care Center	2717 Garber St	Berkeley	45
North Berkeley Hills	BER-E006	Step One School	499 Spruce St	Berkeley	108
North Berkeley Hills	BER-E017	Berkeley Hills Nursery School	1161 Sterling Ave	Berkeley	40
North Berkeley Hills	BER-E020	Childrens Community Center	1140 Walnut St	Berkeley	52
North Berkeley Hills	BER-E021	Dandelion Nursery School, Inc	941 The Alameda	Berkeley	24
North Berkeley Hills	BER-E028	Beth El Nursery School	1301 Oxford St	Berkeley	74
UC Berkeley/South Berkley Hills	BER-E059	UCB - Clark Kerr Campus Children's Center	2900 Dwight Way, Bldg. #5	Berkeley	29
UC Berkeley/South Berkley Hills	BER-E059	UCB - Clark Kerr Preschool	2601 Warring St, Bldg. 15	Berkeley	29
South Berkeley Hills	BER-E076	Kids In Motion	2955 Claremont Ave	Berkeley	70
South Berkeley Hills	OKL-E008	Arbor Preschool East	207 Alvarado St	Berkeley	22
West Berkeley	BER-E023 East	BUSD - Franklin Preschool	1460 - 8th St	Berkeley	192
West Berkeley	BER-E023 East	Centro Vida Bilingual Childcare Center	1000 Camelia St	Berkeley	64
West Berkeley	BER-E023 West	Duck's Nest - Berkeley	1411 - 4th St	Berkeley	91
West Berkeley	BER-E023 West	Golden Gate Learning Center	1450 Sixth St	Berkeley	57

Area(s)	Evacuation Zone	Facility Name	Street Address	Municipality	Enroll-ment
West Berkeley	BER-E035 East	Bahia School Age Program	1718 - 8th St	Berkeley	65
West Berkeley	BER-E035 East	Dolma Child Care Center	1700 - 7th St	Berkeley	14
West Berkeley	BER-E047 East	Berkeley YMCA Head Start - West	2009 10th St	Berkeley	86
West Berkeley	BER-E047 East	Nia House Learning Center	2234 - 9th St	Berkeley	94
West Berkeley	BER-E050 East	Ecole Bilingue De Berkeley	1009 Heinz Ave	Berkeley	426
West Berkeley	BER-E050 East	Global Montessori International School	2830 - 9th St	Berkeley	90
West Berkeley	BER-E050 East	Pixar Child Development Center	2600 10th St	Berkeley	108
West Berkeley	BER-E050 East	Sunshine Preschool (CEID)	1035 Grayson St, Rm #8	Berkeley	45
West Berkeley	BER-E050 West	Aquatic Park School	830 Heinz Ave	Berkeley	77
				TOTAL:	**4,202**

Table C-3. Medical Facilities within the City of Berkeley

Area(s)	Evacuation Zone	Facility Name	Street Address	Municipality	Current Census	Ambu-latory Patients	Wheel-chair Patients	Bed-ridden Patients
Berkeley Flats	BER-E045	Silverado Memory Care Center	2235 Sacramento St	Berkeley	87	37	22	28
Berkeley Flats	BER-E046	Chaparral House	1309 Allston Way	Berkeley	42	6	18	18
Berkeley Flats	BER-E047 East	Elegance Berkeley	2100 San Pablo Ave	Berkeley	47	20	12	15
Berkeley Flats	BER-E053	Alta Bates Summit Medical Center - Herrick Campus	2001 Dwight Way	Berkeley	58	58	0	0
Berkeley Flats	BER-E061	Kyakameena Care Center	2131 Carleton St	Berkeley	60	26	15	19
Berkeley Flats	BER-E064	Berkeley Pines Care Center	2223 Ashby Ave	Berkeley	32	4	18	10
Berkeley Flats	BER-E064	Elmwood Care Center	2829 Shattuck Ave	Berkeley	77	33	19	25
Berkeley Flats	BER-E067	Alta Bates Summit Medical Center - Alta Bates Campus	2450 Ashby Ave	Berkeley	183	73	37	73
Berkeley Flats	BER-E068	Ashby Care Center	2270 Ashby Ave	Berkeley	29	5	14	10
North Berkeley Hills	BER-E012	New Bridge Foundation	2325 Hearst Ave & 1816 Scenic Ave	Berkeley	45	20	14	11
UC Berkeley/South Berkley Hills	BER-E059	Redwood Gardens Apartments	2951 Derby St	Berkeley	168	76	50	42
Berkeley Flats	BER-E061	Other medical facilities within the city[1]		Berkeley	10	10	-	-
Berkeley Flats	BER-E068			Berkeley	23	23	-	-
				TOTAL:	**861**	**391**	**219**	**251**

[1] In addition to the medical facilities identified by the City of Berkely, this table also includes data obtained from the 2020 Census, which gathered population data for skilled nursing facilities at the census block level. See Section 3, Sub-section 3.5.1 for additional information.

Table C-4. Juvenile Homes[2] within the City of Berkeley

Area	Evacuation Zone	Facility Name	Street Address	Municipality	Current Census
Berkeley Flats	BER-E070	Juvenile homes within the city		Berkeley	2
West Berkeley	BER-E047 West			Berkeley	3
West Berkeley	BER-E047 East			Berkeley	4
				TOTAL:	**9**

Table C-5. Major Employers[3] within the City of Berkeley

Area(s)	Evacuation Zone	Facility Name	Street Address	Municipality	Employees Commuting into the City	Employees Commuting into the City by Public Transit	Employees Commuting into the City by Private Vehicles
Berkeley Flats	BER-E026	Various Locations throughout the city			111	40	71
Berkeley Flats	BER-E027				92	33	59
Berkeley Flats	BER-E036				271	97	174
Berkeley Flats	BER-E037				107	38	69
Berkeley Flats	BER-E038				578	206	372
Berkeley Flats	BER-E044				246	88	158
Berkeley Flats	BER-E044				157	56	101
Berkeley Flats	BER-E044				144	51	93
Berkeley Flats	BER-E044				124	44	80
Berkeley Flats	BER-E044				116	41	75
Berkeley Flats	BER-E044				90	32	58
Berkeley Flats	BER-E045				146	52	94
Berkeley Flats	BER-E053				261	93	168

[2] The 2020 Census data indicates that 9 people live at juvenile homes within the City of Berkeley. See Section 3, Sub-section 3.5.2 for additional information.

[3] The major employer locations identified by the City of Berkeley are shown in Figure C-12. The locations are represented by circles which increase in size proportional to the number of employees commuting into the city. See Section 3, Sub-section 3.4 for detailed information.

Area(s)	Evacuation Zone	Facility Name	Street Address	Municipality	Employees Commuting into the City	Employees Commuting into the City by Public Transit	Employees Commuting into the City by Private Vehicles
Berkeley Flats	BER-E053				87	31	56
Berkeley Flats	BER-E053				87	31	56
Berkeley Flats	BER-E061				89	32	57
Berkeley Flats	BER-E064				179	64	115
Berkeley Flats	BER-E065				288	103	185
Berkeley Flats	BER-E065				116	41	75
Berkeley Flats	BER-E067				1,289	460	829
Berkeley Flats	BER-E067				301	107	194
Berkeley Flats	BER-E067				119	42	77
Berkeley Flats	BER-E067				97	35	62
Berkeley Flats	BER-E068				130	46	84
Berkeley Flats	BER-E069				119	42	77
Berkeley Flats	BER-E069				115	41	74
Berkeley Flats	BER-E069				94	34	60
Lawrence Berkeley National Lab	LBL Zones				3,028	1,081	1,947
South Berkeley Hills	BER-E055				172	61	111
UC Berkeley	BER-E043				11,435	4,082	7,353
UC Berkeley	BER-E043				118	42	76
West Berkeley	BER-E023 East				249	89	160
West Berkeley	BER-E023 East				100	36	64
West Berkeley	BER-E023 East				102	36	66
West Berkeley	BER-E023 West				358	128	230
West Berkeley	BER-E023 West				168	60	108
West Berkeley	BER-E023 West				180	64	116
West Berkeley	BER-E023 West				159	57	102

Area(s)	Evacuation Zone	Facility Name	Street Address	Municipality	Employees Commuting into the City	Employees Commuting into the City by Public Transit	Employees Commuting into the City by Private Vehicles
West Berkeley	BER-E034				126	45	81
West Berkeley	BER-E035 West				728	260	468
West Berkeley	BER-E035 West				142	51	91
West Berkeley	BER-E047 East				341	122	219
West Berkeley	BER-E047 West				837	299	538
West Berkeley	BER-E047 West				209	75	134
West Berkeley	BER-E047 West				158	56	102
West Berkeley	BER-E047 West				89	32	57
West Berkeley	BER-E050 East				279	100	179
West Berkeley	BER-E050 East				129	46	83
West Berkeley	BER-E050 East				106	38	68
West Berkeley	BER-E050 East				95	34	61
West Berkeley	BER-E050 East				87	31	56
West Berkeley	BER-E050 West				164	59	105
West Berkeley	BER-E050 West				139	50	89
West Berkeley	BER-E050 West				90	32	58
				TOTAL:	**25,341**	**9,046**	**16,295**

Table C-6. Tourists[4] within the Study Area

Area(s)	Evacuation Zone	Facility Name	Street Address	Municipality	Tourists
Berkeley Flats	ALB-E006	Various Locations throughout the city			151

[4] The locations of the tourists are unavailable. It is assumed that tourists can visit any tourist attractions within the City of Berkeley and their vehicles are located along streets where street parking is allowed as well as in the parking garages available. See Section 3, Sub-section 3.3 for more details.

Area(s)	Evacuation Zone	Facility Name	Street Address	Municipality	Tourists
Berkeley Flats	ALB-E007				1
Berkeley Flats	ALB-E008				130
Berkeley Flats	BER-E014				207
Berkeley Flats	BER-E022				549
Berkeley Flats	BER-E024				395
Berkeley Flats	BER-E025				271
Berkeley Flats	BER-E026				600
Berkeley Flats	BER-E027				445
Berkeley Flats	BER-E036				751
Berkeley Flats	BER-E037				624
Berkeley Flats	BER-E038				362
Berkeley Flats	BER-E039				180
Berkeley Flats	BER-E044				351
Berkeley Flats	BER-E045				467
Berkeley Flats	BER-E046				500
Berkeley Flats	BER-E051				765
Berkeley Flats	BER-E052				609
Berkeley Flats	BER-E053				612
Berkeley Flats	BER-E054				357
Berkeley Flats	BER-E056				184
Berkeley Flats	BER-E060				119
Berkeley Flats	BER-E061				344
Berkeley Flats	BER-E062				408
Berkeley Flats	BER-E063				569
Berkeley Flats	BER-E064				497
Berkeley Flats	BER-E065				331
Berkeley Flats	BER-E067				246
Berkeley Flats	BER-E068				322

Area(s)	Evacuation Zone	Facility Name	Street Address	Municipality	Tourists
Berkeley Flats	BER-E069				142
Berkeley Flats	BER-E070				568
Berkeley Flats	BER-E071				315
Berkeley Flats	BER-E072				330
Berkeley Flats	BER-E073				397
Berkeley Flats	BER-E074				13
Berkeley Flats	BER-E075				19
Berkeley Flats	OKL-E020				2
Berkeley Flats	OKL-E021				3
Berkeley Flats	OKL-E022				9
Berkeley Flats	OKL-E241				85
Lawrence Berkeley National Lab	LBL-E001				0
Lawrence Berkeley National Lab	LBL-E002				0
Lawrence Berkeley National Lab	LBL-E003				0
Lawrence Berkeley National Lab	LBL-E004				0
Lawrence Berkeley National Lab	LBL-E005				0
Lawrence Berkeley National Lab	LBL-E006				0
North Berkeley Hills	BER-E001				341
North Berkeley Hills	BER-E002				446
North Berkeley Hills	BER-E003				200
North Berkeley Hills	BER-E004				256
North Berkeley Hills	BER-E005				145
North Berkeley Hills	BER-E006				164
North Berkeley Hills	BER-E007				199
North Berkeley Hills	BER-E008				268
North Berkeley Hills	BER-E009				264
North Berkeley Hills	BER-E010				270
North Berkeley Hills	BER-E011				345

Area(s)	Evacuation Zone	Facility Name	Street Address	Municipality	Tourists
North Berkeley Hills	BER-E012				138
North Berkeley Hills	BER-E015				351
North Berkeley Hills	BER-E016				422
North Berkeley Hills	BER-E017				271
North Berkeley Hills	BER-E018				250
North Berkeley Hills	BER-E019				327
North Berkeley Hills	BER-E020				358
North Berkeley Hills	BER-E021				232
North Berkeley Hills	BER-E028				544
North Berkeley Hills	BER-E029				316
North Berkeley Hills	BER-E030				203
North Berkeley Hills	BER-E031				353
North Berkeley Hills	BER-E032				327
North Berkeley Hills	BER-E033				133
North Berkeley Hills	BER-E040				369
South Berkeley Hills	BER-E013				245
South Berkeley Hills	BER-E055				106
South Berkeley Hills	BER-E057				95
South Berkeley Hills	BER-E058				266
UC Berkeley/South Berkley Hills	BER-E059				220
South Berkeley Hills	BER-E066				38
South Berkeley Hills	BER-E076				193
South Berkeley Hills	BER-E077				10
South Berkeley Hills	BER-E078				178
South Berkeley Hills	OKL-E004				11
South Berkeley Hills	OKL-E007				13
South Berkeley Hills	OKL-E008				115
South Berkeley Hills	OKL-E009				28

Area(s)	Evacuation Zone	Facility Name	Street Address	Municipality	Tourists
South Berkeley Hills	OKL-E010				51
South Berkeley Hills	OKL-E015				22
South Berkeley Hills	OKL-E017				13
South Berkeley Hills	OKL-E018				180
South Berkeley Hills	OKL-E019				82
UC Berkeley	BER-E041				354
UC Berkeley	BER-E042				404
UC Berkeley	BER-E043				439
UC Berkeley	OKL-E001				239
UC Berkeley	OKL-E002				483
West Berkeley	BER-E023 East				427
West Berkeley	BER-E023 West				680
West Berkeley	BER-E034				1,920
West Berkeley	BER-E035 East				316
West Berkeley	BER-E035 West				492
West Berkeley	BER-E047 East				418
West Berkeley	BER-E047 West				512
West Berkeley	BER-E048				537
West Berkeley	BER-E049				85
West Berkeley	BER-E050 East				527
West Berkeley	BER-E050 West				513
Shadow Region		Tilden Park Golf Course[5]	10 Golf Course Dr	Berkeley	260
Shadow Region		Tilden Regional Park[5]	2501 Grizzly Peak Blvd	Orinda	993
				TOTAL:	**32,187**

[5] Tilden Park Golf Course and Tilden Regional Park are located in the Shadow Region and considered in this study due to the close proximity to the city.

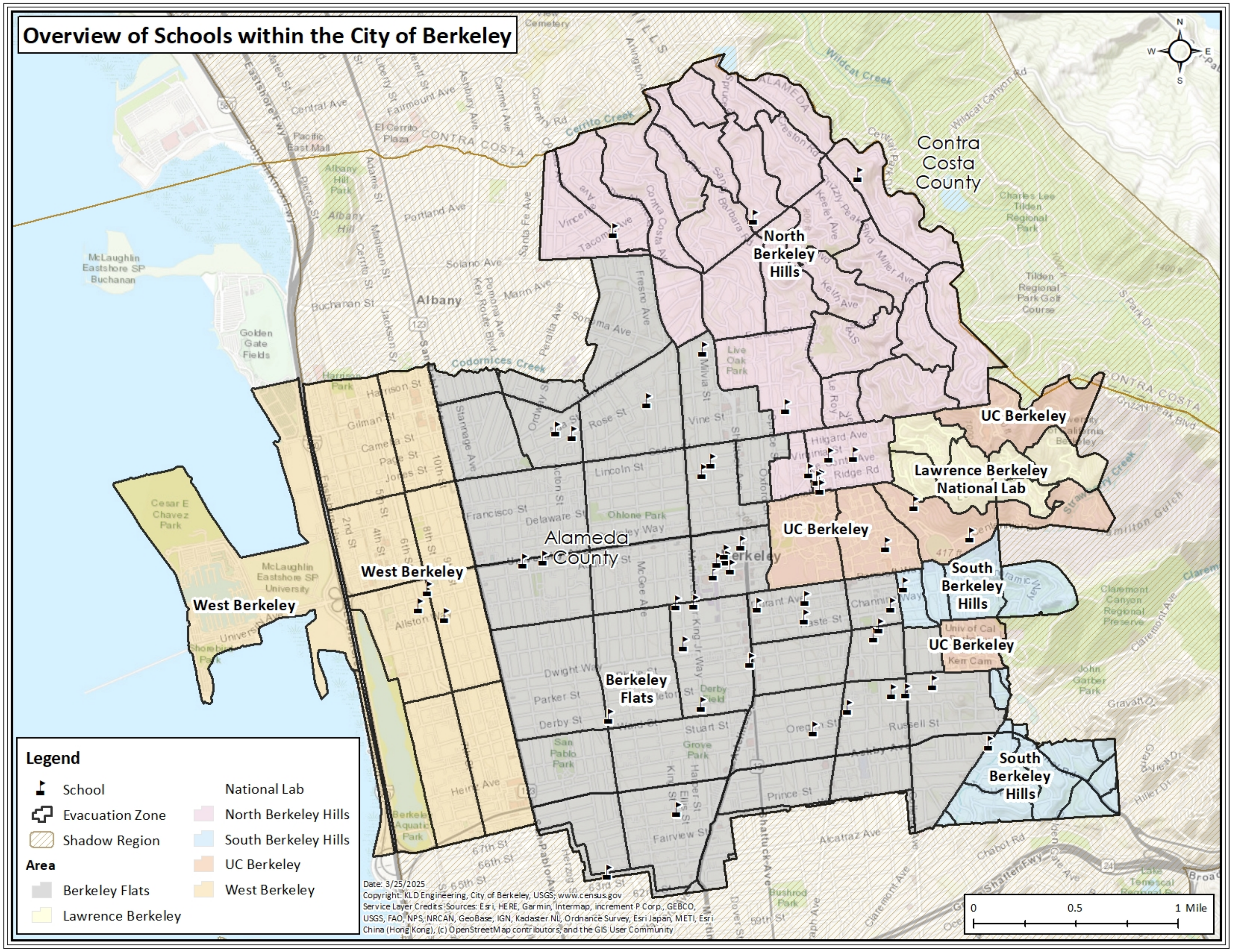


Figure C-1. Overview of K-12 Schools and Higher Education Sites within the City of Berkeley

Map No.	Facility Name
1	Acupuncture and Integrative Medicine College-Berkeley
2	Bayhill High School
3	Berkeley Arts Magnet at Whittier School
4	Berkeley City College
5	Berkeley High School
6	Berkeley Rose Waldorf School
7	Berkeley School of Theology
8	Berkeley Technology Academy
9	Berkwood Hedge School
10	California Jazz Conservatory
11	East Bay School for Boys
12	Emerson Elementary School
13	Escuela Bilingue Internacional School
14	Institute of Buddhist Studies
15	Longfellow Arts and Technology Middle School
16	Malcolm X Elementary School
17	Martin Luther King Middle School
18	Maybeck High School
19	Oxford Elementary at West Campus
20	Pacific Boychoir Academy
21	Ruth Acty Elementary School
22	School of the Madeleine
23	Sylvia Mendez Elementary School
24	The Berkeley School
25	The Crowden School
26	The Elmwood Academy
27	Walden Center & School
28	Washington Elementary School
29	Willard Middle School

Schools in Berkeley Flats Area

Legend

School | Evacuation Zone | Shadow Region

Date: 3/5/2025
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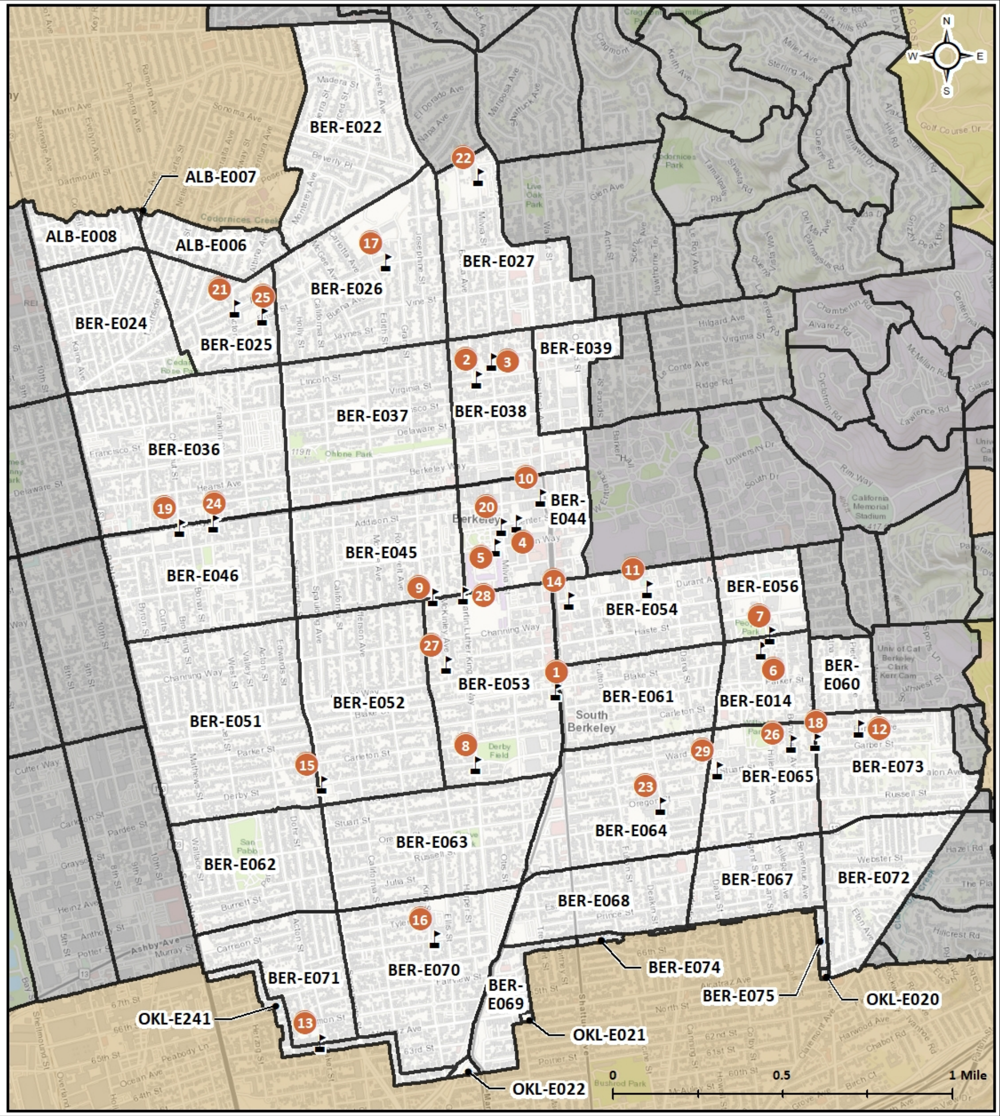
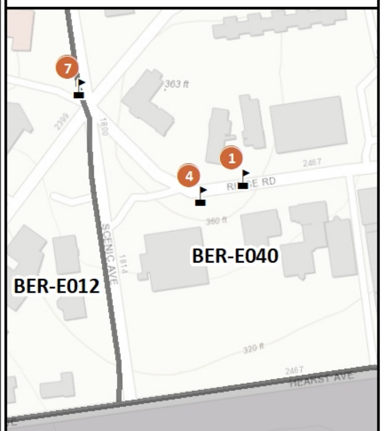


Figure C-2. K-12 Schools and Higher Education Sites in Berkeley Flats Area

Map No.	Facility Name
1	Church Divinity School of the Pacific
2	Cragmont Elementary School
3	Dominican School of Philosophy & Theology
4	Graduate Theological Union
5	Jesuit School of Theology
6	Pacific Lutheran Theological Seminary
7	Pacific School of Religion
8	Thousand Oaks Elementary School
9	Zaytuna College



Schools in North Berkeley Hills Area

Legend

School
Evacuation Zone
Shadow Region

Date: 3/5/2025

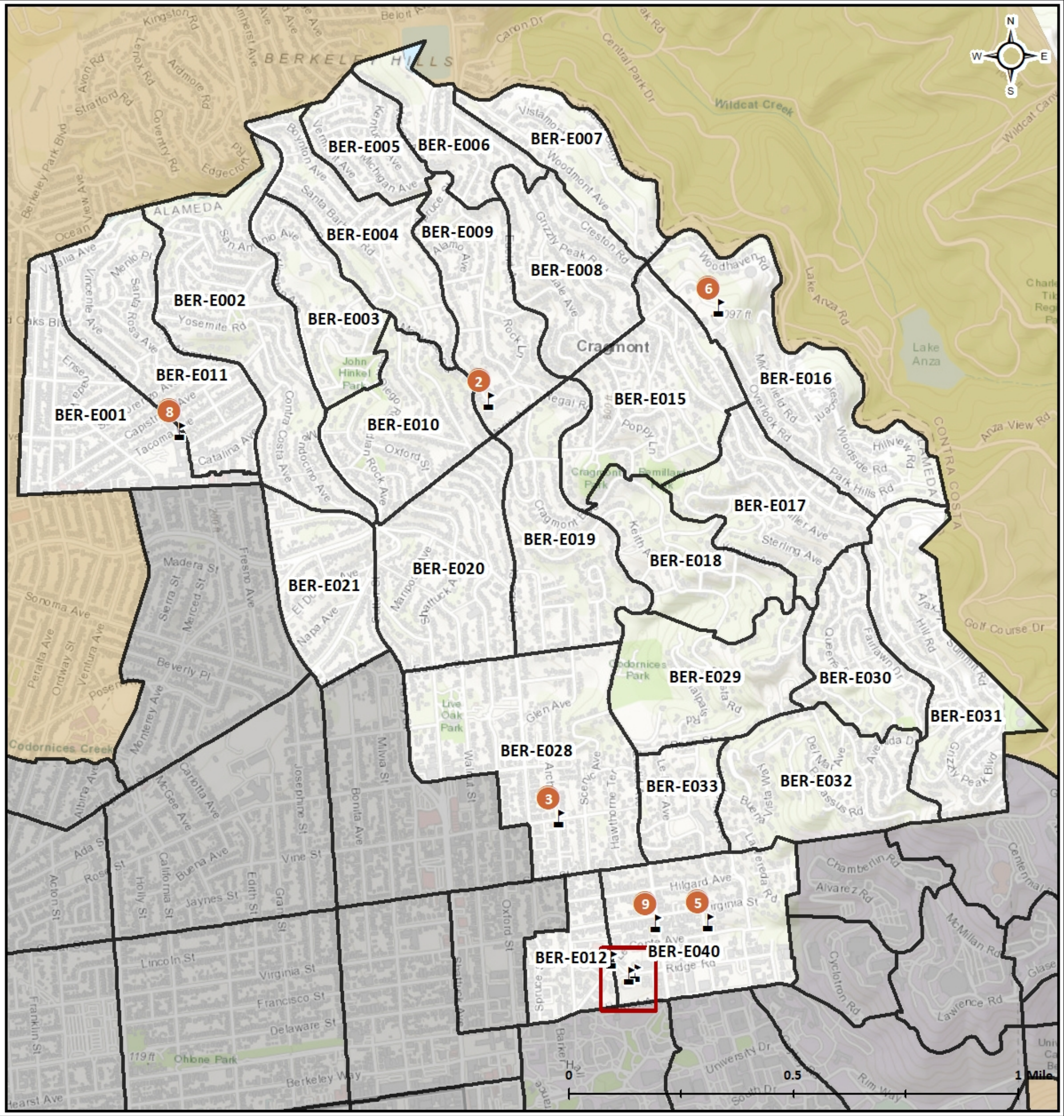


Figure C-3. K-12 Schools and Higher Education Sites in North Berkeley Hills Area

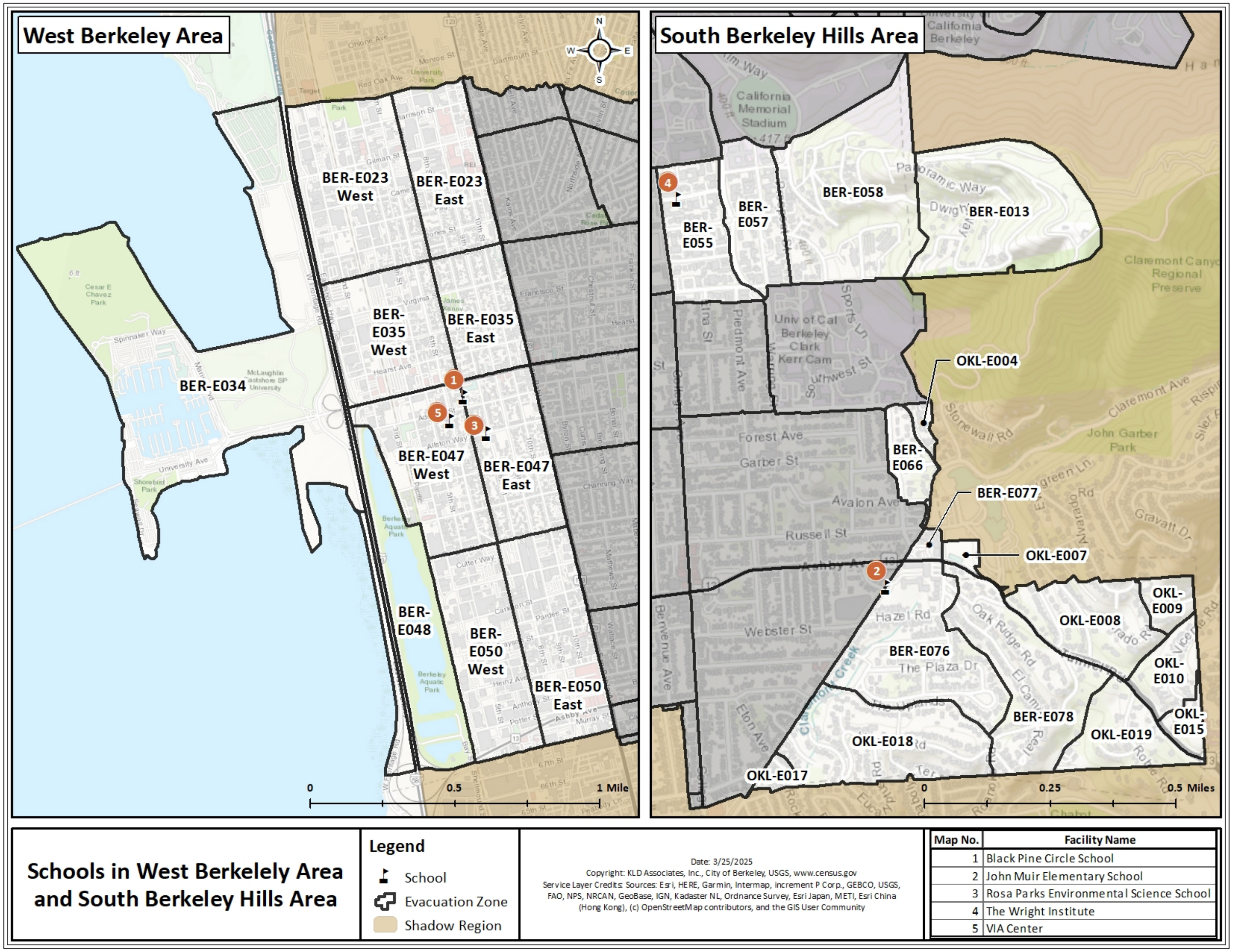


Figure C-4. K-12 Schools and Higher Education Sites in West Berkeley and South Berkeley Hills Areas

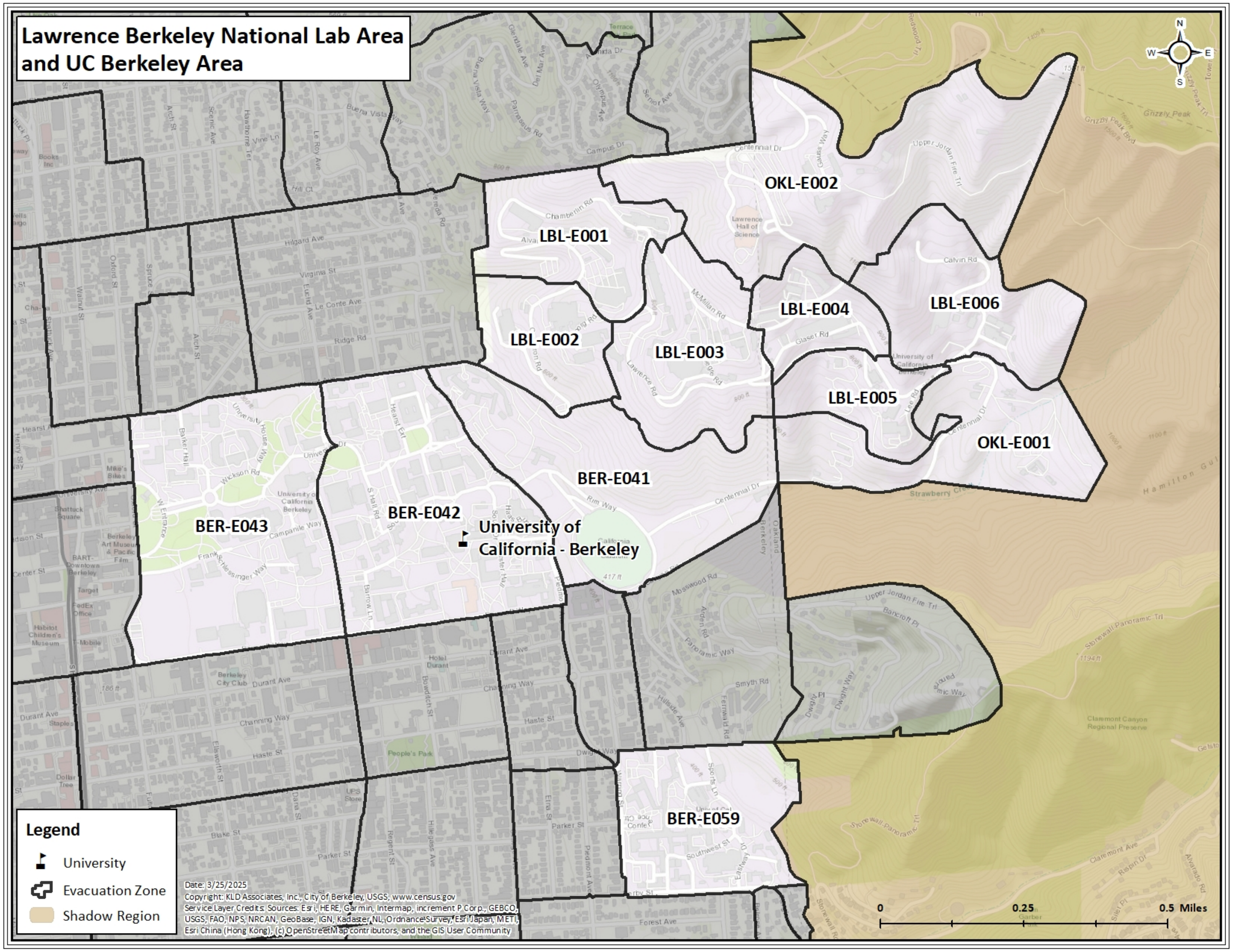


Figure C-5. S K-12 Schools and Higher Education Sites in Lawrence Berkeley National and UC Berkeley Areas

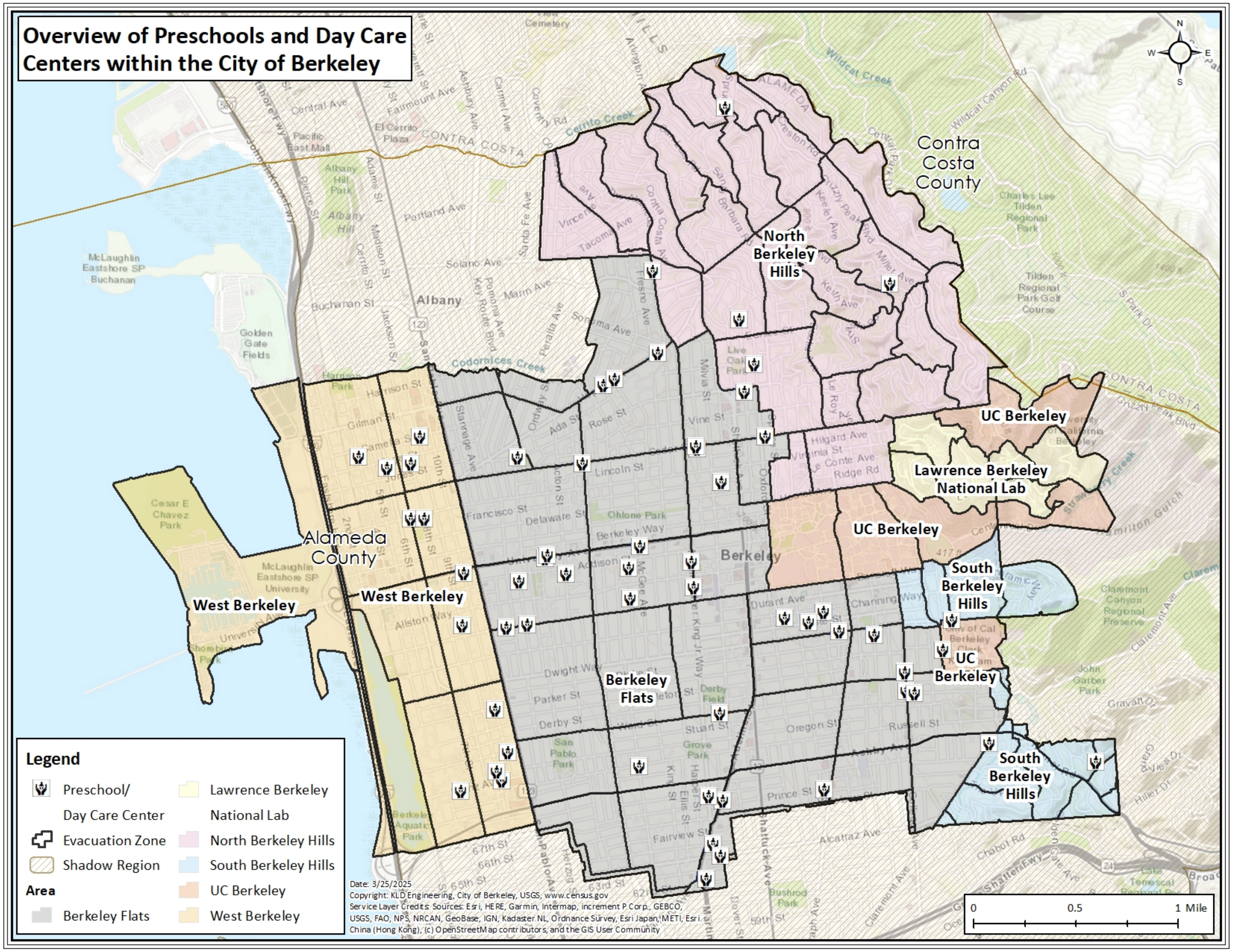


Figure C-6. Overview of Preschools and Day Care Centers within the City of Berkeley

Map No.	Facility Name
1	Ala Costa Ctr. For The Developmentally Disabled
2	American International Montessori School
3	Berkeley International Montessori School
4	Berkeley Little School
5	Berkeley Montessori School
6	Berkeley Rose Waldorf School
7	Berkeley Special Education Preschool
8	Berkeley YMCA EHS - Vera Casey
9	Berkeley YMCA Head Start - South YMCA
10	BUSD - Hopkins Street
11	BUSD - King Child Development Center
12	Cedar Creek Montessori School
13	Child Education Center
14	Congregation Beth Israel-Gan Shalom
15	Congregation Netivot Shalom
16	Cornerstone Children's Center
17	Ephesian Children's Center
18	Hearts Leap Beginnings
19	Hearts Leap ICRI Preschool
20	Hearts Leap North
21	Jewish Community Ctr of The East Bay-Berkeley
22	Little Beans Preschool
23	Little Elephant Montessori, Inc.
24	Mi Mundo Preschool
25	Model School Comprehensive Humanistic Learning Ctr
26	Mustard Seed Preschool
27	Rosemarie's Motivational Preschool
28	Shu Ren International School
29	St. John's Child Care Center
30	The Monteverde School
31	The New School of Berkeley
32	The New School Of Berkeley-Schoolage
33	Through the Looking Glass Early Head Start
34	UCB - Dwight Way Center
35	UCB - Harold E. Jones Child Study Ctr/Childcare
36	UCB - Haste Street Child Development Center
37	VIA Nova Children's School
38	Woolly Mammoth Childcare & Preschool

Preschools and Day Care Centers in Berkeley Flats Area

Legend

Preschool/ Day Care Center

Evacuation Zone

Shadow Region

Date: 3/5/2025

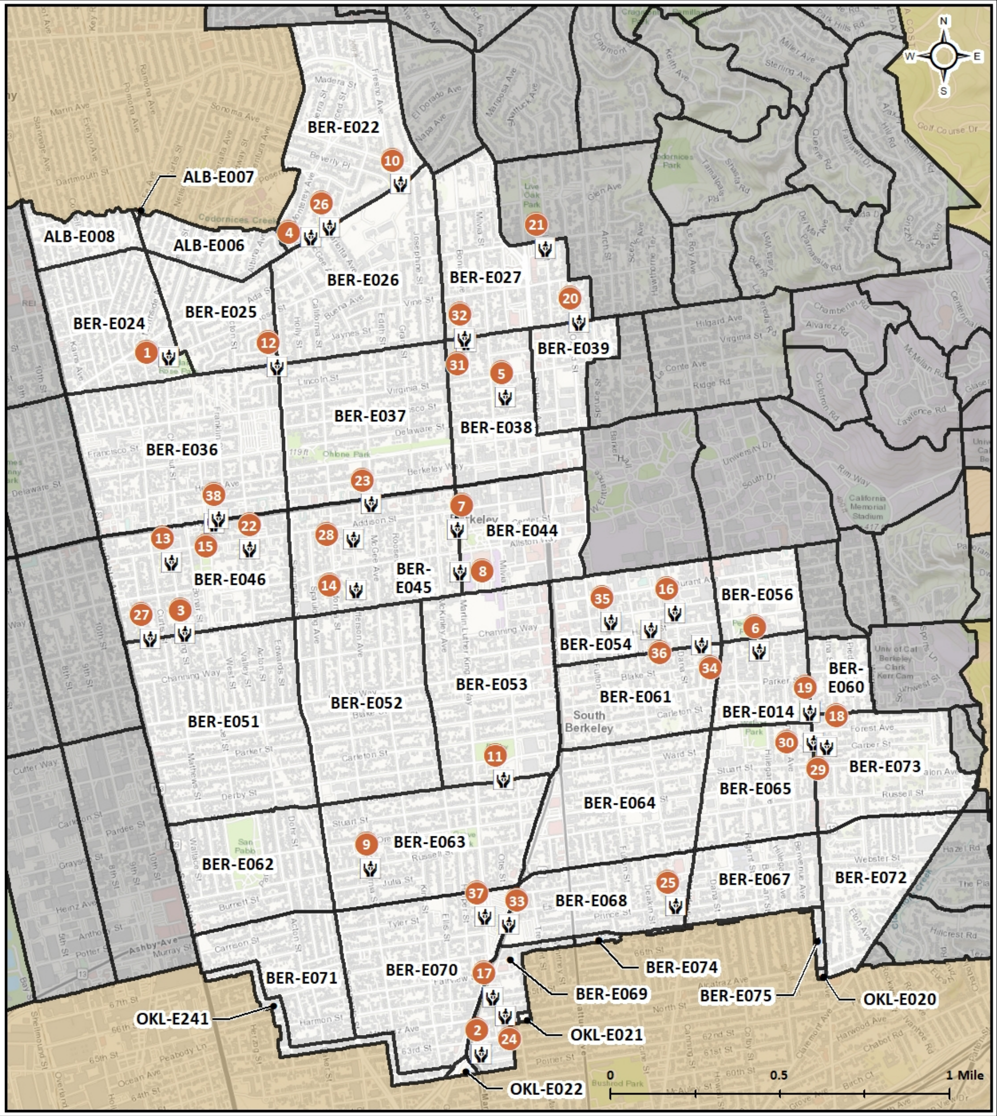
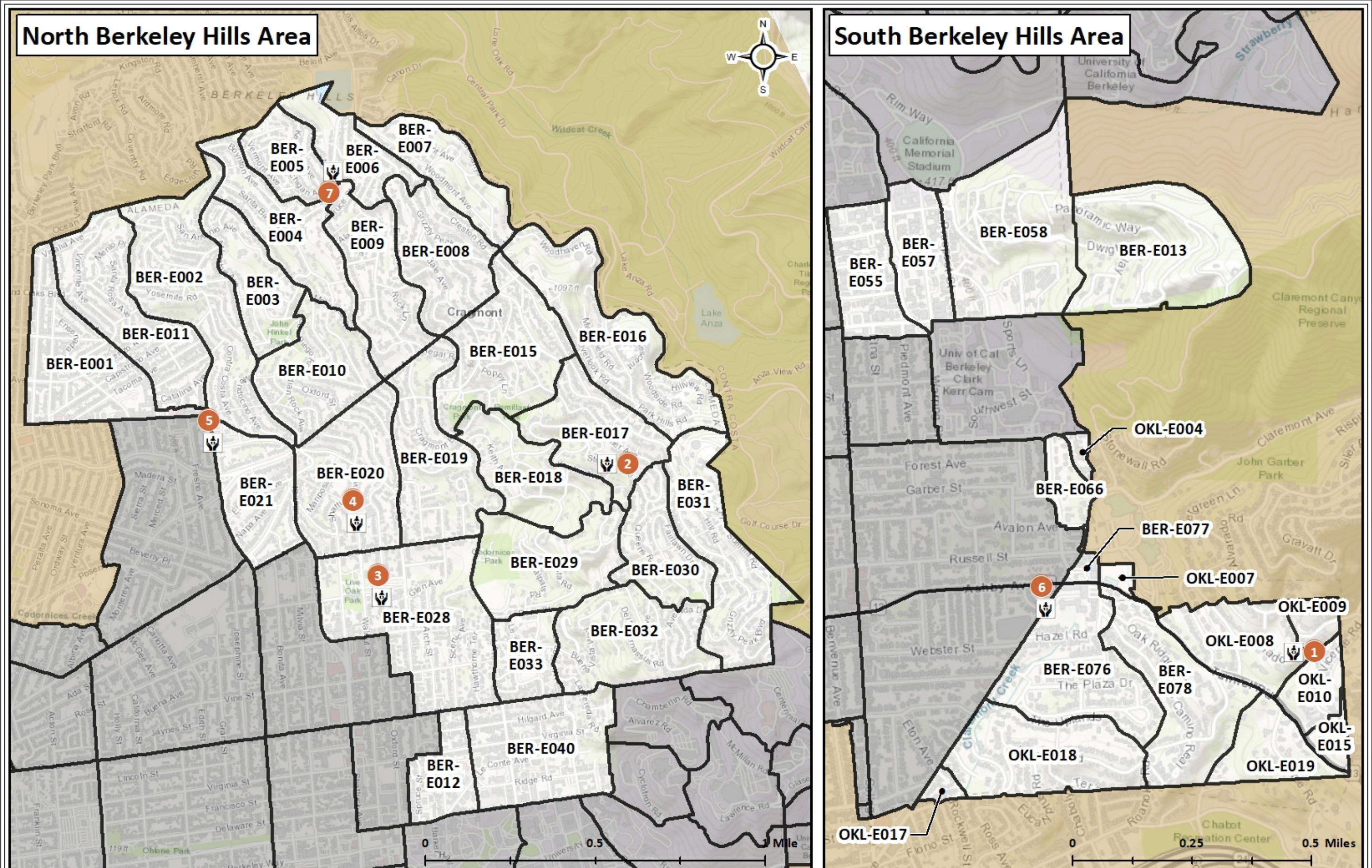


Figure C-7. Preschools and Day Care Centers in Berkeley Flats Area



Preschools and Day Care Centers in North Berkeley Hills Area and South Berkeley Hills Area

Legend

- Preschool/ Day Care Center
- Evacuation Zone
- Shadow Region

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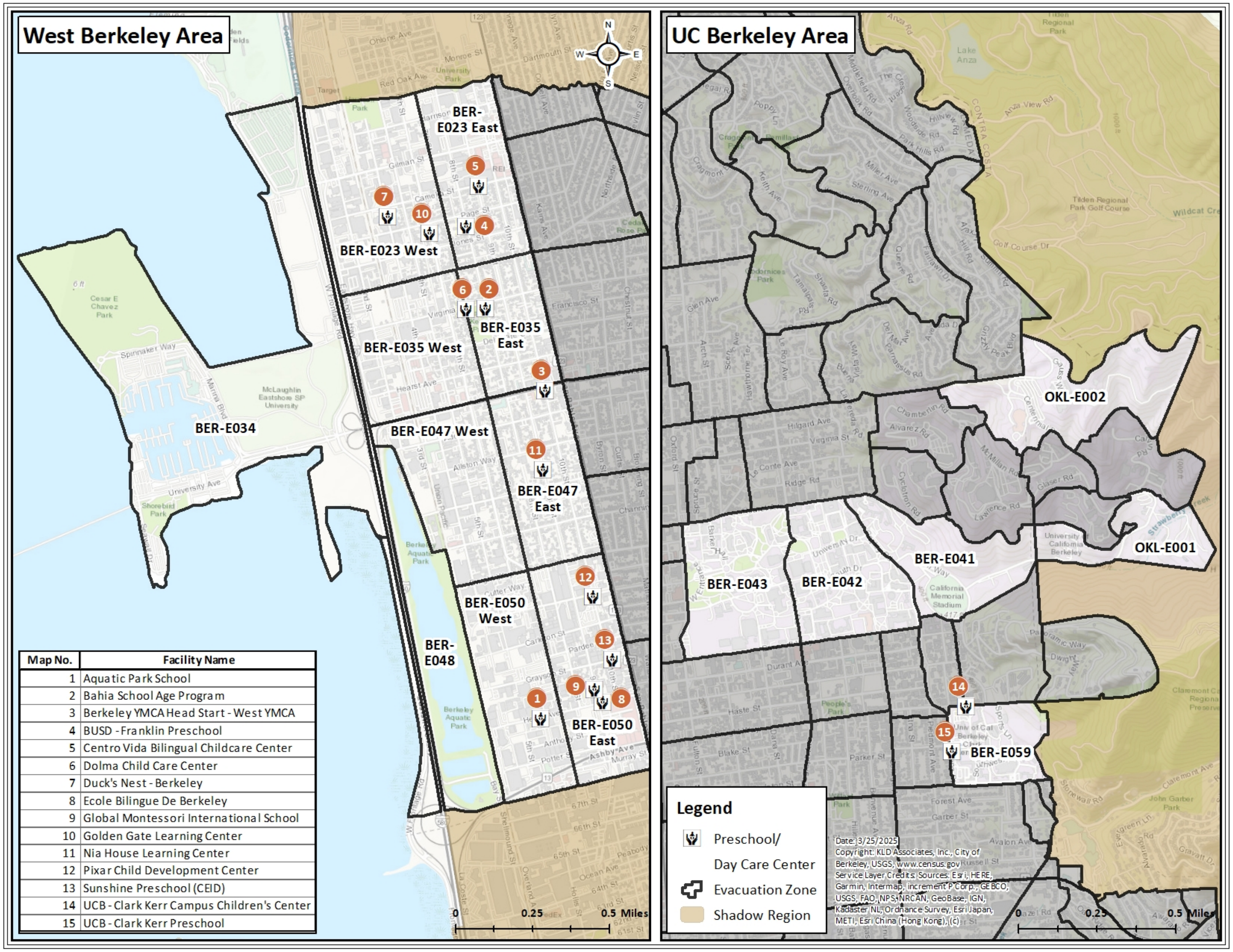
Map No.	Facility Name
1	Arbor Preschool East
2	Berkeley Hills Nursery School
3	Beth El Nursery School
4	Childrens Community Center
5	Dandelion Nursery School, Inc
6	Kids In Motion
7	Step One School

Figure C-8. Preschools and Day Care Centers in North Berkeley Hills and South Berkeley Hills Areas



Map No.	Facility Name
1	Aquatic Park School
2	Bahia School Age Program
3	Berkeley YMCA Head Start - West YMCA
4	BUSD - Franklin Preschool
5	Centro Vida Bilingual Childcare Center
6	Dolma Child Care Center
7	Duck's Nest - Berkeley
8	Ecole Bilingue De Berkeley
9	Global Montessori International School
10	Golden Gate Learning Center
11	Nia House Learning Center
12	Pixar Child Development Center
13	Sunshine Preschool (CEID)
14	UCB - Clark Kerr Campus Children's Center
15	UCB - Clark Kerr Preschool

Figure C-9. Preschools and Day Care Centers in West Berkeley and UC Berkeley Areas

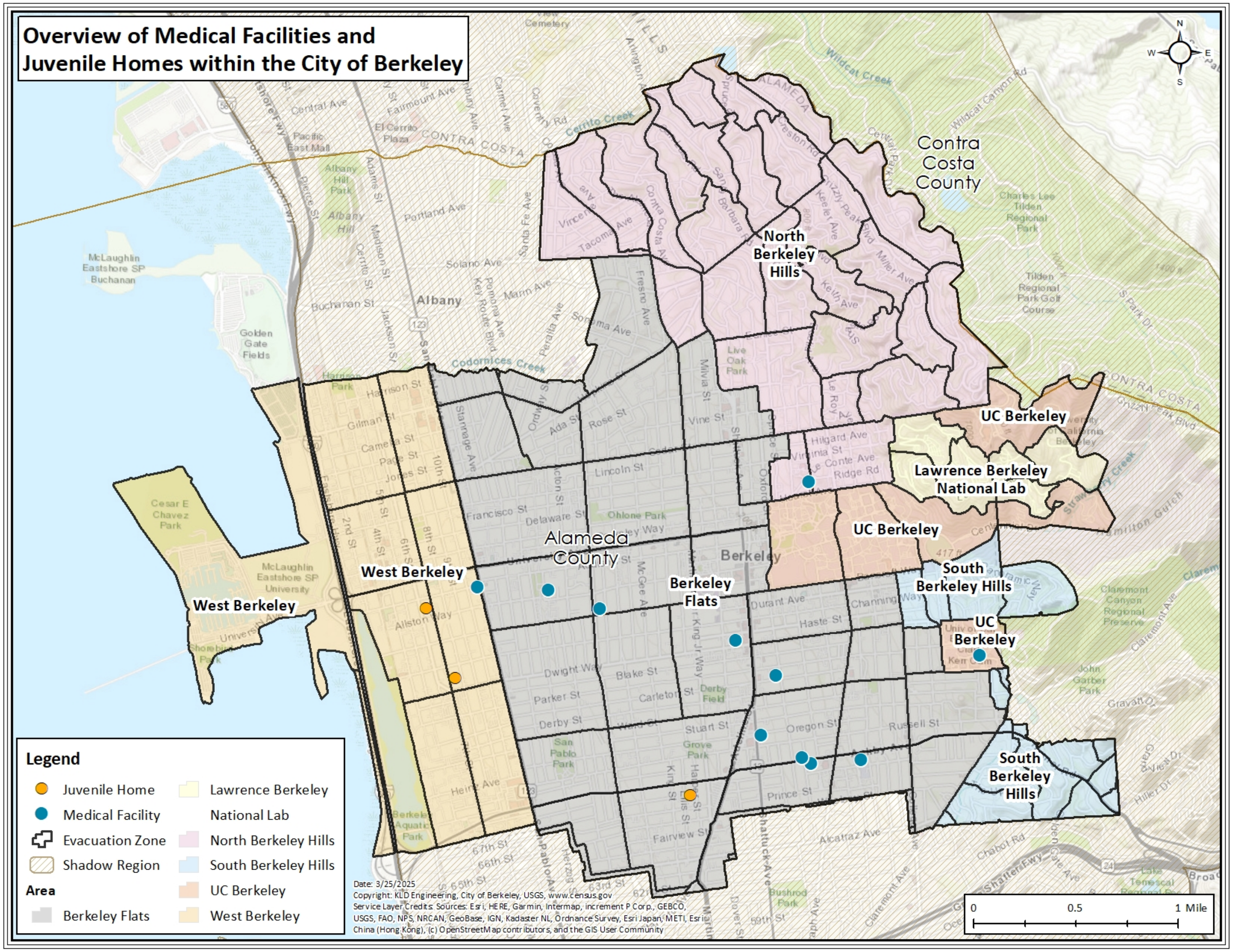
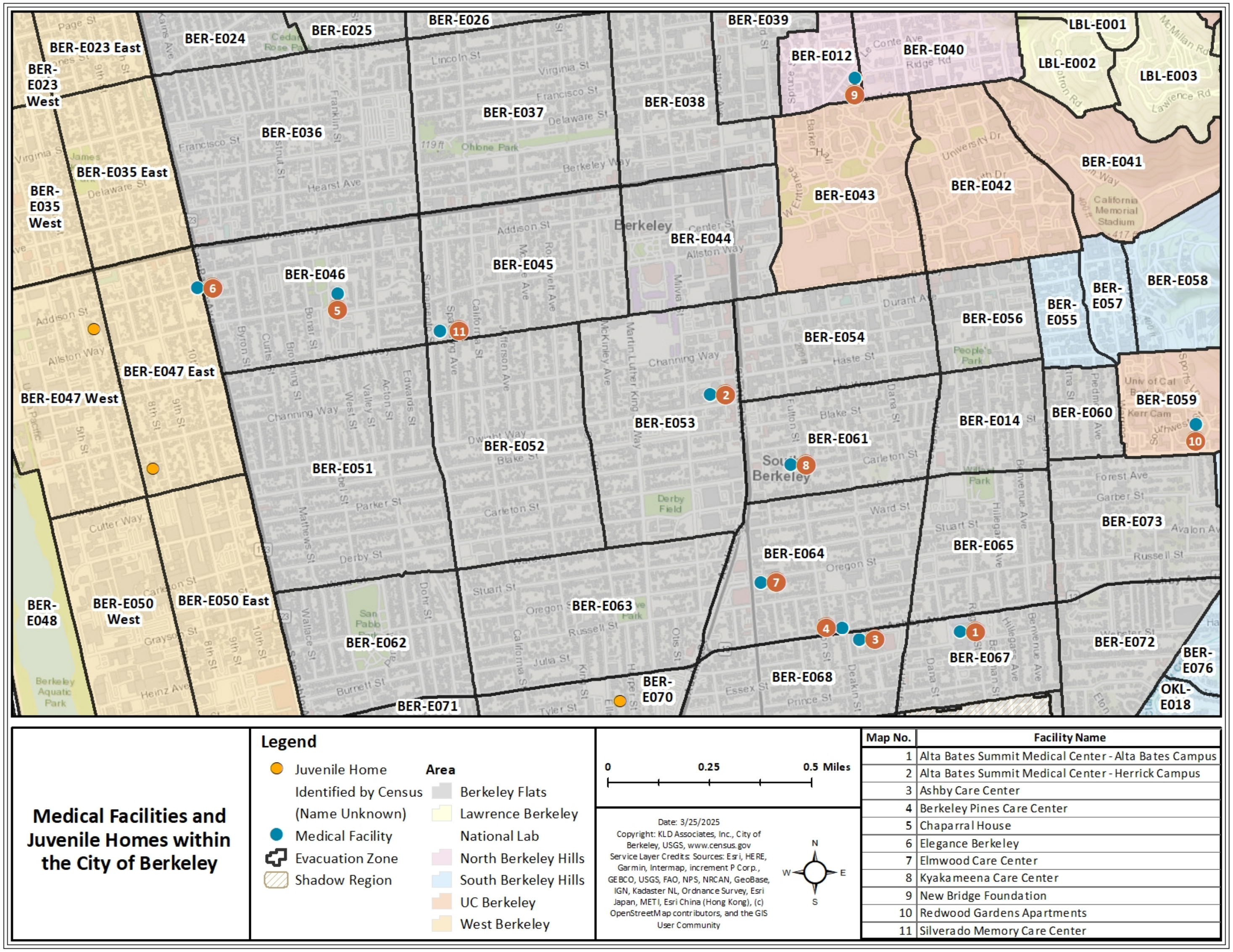


Figure C-10. Overview of Medical Facilities and Juvenile Homes within the City of Berkeley



Map No.	Facility Name
1	Alta Bates Summit Medical Center - Alta Bates Campus
2	Alta Bates Summit Medical Center - Herrick Campus
3	Ashby Care Center
4	Berkeley Pines Care Center
5	Chaparral House
6	Elegance Berkeley
7	Elmwood Care Center
8	Kyakameena Care Center
9	New Bridge Foundation
10	Redwood Gardens Apartments
11	Silverado Memory Care Center

Figure C-11. Medical Facilities and Juvenile Homes within the City of Berkeley

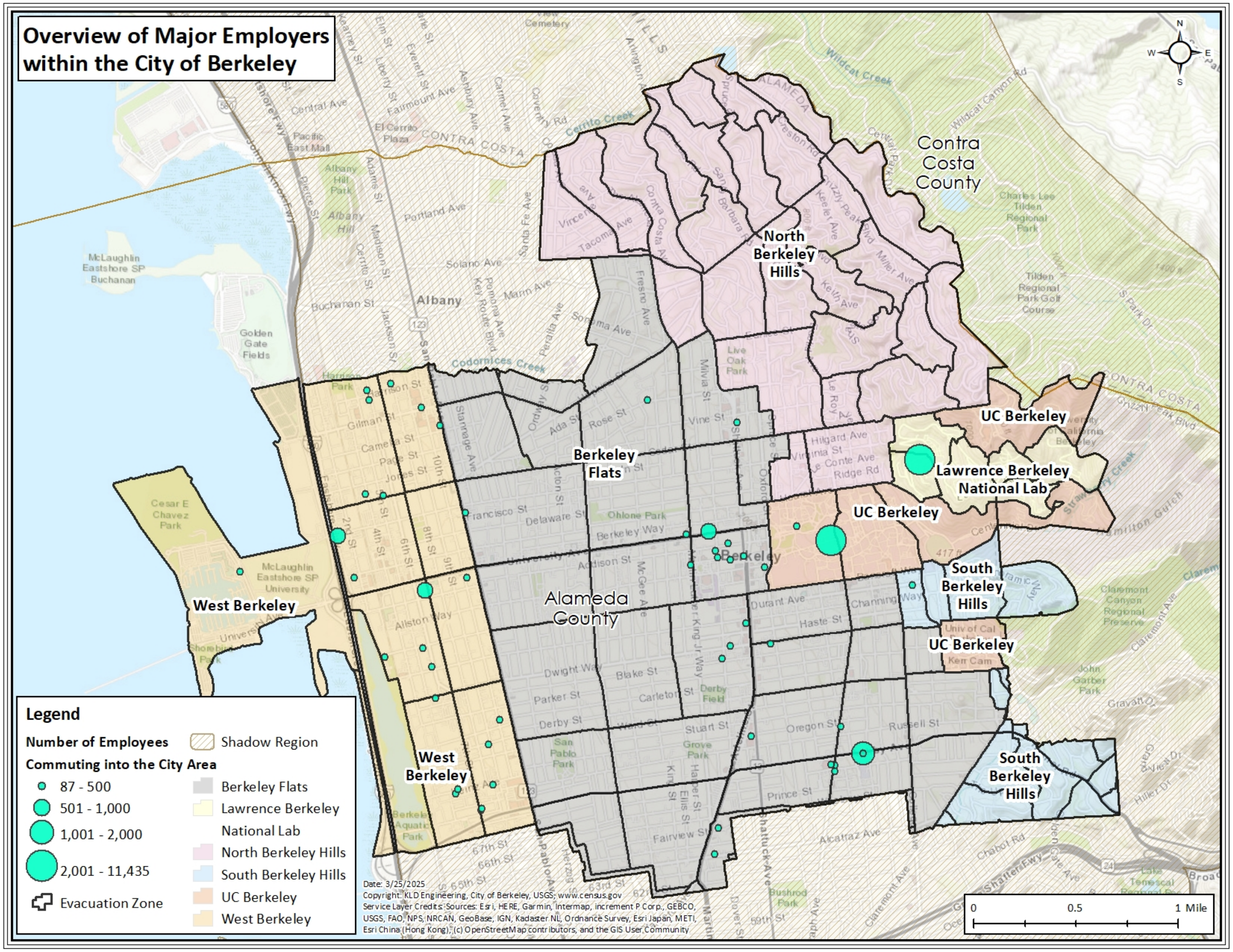


Figure C-12. Overview of Major Employers within the City of Berkeley

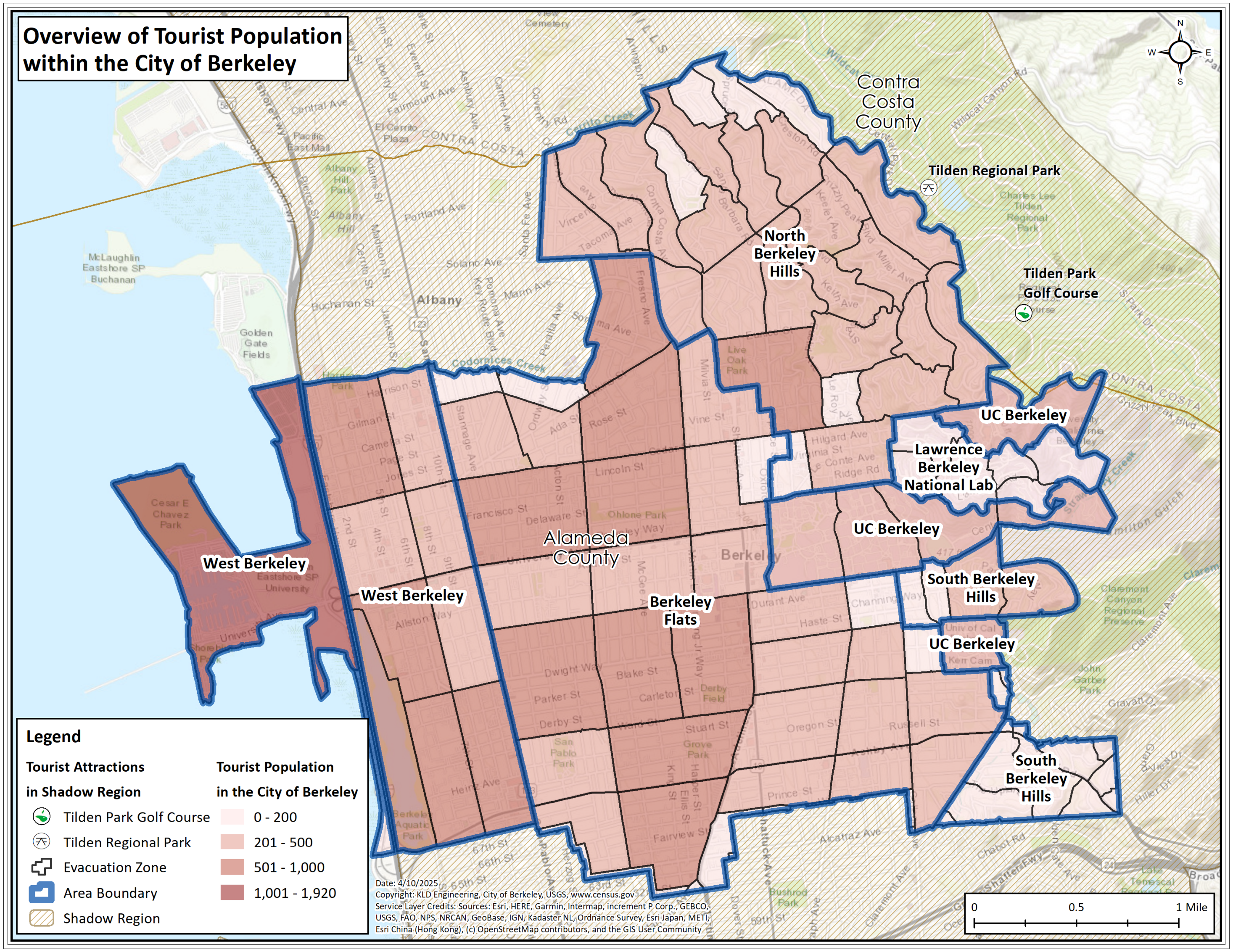


Figure C-13. Overview of Tourist Population within the City of Berkeley

APPENDIX D

Demographic Survey

D. DEMOGRAPHIC SURVEY

This appendix presents the results obtained from a Demographic Survey that was conducted from August 10 – October 8, 2023 in support of this study. Outlined below is the survey sampling plan, results obtained, and survey instrument (See Attachment A).

D.1 Introduction

The analyses conducted in this study require the identification of travel patterns, car ownership and household size of the population. Demographic information can be obtained from Census data; however, the use of this data has several limitations when applied to emergency planning. First, the Census data do not encompass the range of information needed to identify the time required for preliminary activities (mobilization) that must be undertaken prior to evacuating the area. Secondly, Census data do not contain attitudinal responses needed from the population within the city and consequently may not accurately represent the anticipated behavioral characteristics of the evacuating populace.

These concerns are addressed by conducting a demographic survey of a representative sample of the study area population. The survey is designed to elicit information from the public concerning family demographics and estimates of response times to well defined events. The design of the survey includes a limited number of questions of the form "What would you do if …?" and other questions regarding activities with which the respondent is familiar ("How long does it take you to…?").

D.2 Survey Instrument and Sampling Plan

Attachment A presents the final survey instrument used in this study for the demographic survey. A draft of the instrument was submitted to stakeholders for comment. Comments were received and the survey instrument was modified accordingly, prior to conducting the survey.

The survey results were drawn from the various subdivisions within the city and a statistically reliable sample was obtained Citywide, for residents of the Berkeley Flats, and for residents of the Berkeley hills. A total of 1,453 completed surveys were obtained within the city, which corresponds to a sampling error of ±2.5% at the 95% confidence level based on the 2020 Census household data.

D.3 Survey Results

The results of the survey fall into three categories. The first category is household demographic results. Household demographic information includes such factors as household size, automobile ownership, automobile availability, and commuters. The second category of survey results is about evacuation responses. This section contains results regarding how residents in the study area would respond to an evacuation. The third category of results contains time distributions for performing certain pre-evacuation activities. These data are processed to develop the trip generation distributions used in the evacuation modeling effort, as discussed in Section 5.

A review of the survey instrument reveals that several questions have a "Don't Know" (DK) or "Prefer Not to Say" option for a response. It is accepted practice in conducting surveys of this type to accept the answers of a respondent who offers a DK or "Prefer Not to Say" response for a few questions. To address the issue of occasional DK responses from a large sample, the practice is to assume that the distribution of these responses is the same as the underlying distribution of the positive responses. In effect, the DK responses are ignored, and the distributions are based upon the positive data that is acquired.

D.3.1 Household Demographic Results

Household Size

Figure D-1 presents the distribution of household size within each Area, based on the responses to the demographic survey. The average household contains 2.39[1] people according to the survey results.

Automobile Ownership

The average number of automobiles available per household in the study area is 1.55. The distribution of automobile ownership is presented in Figure D-2. It should be noted that only 7.5% responded that they do not have access to a vehicle. Figure D-3 and Figure D-4 present the automobile availability by household size. As expected, the majority (approximately 97%) of households of 2 or more people have access to at least one vehicle.

Ridesharing

Approximately 87% of the households surveyed responded that they would share a ride with a neighbor, relative, or a friend, if a car was not available to them when advised to evacuate in the event of an emergency (49.1% specified that they would only be able to rideshare if their neighbor/friend were home). Approximately 13% of the households would not rideshare with a neighbor, relative, or friend. Figure D-5 displays these results.

Evacuation Assistance and Specialized Transportation Needs

Six percent of households indicated that someone in the household would need help from someone outside the household (caretaker, personal attendant) to prepare to evacuate or to get to a vehicle.

Figure D-6 presents the percentage of people citywide who will need outside help as described above, along with specialized transportation assistance. Approximately 1.6% require a wheelchair accessible van, 0.2% require an ambulance and 0.4% require other modes of transportation. The remaining 3.8% do not require a specialized vehicle to evacuate.

Note that when compared to the emPOWER data described in Section 3.8 the survey results show lower estimates for people requiring an ambulance to evacuate and higher estimates for people requiring a wheelchair accessible van to evacuate.

[1] The average household size of 2.39 is only reported for informational purposes and was not used in the study. The average household size of 2.61 was used instead, which was taken from the 2020 U.S., as stated in Section 3.1.

Commuters

Figure D-7 presents the distribution of the number of commuters in each household. Commuters are defined as household members who travel to work or college on a daily basis. The data shows the majority of households (58%) do not have commuters who travel to work or college on a daily basis. There is an average of 0.64 commuters per household in the study area, and approximately 42% of households have at least one commuter who travels to work or college on a daily basis.

Berkeley Marina & UC Berkeley

A question was asked to estimate the respondents who lived in the Berkeley Marina, and/or if they were a UC Berkeley undergraduate student, graduate student, visiting scholar, student researcher, or postdoctoral. 10 respondents live at Berkeley Marina, 31 are UC Berkeley undergraduate students, and 24 are graduate students at UC Berkeley. See Figure D-10.

Commuter Travel Modes

Figure D-8 presents the mode of travel that commuters use on a daily basis. The majority (44.3%) of commuters use their private automobiles to travel to work. 25.3% of commuters walk/bicycle, 6.8% of commuters take a bus, 11.2% of commuters utilize BART, 8.7% use a combination of public transit, and 3.7% of commuters carpool to travel to work. The data shows an average of 1.08 employees per vehicle, assuming 2 people per vehicle – on average – for carpools.

Commuter Work Location

Approximately 51% of households with commuters responded that they work within Zip Codes that belong to the Areas. The other 49% commute outside of the Areas to work.

Number of Days Commuting to Work/College

Figure D-9 presents the distribution of the number of days each commuter travels to work or college. Approximately, 64% of commuters travel to work at least 4 days or more a week, 21% of commuters travel 3 times a week and the remaining 15% travel once or twice a week.

D.3.2 Evacuation Response

Several questions were asked to gauge the population's response to an emergency. These are now discussed:

"Do you have any children attending K-12 school/childcare? If an evacuation is ordered for my home area during the school day, I would:" Approximately 22% of households have children within Areas. Of the 22% of households, as shown in Figure D-10, 83.4% of them will pick up their children at the school during an emergency, 2.5% would wait for buses to bring their children home if there is an early dismissal, 4.8% would not be home and would have a trusted guardian pick up their children from school/childcare, 0.6% would not be home and would have a trusted guardian pick up their children after they get off if the bus if there is an early dismissal, 4.5% would not pick up their children or send a guardian to pick up their children, 2.9% would wait for their children to walk/bike home, and the remaining 1.3% have other plans for reuniting with their children.

"How many cars would your household use during an evacuation?" The response is shown in Figure D-11. On average, evacuating households would use 1.14 vehicles.

"Would your family await the return of other family members prior to evacuating the area?" Of the survey participants who responded, approximately 30% said they would await the return of other family members before evacuating and the remaining 70% indicated that they would not await the return of other family members before evacuating.

"An evacuation is occurring in parts of Berkeley and you are worried. Emergency officials say that your area is not in danger. People in your area are told to stay off the roads to help the evacuation of areas in danger. Would you evacuate/not evacuate?" This question is designed to elicit information regarding compliance with instructions to shelter-in-place (not evacuate). The results indicate that approximately 90% of households who are advised to shelter at home would do so; the remaining 10% would choose to evacuate the area.

"Emergency officials advise you to evacuate due to an emergency. Where would you evacuate to?" Based on the responses, approximately 61% would evacuate to a friend/relative's home. Approximately 6% would evacuate to an evacuation shelter, 23% would evacuate to a hotel, motel, short-term rental (ex. AirBnB/VRBO), or campground, about 5% would evacuate to a second/seasonal home, about 2% responded that it depends on the emergency, and about 2% answered the question as other (work/office, vehicle, UC Berkeley campus, Berkeley marina, etc.). The remaining 1% of households would not evacuate. See Figure D-12 for complete results.

"If emergency officials told your area to evacuate, would you also tell a neighbor or friend in your area to evacuate?" This question is designed to elicit information regarding notification between residents in the study area. Approximately 95% of respondents said they would notify a neighbor or a friend. The remaining 5% said they would not.

"How would you tell your neighbor or friend to evacuate?" This question is designed to see how respondents in the study area would notify neighbors or friends during an evacuation, if they chose to do so. From the respondents who elected to notify a neighbor or friend during an evacuation (approximately 95% of respondents), 33.1% would notify using text message, 20.6% would make a phone call, 2.6% would use social media outlets, 42.6% of respondents would notify their neighbors in person, 0.8% of respondents would notify using a neighborhood email group, and 0.3% indicated they would use other methods. Figure D-13 displays these results.

"How would you rate your cell phone coverage near your home?" Figure D-14 presents how the respondents rated the cell phone coverage within their area. The purpose of this question was to gain insight into how well a cell phone-based alert and/or notification would be received. This question was added for informational purposes only and was not used in this study. As shown in the figure, the data is more heavily weighted towards good or better with 75% of respondents rating their cell phone reception in their area as good, very good, or excellent. Approximately 24% rated cell phone coverage as fair, poor or very poor in their area and the remaining 1% indicated that they do not have a cell phone.

"Do you have an AT&T landline?" Approximately 27% of the households have an AT&T landline, and 73% do not have an AT&T landline.

"Do you have any pet(s) and/or animal(s)? What type(s) of pet and/or animal do you have?" Approximately 50% of households have pets. Approximately 38.4% of households have small pets/animals and 11.3% have large pets/animals, and less than 0.1% report having large livestock. Figure D-15 displays these results.

"What would you do with your pet(s) and/or animal(s) if you had to evacuate?" Due to an error in the questionnaire, the responses to this question are omitted from the report.

D.3.3 Time Distribution Results

The survey asked several questions about the amount of time it takes to perform certain pre-evacuation activities. These activities involve actions taken by residents during the course of their day-to-day lives. Thus, the answers fall within the realm of the responder's experience.

The mobilization distributions provided below are the result of having applied the analysis described in Section 5.4.1 on the component activities of the mobilization.

"How long would it take you to notify a neighbor or friend to evacuate?" This question is designed to see how long it would take respondents to notify a neighbor or friend should they choose to do so. This distribution is displayed in Figure D-16 from the respondents who elected to notify a neighbor or friend during an evacuation. Approximately 85% of respondents can notify a neighbor or friend within 10 minutes; 100% within 20 minutes.

"How long would it take you to pick up your children from school?" This question is designed to see how long it would take respondents to pick up their children from school. This distribution is displayed in Figure D-17 from the respondents have school children, approximately 64% can pick up their school children within 20 minutes and all (100%) children are pick up within 45 minutes.

"How long does it take the commuter to complete preparation for leaving work/college?" Figure D-18 presents the cumulative distribution; in all cases, the activity is completed by 35 minutes. Approximately 90% can leave in less than 25 minutes.

"How long would it take the commuter to travel home?" Figure D-19 presents the work to home travel time for the Areas. Approximately 80% of commuters can arrive home within 40 minutes of leaving work; all within 90 minutes.

"If an emergency evacuation was ordered for your area, how long would it take your household to get ready to leave? Think about time to pack clothing, medications, other critical items, to prepare your pets, secure your home, and pack the car?" Figure D-20 presents the time required to prepare for leaving on an evacuation trip. In many ways this activity mimics a family's preparation for a short holiday or weekend away from home. Hence, the responses represent the experience of the responder in performing similar activities. The distribution shown in Figure D-20 has a long "tail." Approximately 90% of households can be ready to leave home within 75 minutes; the remaining 10% of households require up to an additional 60 minutes.

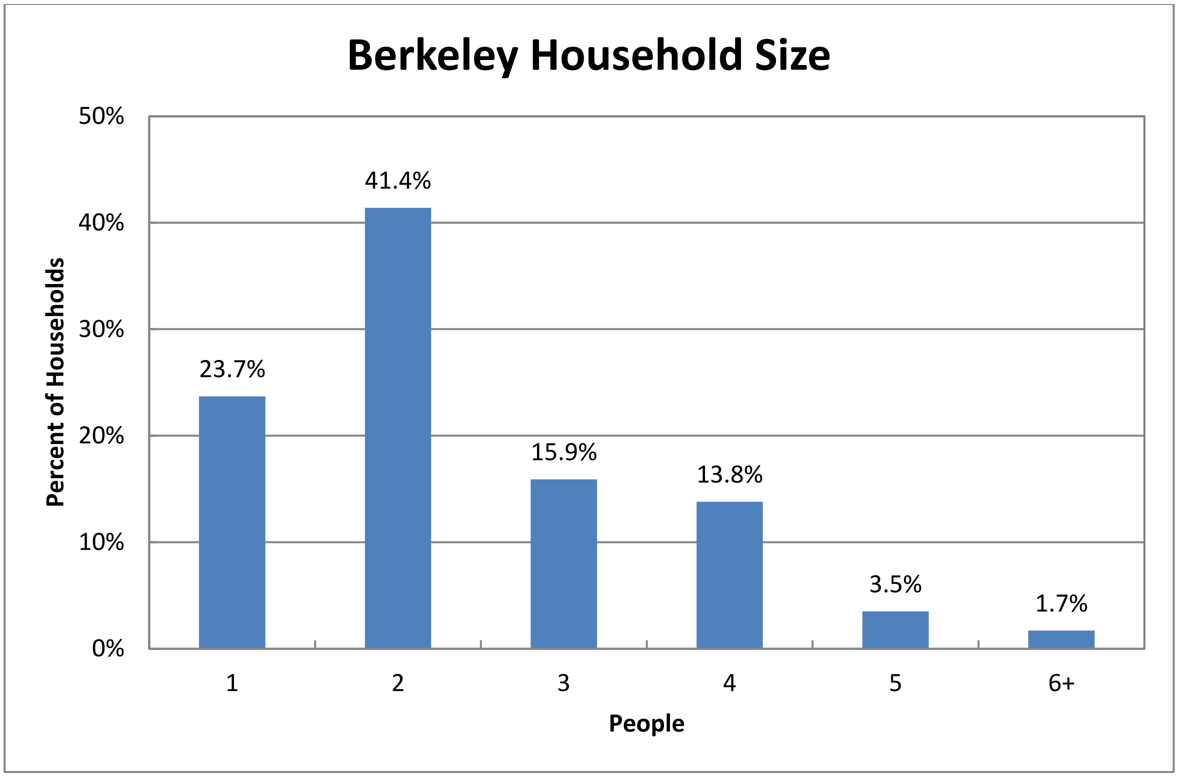


Figure D-1. Household Size in the Study Area

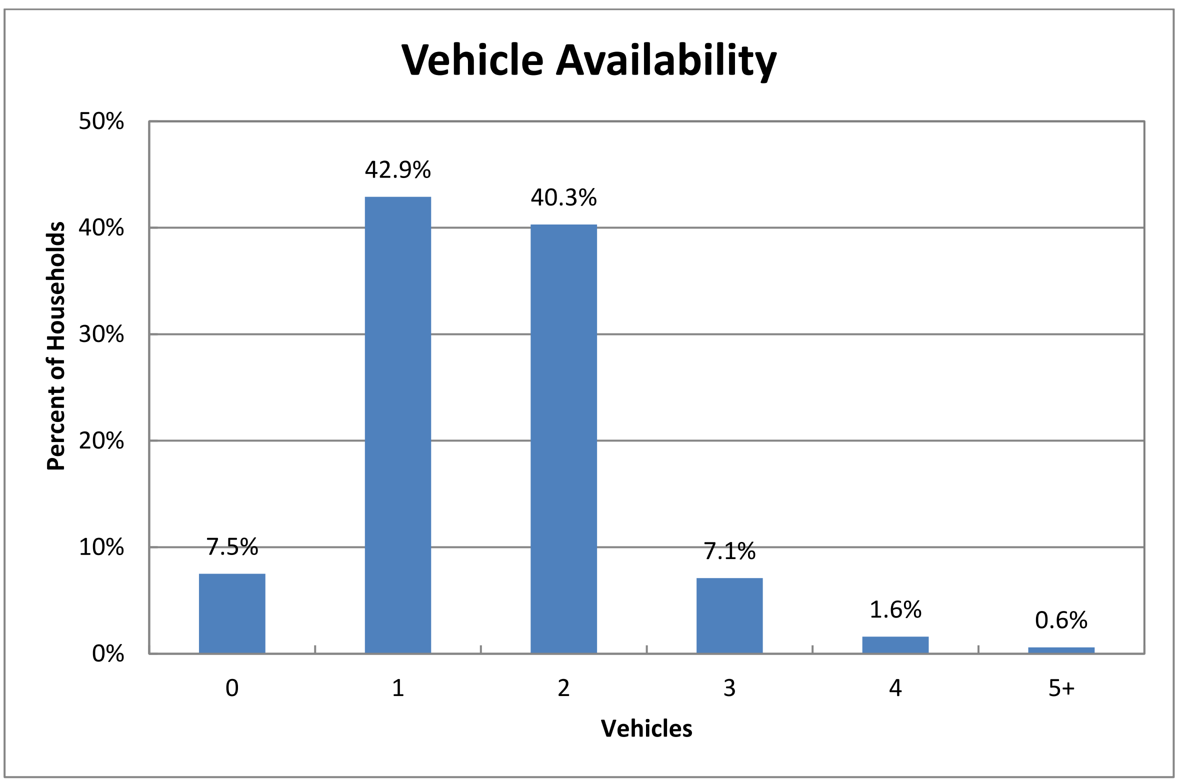


Figure D-2. Vehicle Availability

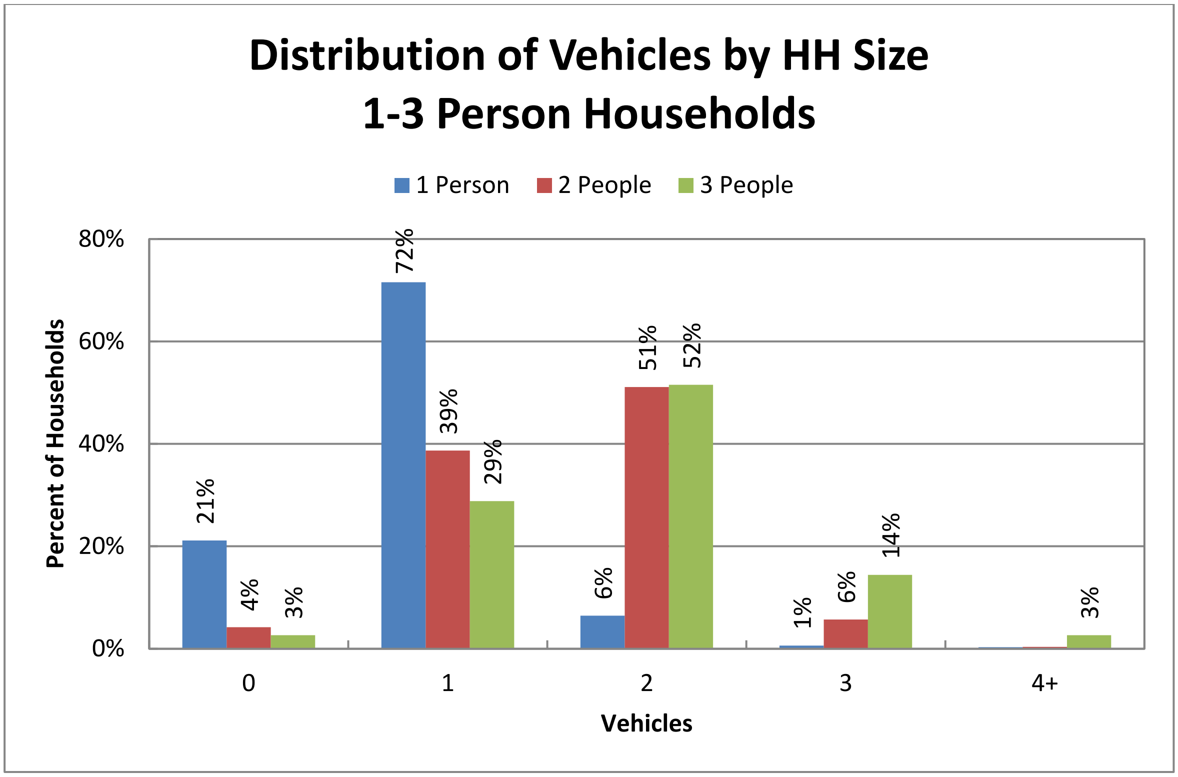


Figure D-3. Vehicle Availability - 1 to 3 Person Households

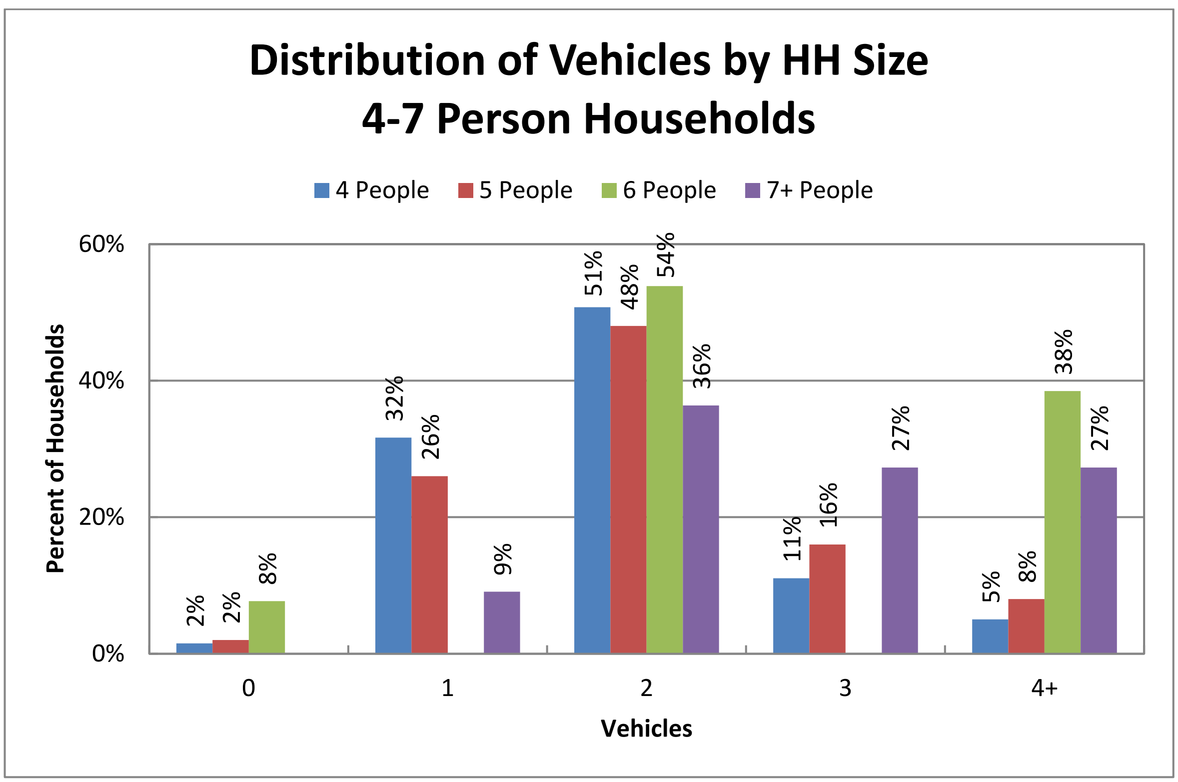


Figure D-4. Vehicle Availability – 4 to 7 Person Households

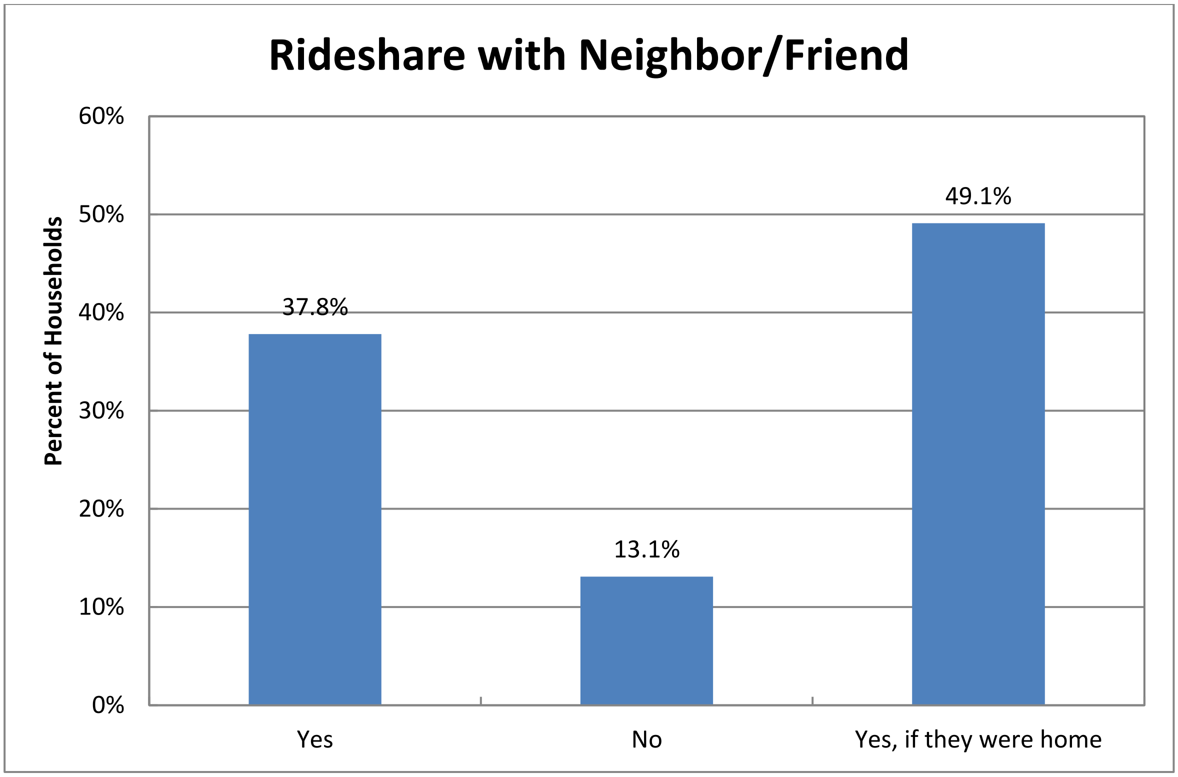


Figure D-5. Rideshare with Neighbor/Friend

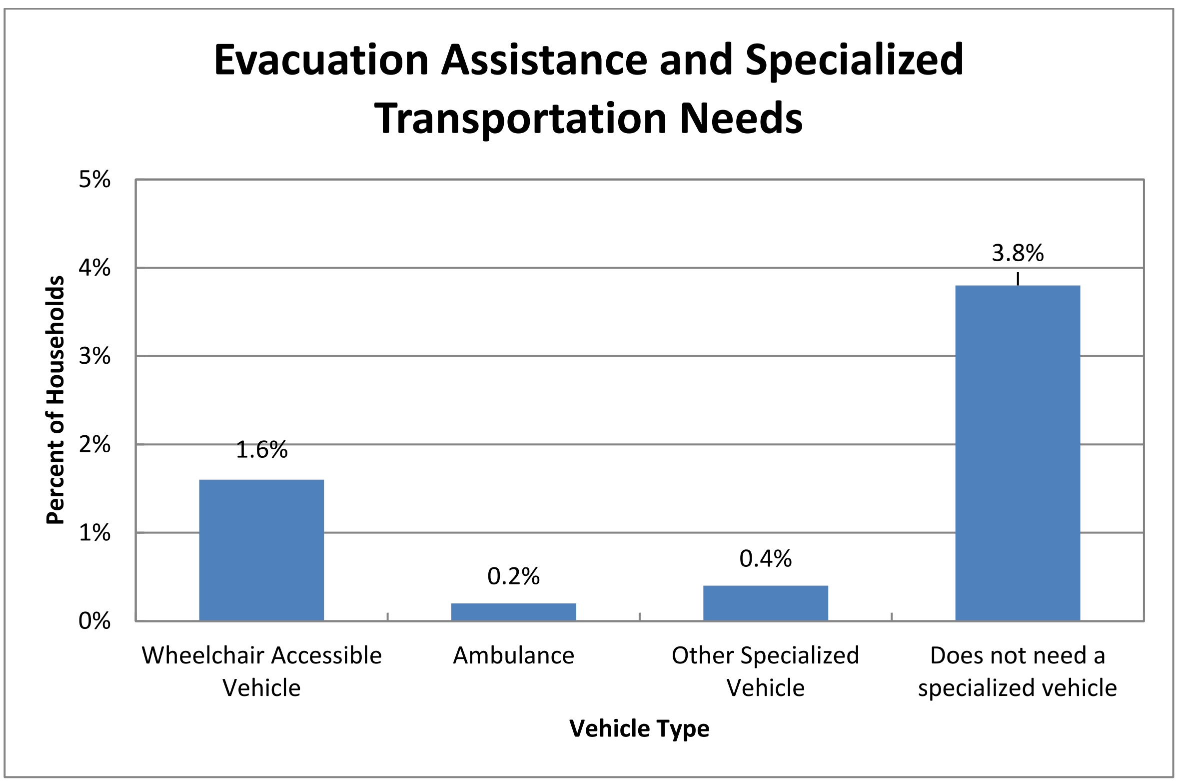


Figure D-6. Specialized Transportation Needs for Households Requiring Evacuation Assistance

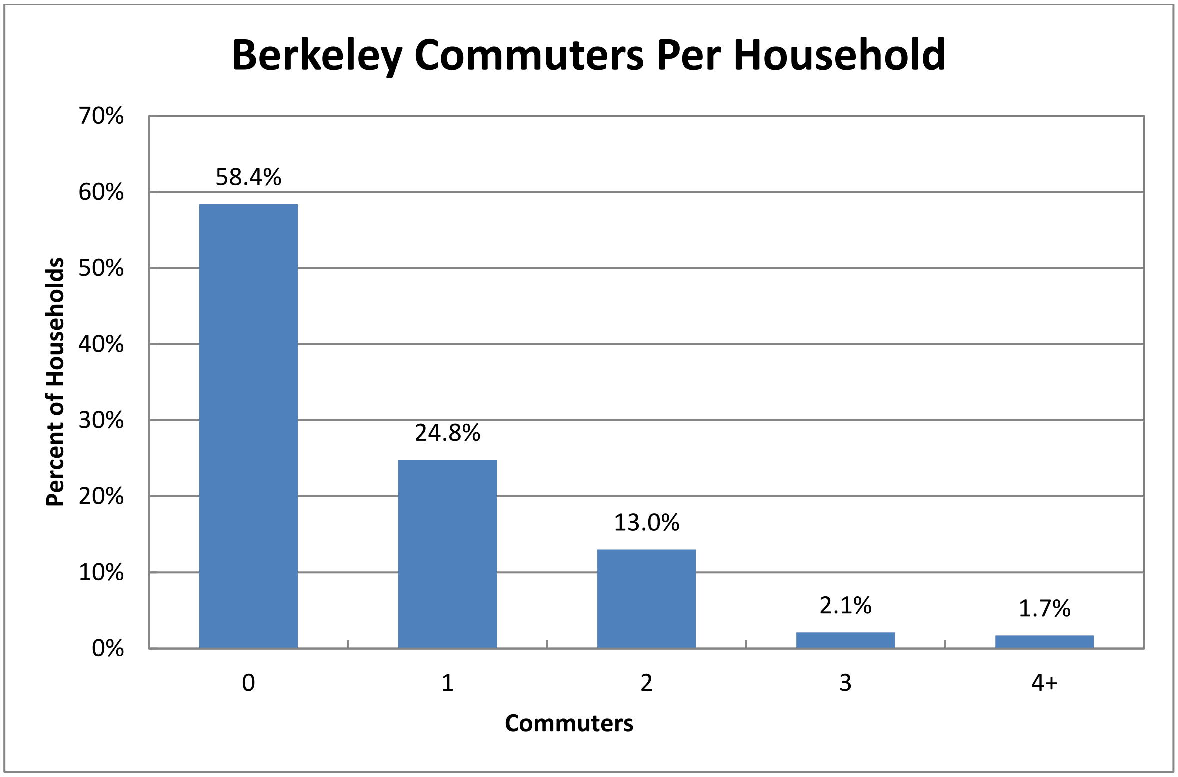


Figure D-7. 5-Day-per-Week Commuters in Households in the Study Area

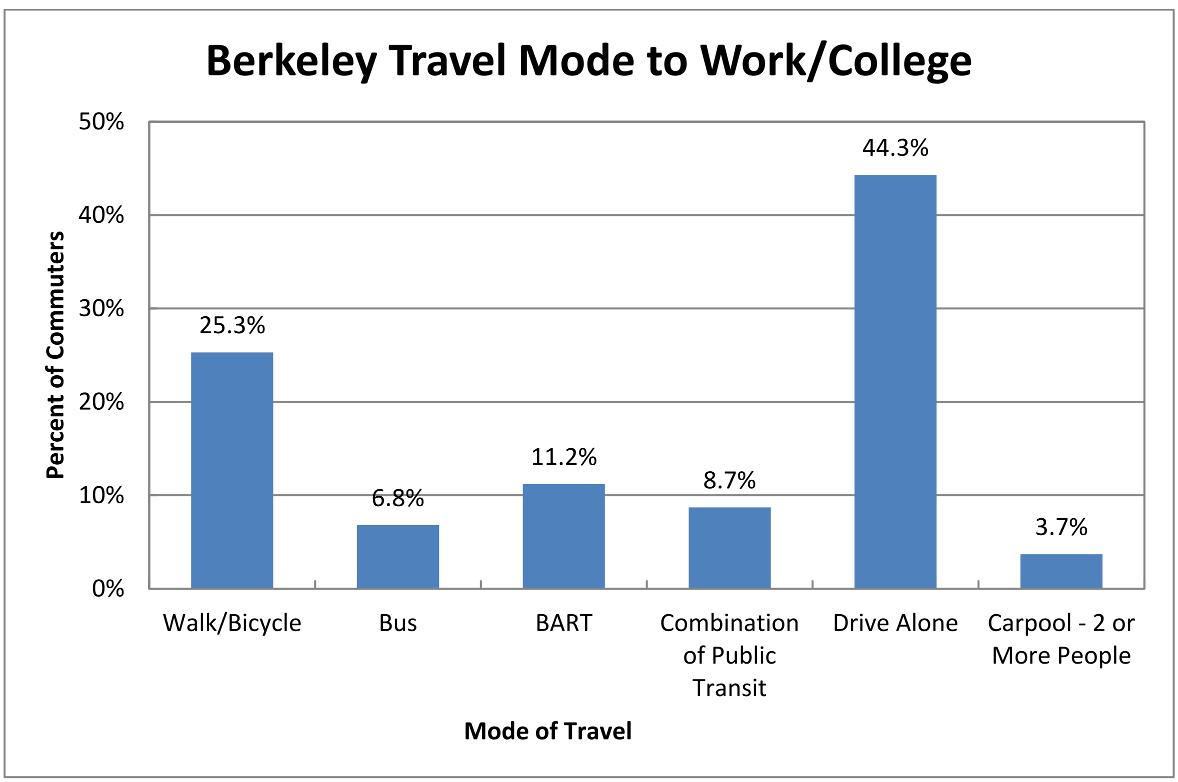


Figure D-8. Travel Modes to Work/College in the Study Area

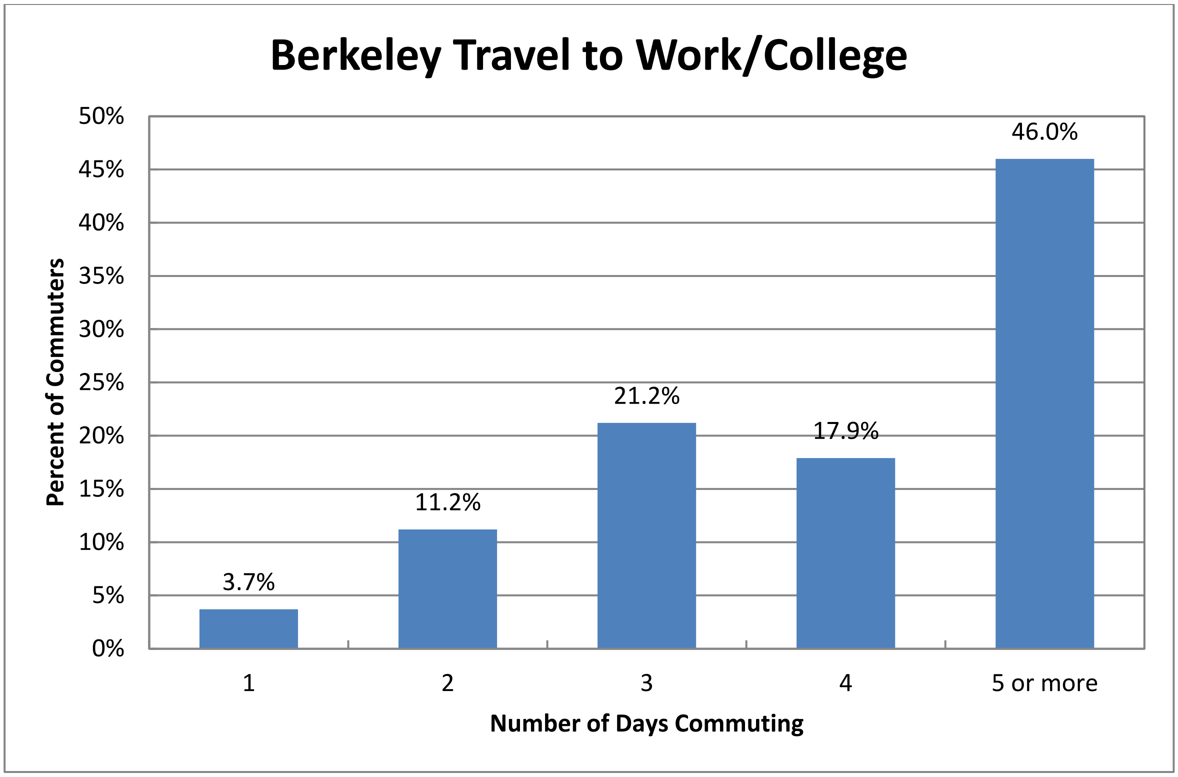


Figure D-9. Number of Days Commuting to Work/College

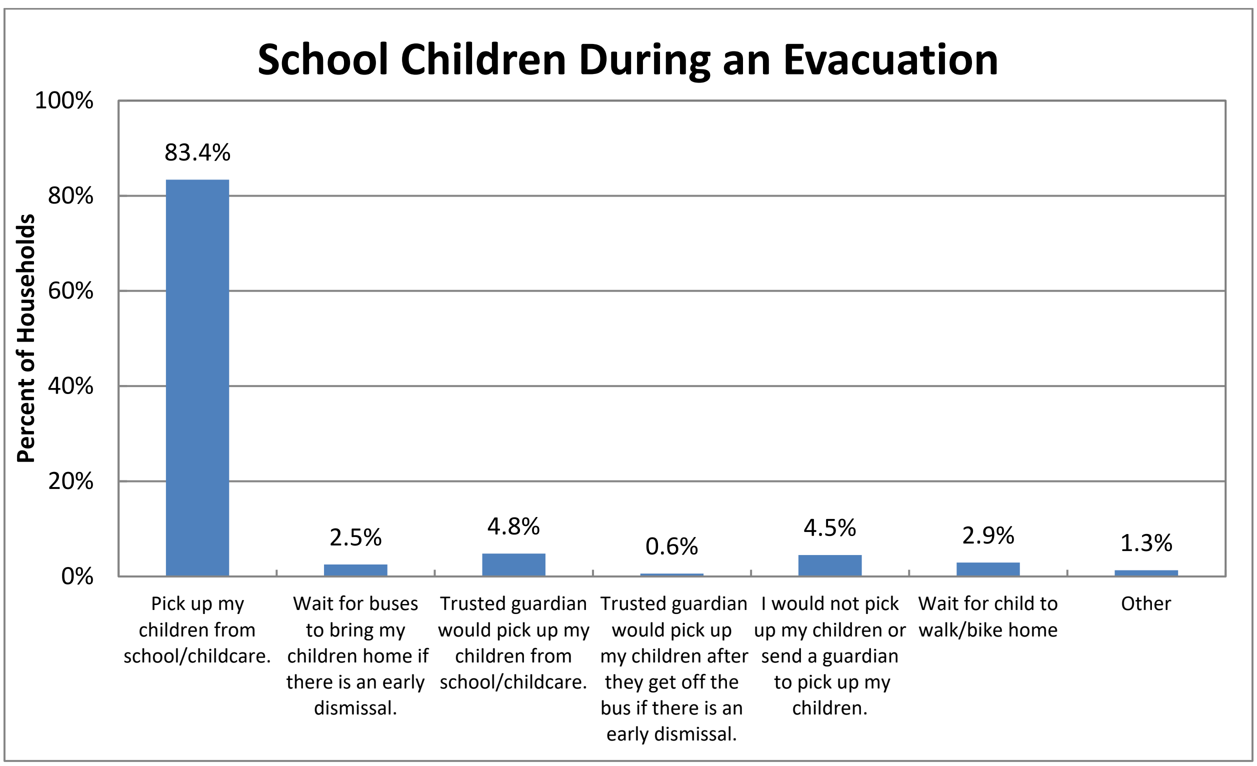


Figure D-10. School Children During an Evacuation

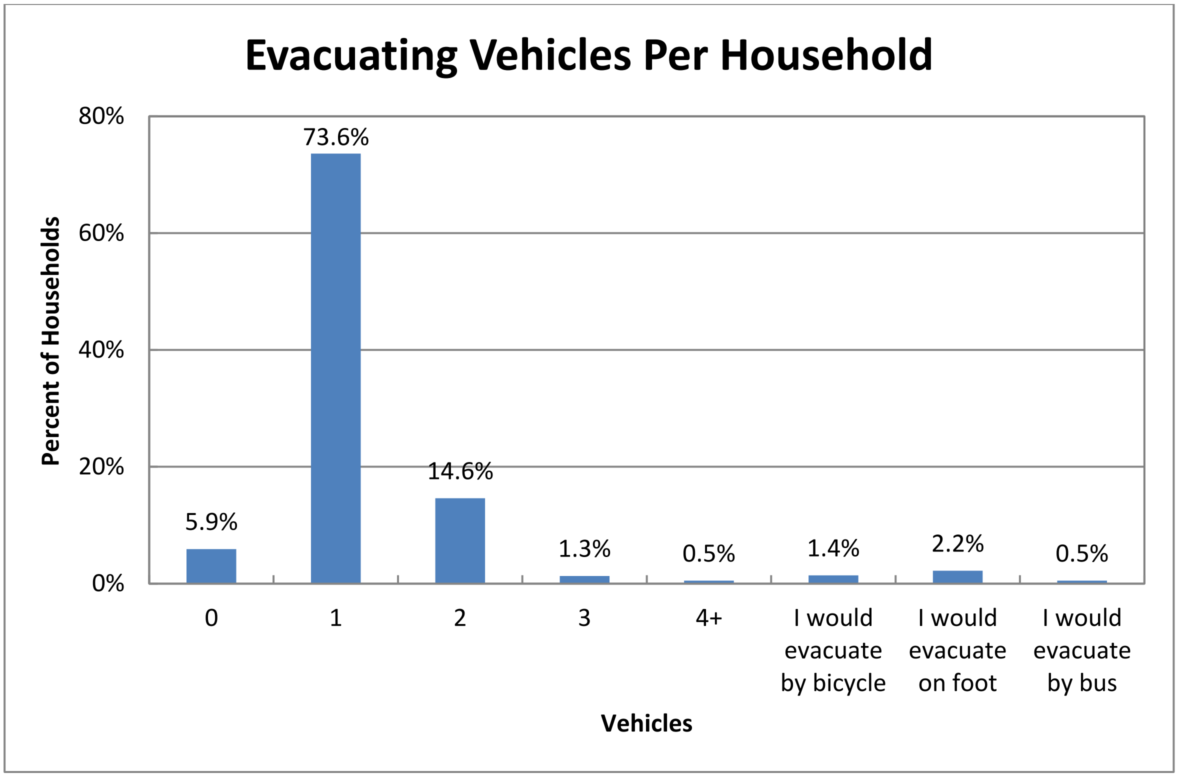


Figure D-11. Number of Vehicles Used for Evacuation

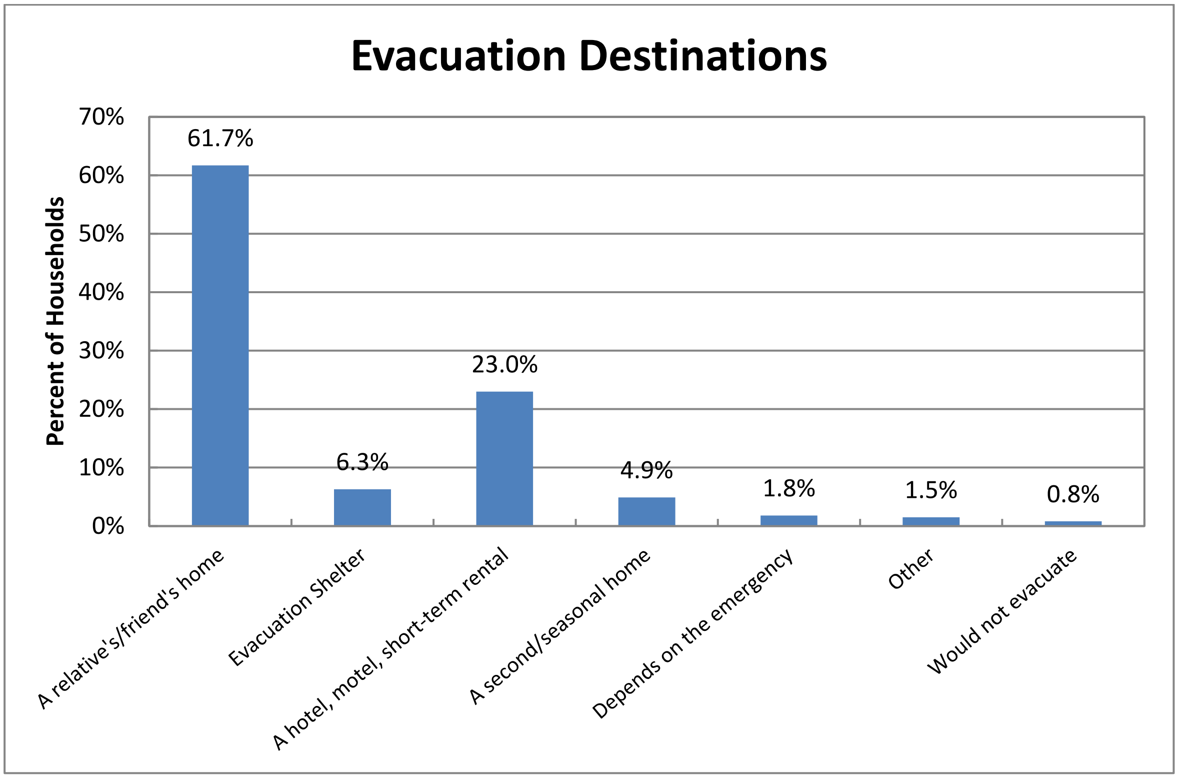


Figure D-12. Study Area Evacuation Destinations

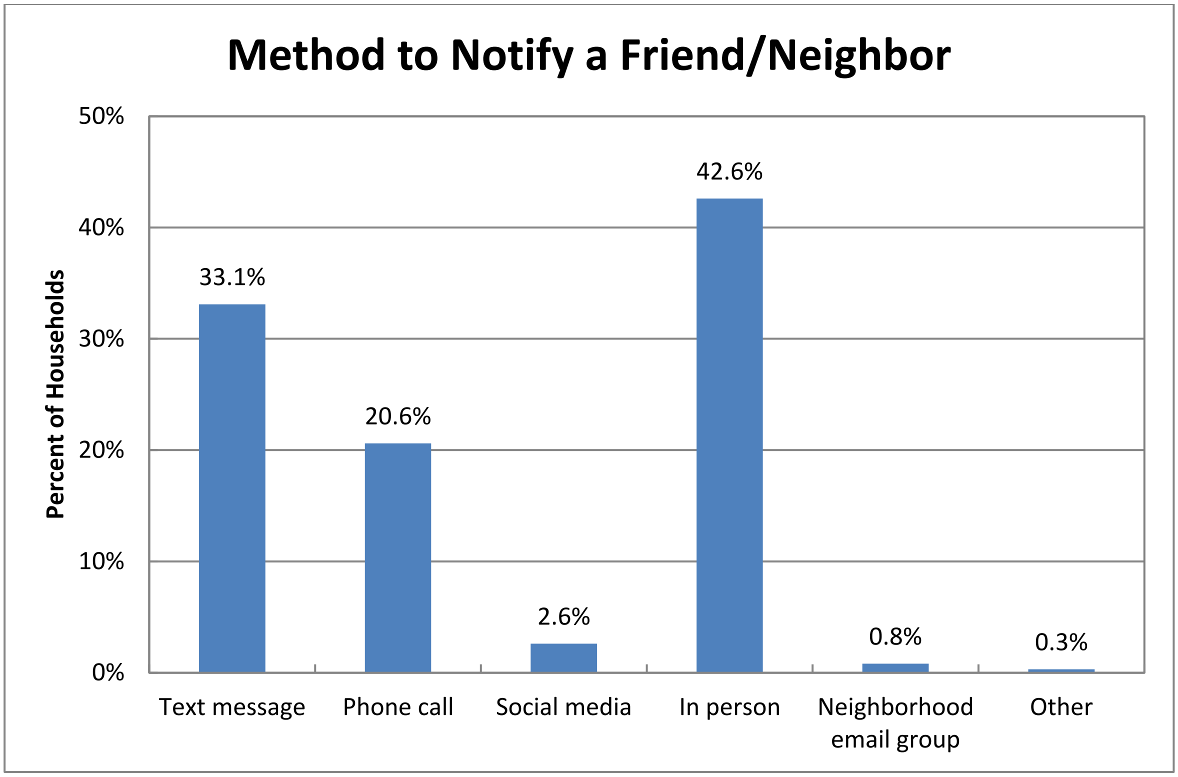


Figure D-13. Method to Notify a Friend/Neighbor

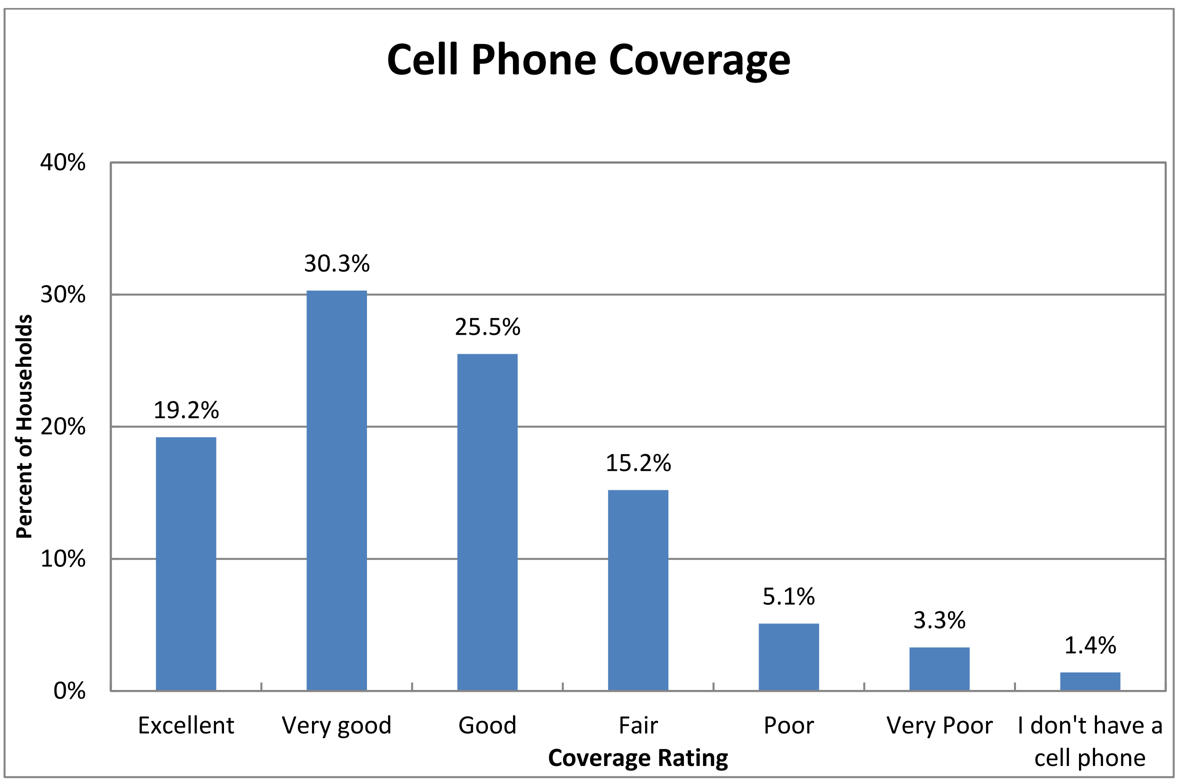


Figure D-14. Cell Phone Coverage

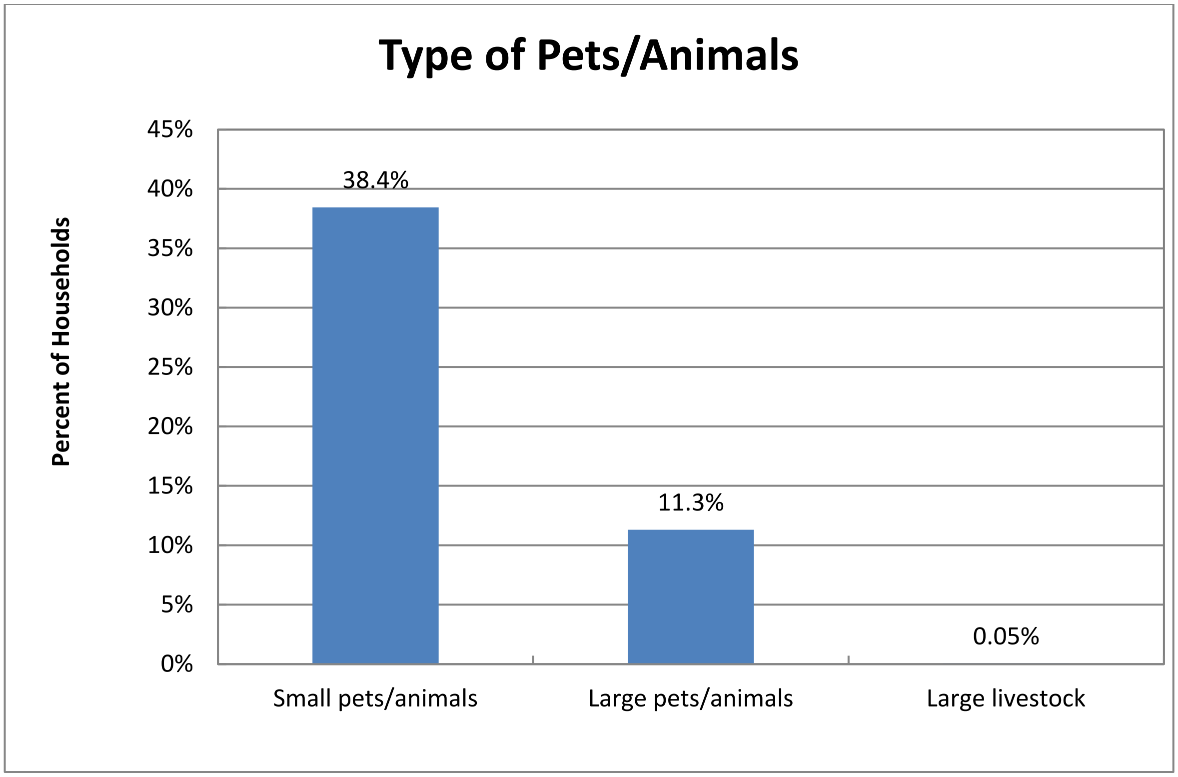


Figure D-15. Pet Ownership in Study Area

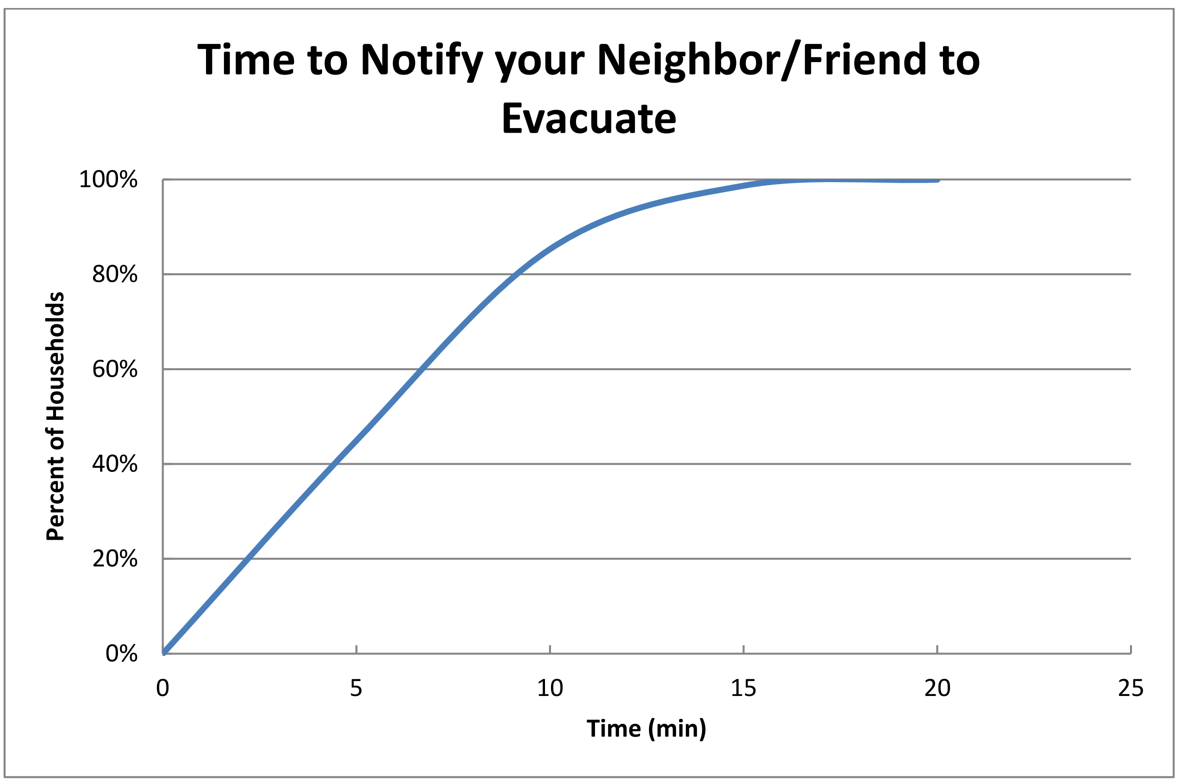


Figure D-16. Time to Take to Notify a Neighbor/Friend to Evacuate

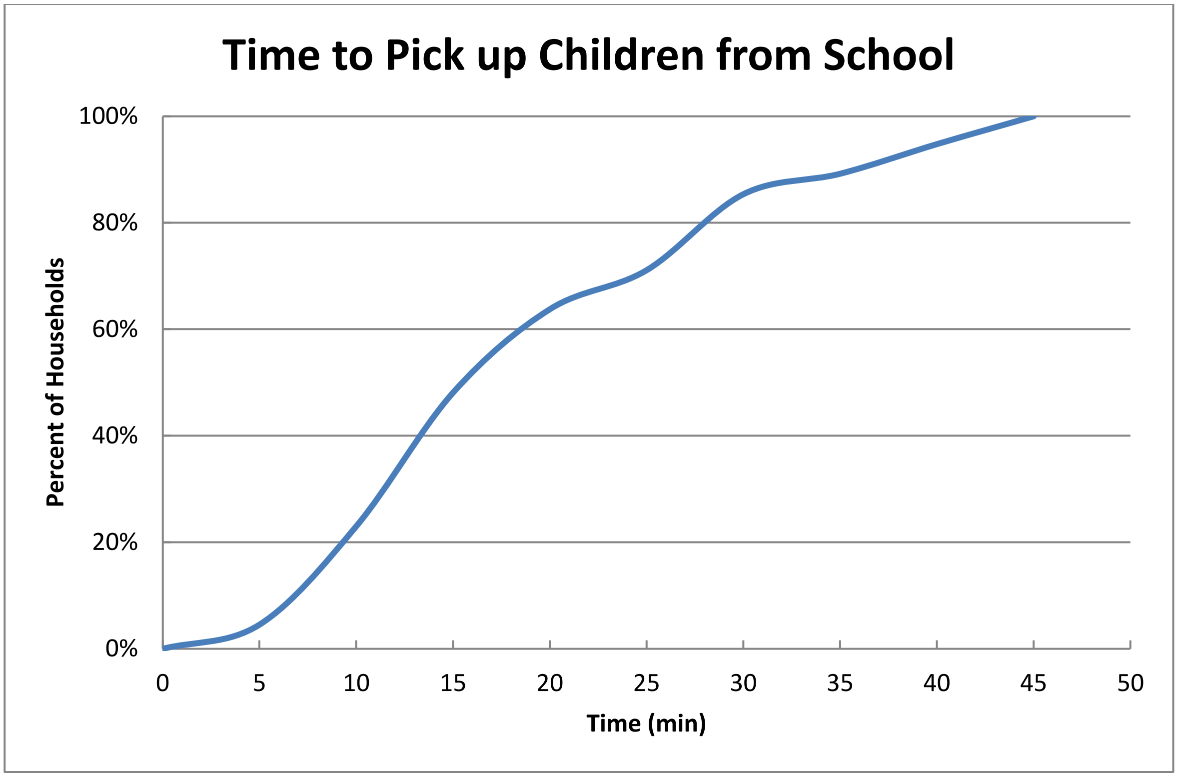


Figure D-17. Time to Pick Up Children from School

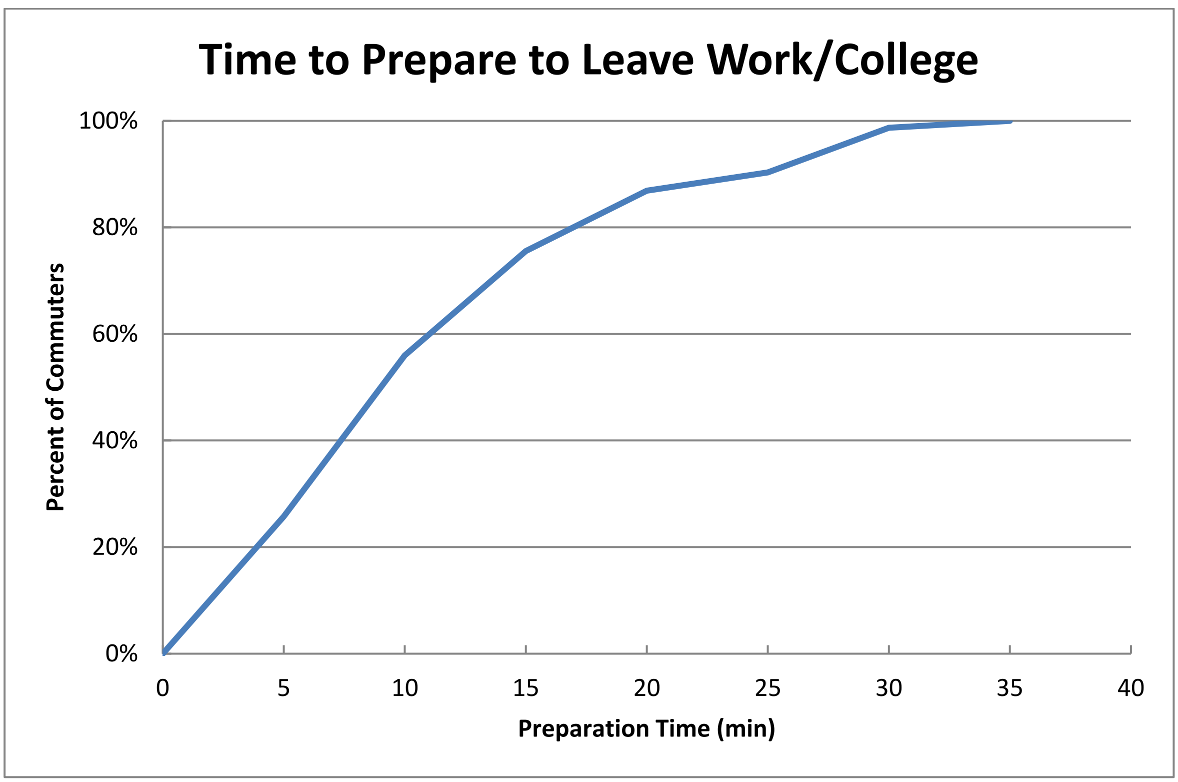


Figure D-18. Time Required to Prepare to Leave Work/College

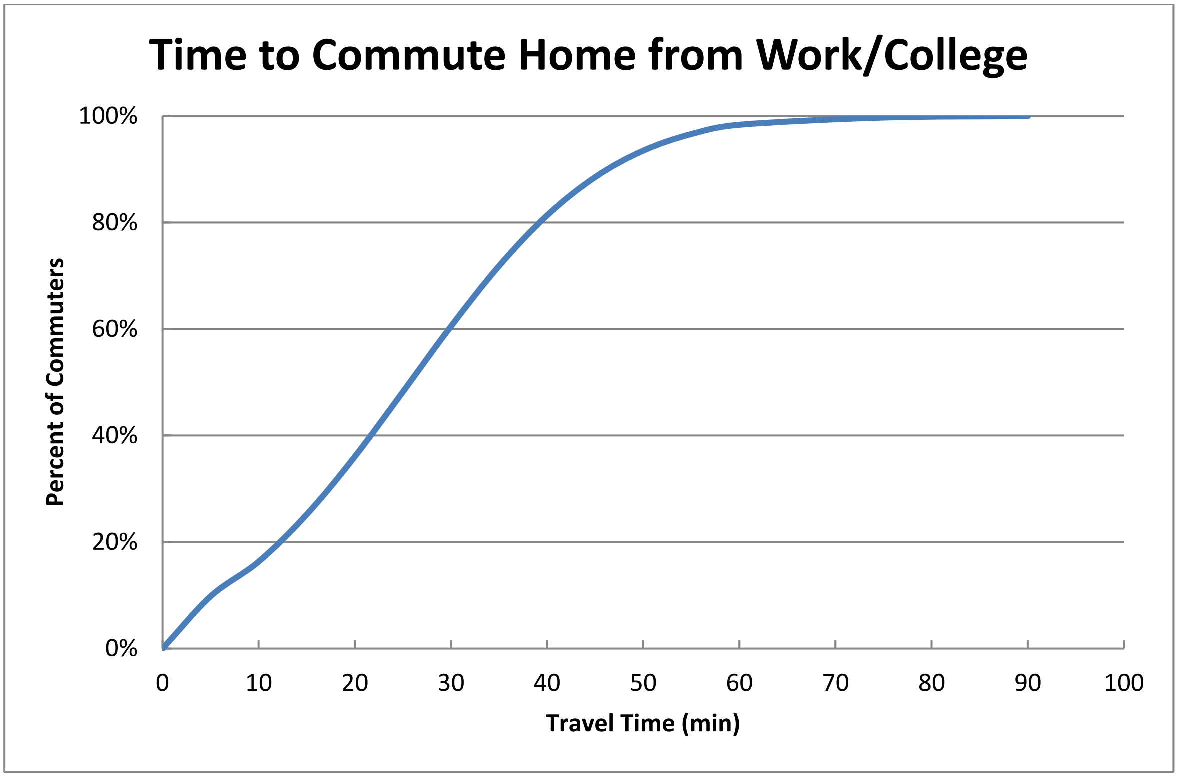


Figure D-19. Time to Travel Home from Work/College

Figure D-20. Time to Prepare Home for Evacuation

ATTACHMENT A

Demographic Survey Instrument

City of Berkeley Community Evacuation Survey

Welcome!

Please help us improve Berkeley's emergency evacuation plans by completing this 10-minute survey. Your responses will help us predict how long it will take people in Berkeley to get out of the path of a fire, tsunami, or other hazard. With this information, we can provide better instructions on how to stay safe in emergencies.
This survey includes prize giveaways to 7 (seven) randomly chosen respondents! There will be 3 (three) first prize winners with a $100 Visa gift card and 4 (four) second prize winners with a $50 Visa gift card. In order to win a prize, please provide your address, phone number and/or email address at the end of the survey. If you wish to not participate, you may opt to not provide your personal information but still complete to survey to help improve our local emergency planning. PLEASE PROVIDE ONLY ONE RESPONSE PER HOUSEHOLD. MULTIPLE ENTRIES WILL BE DISQUALIFIED FOR THE PRIZE GIVEAWAY.
Thank you for taking the time to do this survey. If you have questions please reach out to the Berkeley Fire Department's Office of Emergency Services: oes@berkeleyca.gov.
All your answers will be kept strictly confidential. City of Berkeley staff, its consulting team for this project, and their families are not eligible for the prize giveaways.

1A. What is your home zip code? *

1B: Check off any boxes that describe you. (Leave blank if none of these options describe you):

- ☐ I am a UC Berkeley undergraduate student.
- ☐ I am a UC Berkeley graduate student, visiting scholar, student researcher, or postdoc.
- ☐ I live in the Berkeley Marina.

2. How many people usually live in your household (including roommates)?

Please Select

3A. How many running cars does your household have?

Please Select

3B. How many cars would your household use during an evacuation?

Please Select

4. If you didn't have your own transportation, could you get a ride out of the area with a neighbor or friend in an emergency?

- ◯ Yes
- ◯ No
- ◯ Yes, if they were home
- ◯ Not sure/prefer not to say

5A. Does anyone in your household need help from someone outside the household (caretaker, personal attendant) to prepare to evacuate or to get to a vehicle?

- ◯ Yes
- ◯ No
- ◯ Don't Know/Prefer not to say

If you would like to provide more details on your answer to Question 5A, please describe below:

5B. How many people in your household require a specialized vehicle to evacuate? For each person, choose the vehicle that they would need to evacuate.

	0	1	2	3	4	More than 4
Wheelchair Accessible Vehicle	◯	◯	◯	◯	◯	◯
Ambulance	◯	◯	◯	◯	◯	◯
Other Specialized Vehicle	◯	◯	◯	◯	◯	◯

If you chose "Other Specialized Vehicle" for Question 5B, please describe the vehicle:

6. How many adults in your household commute to work or college on a daily basis? *

Please Select

Travel to Work or College

7. How many days a week does each commuter travel to work?

	1	2	3	4	5 or more
Commuter 1	◯	◯	◯	◯	◯
Commuter 2	◯	◯	◯	◯	◯
Commuter 3	◯	◯	◯	◯	◯
Commuter 4	◯	◯	◯	◯	◯

8. How does each commuter usually travel to work or college on those days?

	Walk/Bicycle	Bus	BART	Combination of Public Transit	Drive Alone	Carpool - 2 or More People	Don't Know
Commuter 1	○	○	○	○	○	○	○
Commuter 2	○	○	○	○	○	○	○
Commuter 3	○	○	○	○	○	○	○
Commuter 4	○	○	○	○	○	○	○

9-1. What zip code does Commuter #1 commute to for work or college?

9-2. What zip code does Commuter #2 commute to for work or college?

9-2. What zip code does Commuter #2 commute to for work or college?

9-4. What zip code does Commuter #4 commute to for work or college?

Getting Ready to Leave Work or College

10-1. On a normal day, how long does it take Commuter #1 to pack up and leave their worksite or college?

Please Select

If you answered "Over 2 Hours" for Question 10-1, please tell us how many hours:

10-2. On a normal day, how long does it take Commuter #2 to pack up and leave their worksite or college?

Please Select

If you answered "Over 2 Hours" for Question 10-2, please tell us how many hours:

10-3. On a normal day, how long does it take Commuter #3 to pack up and leave their worksite or college?

Please Select

If you answered "Over 2 Hours" for Question 10-3, please tell us how many hours:

10-4. On a normal day, how long does it take Commuter #4 to pack up and leave their worksite or college?

Please Select

If you answered "Over 2 Hours" for Question 10-4, please tell us how many hours:

Travel Home From Work or College

11-1. How long does it usually take Commuter #1 to travel home from work or college?

Please Select

If you answered "Over 2 Hours" for Question 11-1, please tell us how many hours:

11-2. How long does it usually take Commuter #2 to travel home from work or college?

Please Select

If Over 2 Hours for Question 11-2, please tell us how many hours:

11-3. How long does it usually take Commuter #3 to travel home from work or college?

Please Select

If Over 2 Hours for Question 11-3, please tell us how many hours:

[ ]

11-4. How long does it usually take Commuter #4 to travel home from work or college?

Please Select

If Over 2 Hours for Question 11-4, please tell us how many hours:

[ ]

Household Evacuation Plan

12. If an emergency evacuation was ordered for your area, how long would it take your household to get ready to leave? Think about time to pack clothing, medications, other critical items, to prepare your pets, secure your home, and pack the car.

Please Select

13. Please choose one of the following:

- ◯ During an emergency, I would await the return of household members to evacuate together.
- ◯ During an emergency, I would evacuate independently and meet other household members later.
- ◯ Don't know

14A. Emergency officials advise you to evacuate due to an emergency. Where would you evacuate to?

- ◯ A relative's or friend's home
- ◯ Wait for an evacuation shelter to be set up, then go there
- ◯ A hotel, motel, short-term rental (ex: AirBnB/VRBO), or campground
- ◯ A second/seasonal home
- ◯ Would not evacuate
- ◯ Don't know
- ◯ Prefer not to say
- ◯ Other [ ]

If you answered "Other" for Question 14A, please tell us more:

[ ]

14B. An evacuation is occurring in parts of Berkeley and you are worried. Emergency officials say that your area is not in danger. People in your area are told to stay off the roads to help the evacuation of areas in danger. Would you:

◯ Not evacuate
◯ Evacuate
◯ Don't know/prefer not to say

Children in School/Childcare

15A. Do you have any children attending K-12 school/childcare?

◯ Yes
◯ No
◯ Prefer not to say

15B. If an evacuation is ordered for my home area during the school day, I would:

◯ Pick up my children from school/childcare.
◯ Wait for buses to bring my children home if there is an early dismissal.
◯ I will not be home - I would have a trusted guardian pick up my children from school/childcare.
◯ I will not be home - I would have a trusted guardian pick up my children after they get off the bus if there is an early dismissal.
◯ I would not pick up my children or send a guardian to pick up my children.
◯ Other ______

15C. How long would it take you or a guardian to pick up your children from school?

Please Select

If you answered "Other" to Question 15B and this question does not apply, please leave it blank.

Pet Questions

16A. Do you have any pet(s) and/or animal(s)? *

◯ Yes
◯ No
◯ Prefer not to say

16B. What type(s) of pet and/or animal do you have?

☐ Small pets/animals
☐ Large pets/animals
☐ Large livestock
☐ Prefer not to say

16C. What would you do with your pet(s) and/or animal(s) if you had to evacuate?

- ◯ Leave pet at home
- ◯ Take pet with me
- ◯ Take pet/animal to a different place than I will go
- ◯ I have different plans for each pet/animal
- ◯ Don't know/Prefer not to say

Emergency Alerting Systems

17. How would you rate the cell phone coverage near your home?

- ◯ Excellent
- ◯ Very Good
- ◯ Good
- ◯ Fair
- ◯ Poor
- ◯ Very Poor
- ◯ I don't have a cell phone
- ◯ Prefer not to say

18. Do you have an AT&T landline?

- ◯ Yes
- ◯ No
- ◯ Prefer not to say

Sharing Evacuation Instructions

19A. If emergency officials told your area to evacuate, would you also tell a neighbor or friend in your area to evacuate?

- ◯ Yes
- ◯ No
- ◯ Prefer not to say

19B. How would you tell your neighbor or friend to evacuate?

- ☐ Text message
- ☐ Phone call
- ☐ Social media
- ☐ In person

- ☐ Neighborhood email group
- ☐ Don't know/prefer not to say
- ☐ Other

19C. How long would it take you to tell your neighbor or friend to evacuate?

Please Select

Prize Giveaway Information

Please only fill this out if you wish to be eligible for the prize giveaways. Please provide an email, mailing address, and/or a phone number to be contacted.

Name

First Name

Last Name

Email

example@example.com

Address

Street Address

Street Address Line 2

City

State / Province

Postal / Zip Code

Phone Number

Please enter a valid phone number.

Please press "Submit" below to complete the survey!

Submit

Thank you for taking the time to complete this survey.

If you would like to learn more about Fire Weather and Evacuations, please visit our website at https://berkeleyca.gov/safety-health/fire/fire-weather-evacuation.

If you have questions or concerns, please email the City of Berkeley Fire Department - Office of Emergency Services: oes@berkeleyca.gov.

APPENDIX E

Evacuation Regions

E EVACUATION REGIONS

This appendix presents maps of all of the Evacuation Regions (groupings of Genasys Zones) considered for this study. These evacuation regions were developed in consultation with the City of Berkeley. They are based on historical evacuation data and represent areas expected to evacuate together in response to a given hazard or emergency.

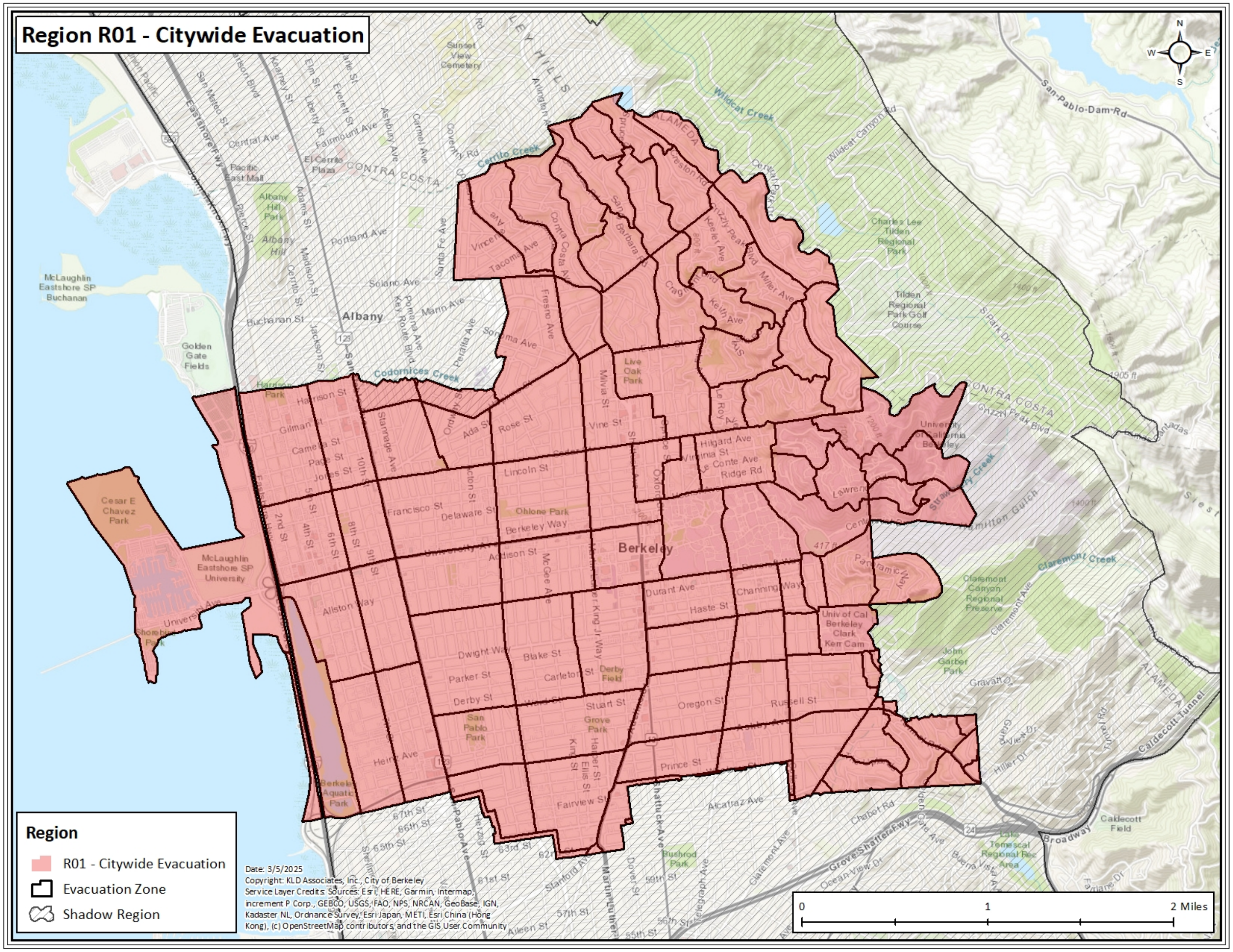


Figure E-1. Citywide Evacuation

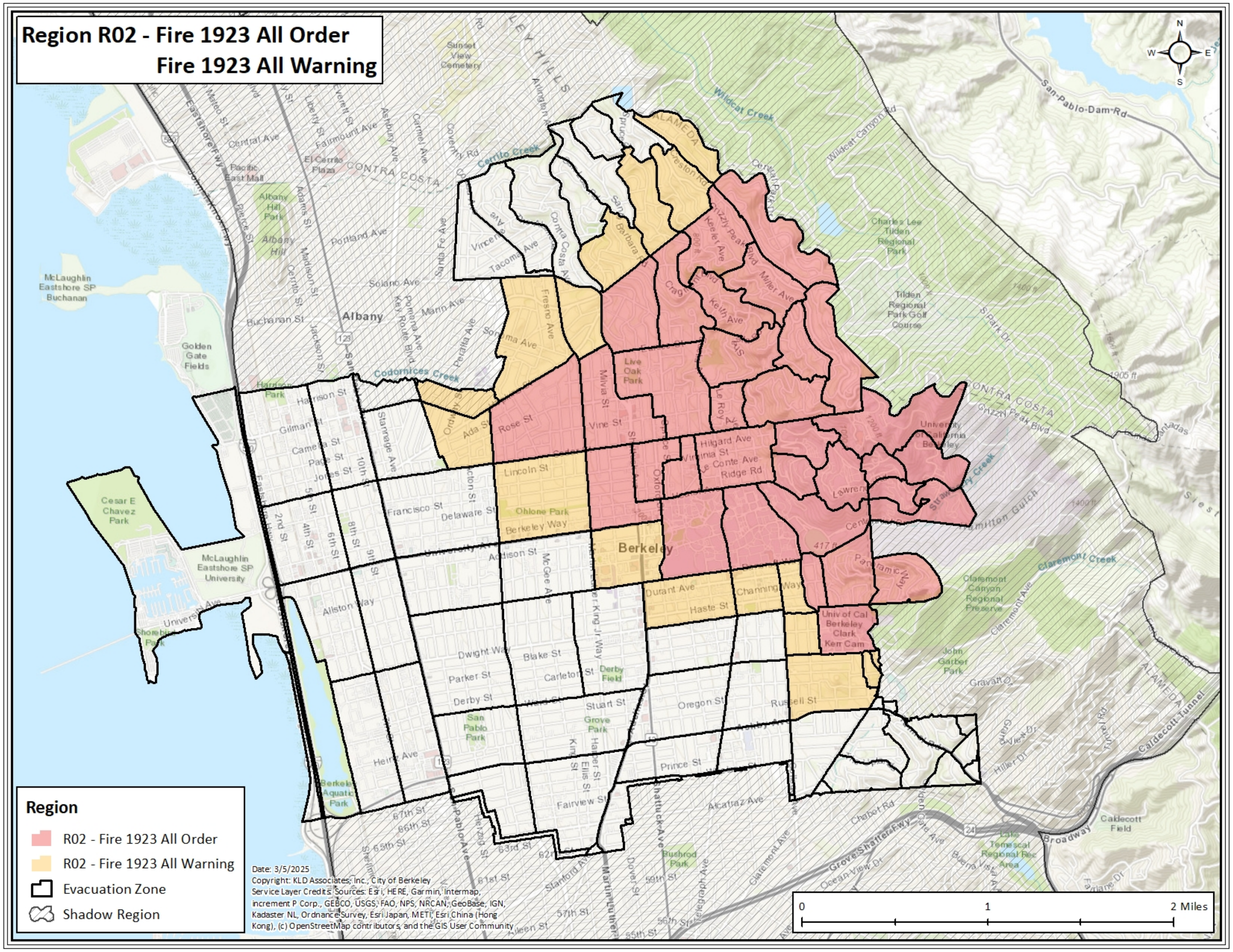


Figure E-2. Fire 1923

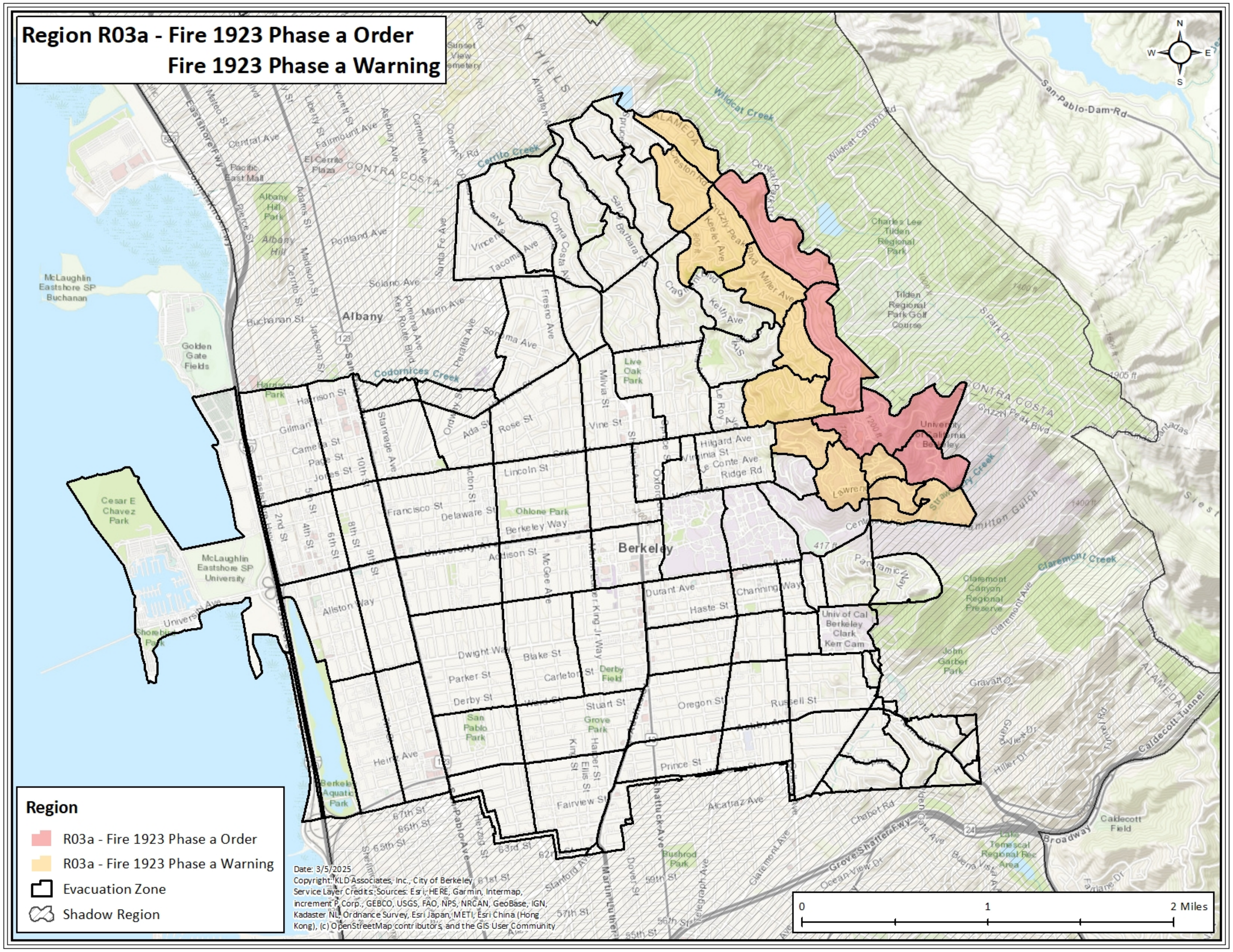


Figure E-3. Fire 1923 Phase a

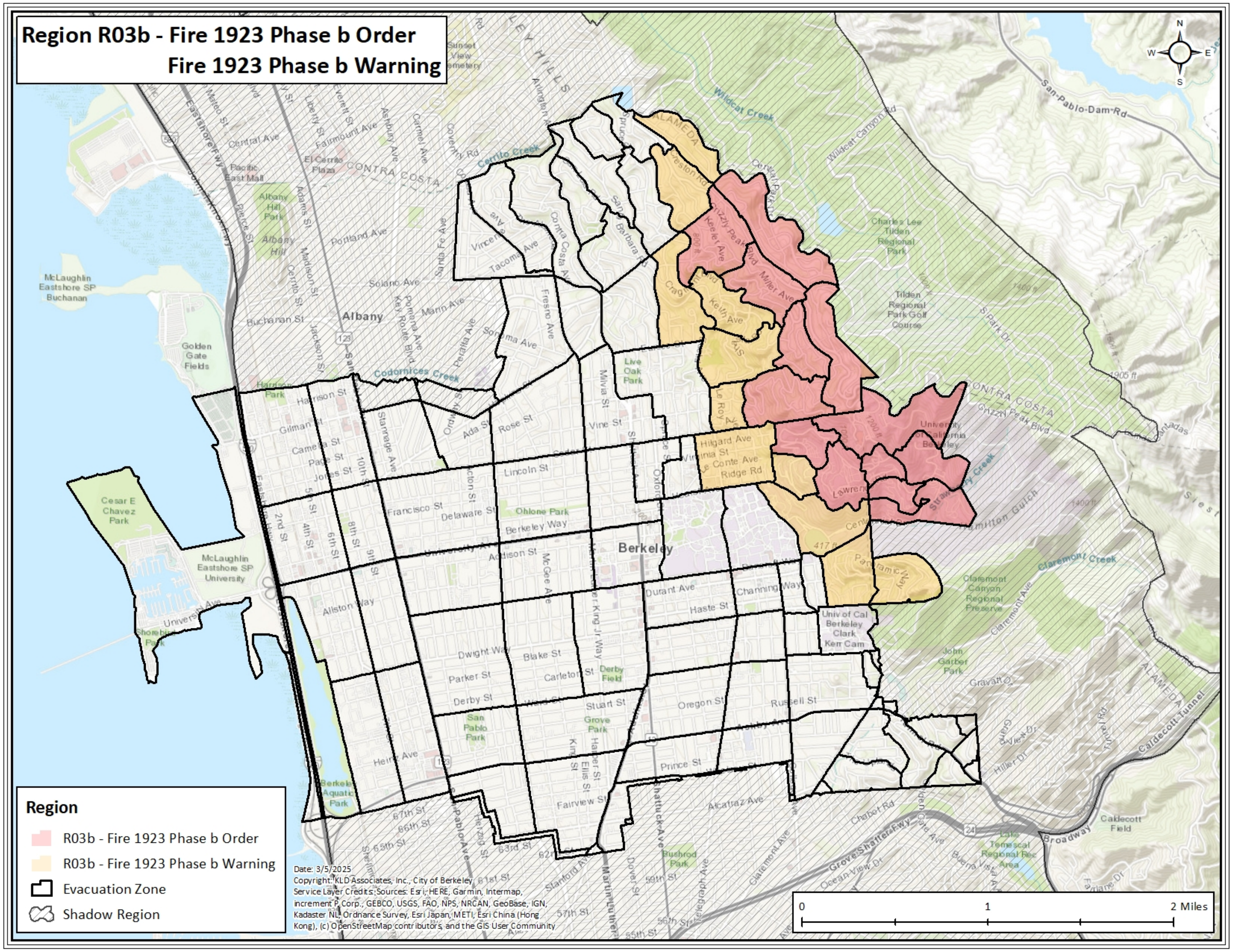


Figure E-4. Fire 1923 Phase b

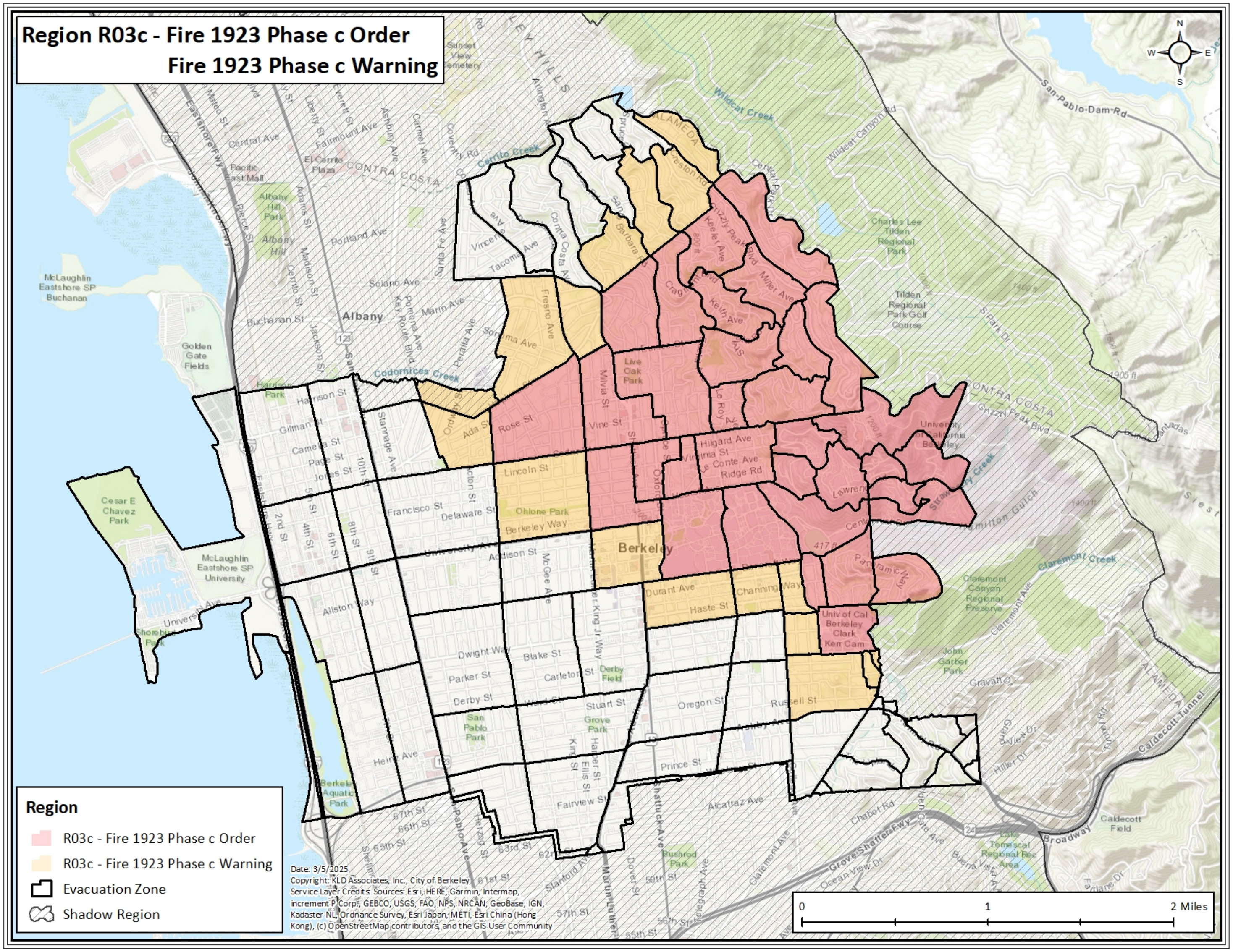


Figure E-5. Fire 1923 Phase c

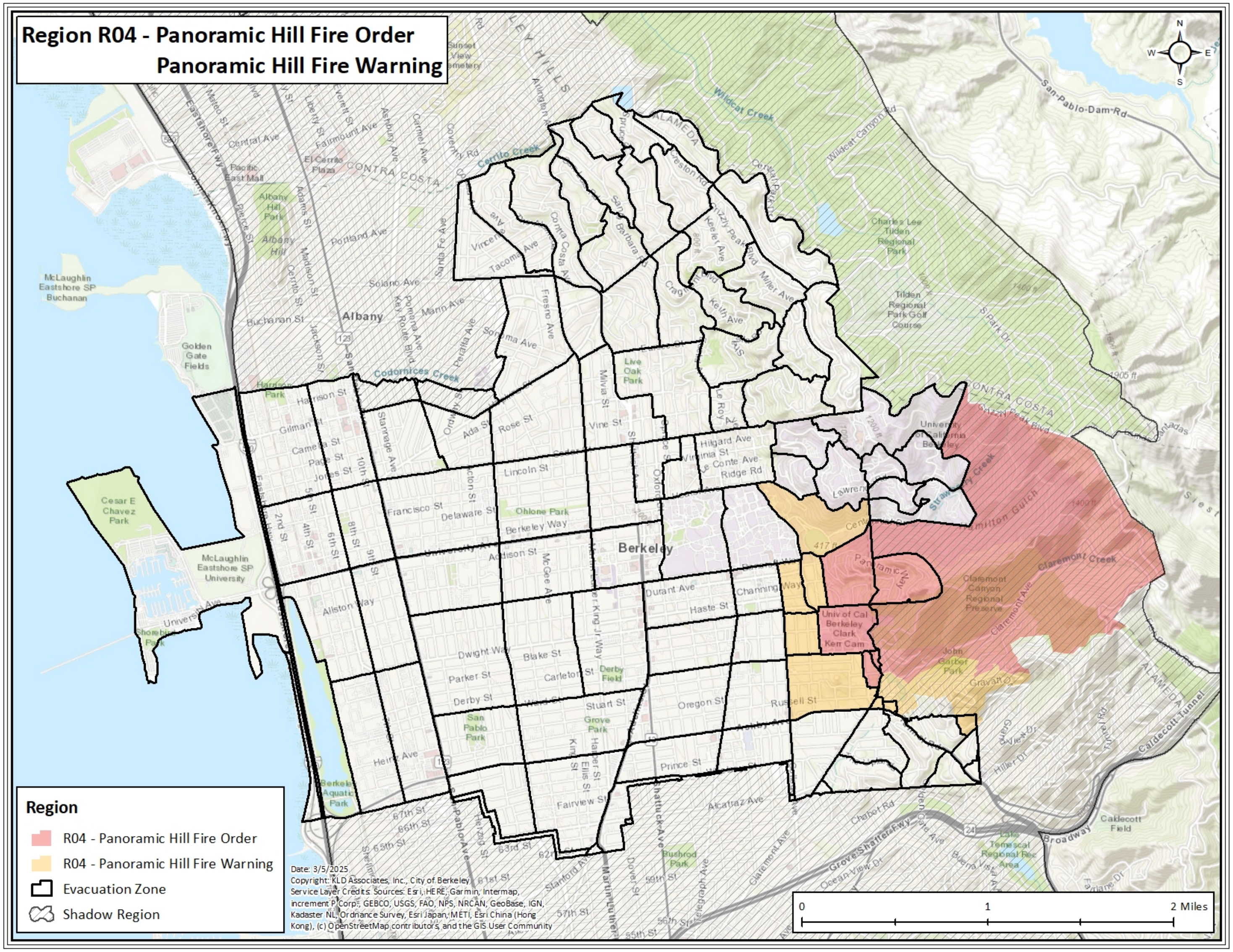


Figure E-6. Panoramic Hill Fire

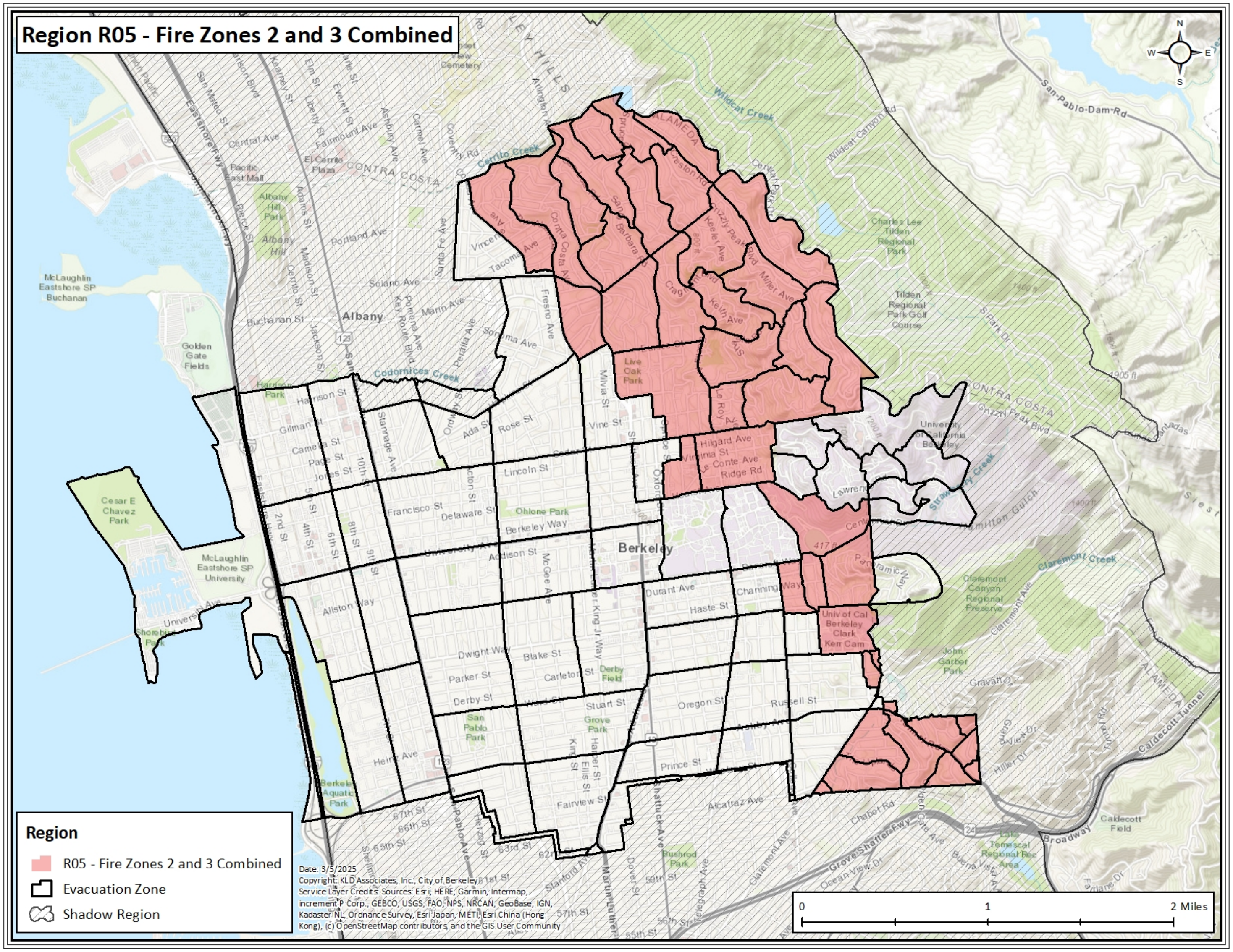


Figure E-7. Fire Zone 2 and 3 Combined

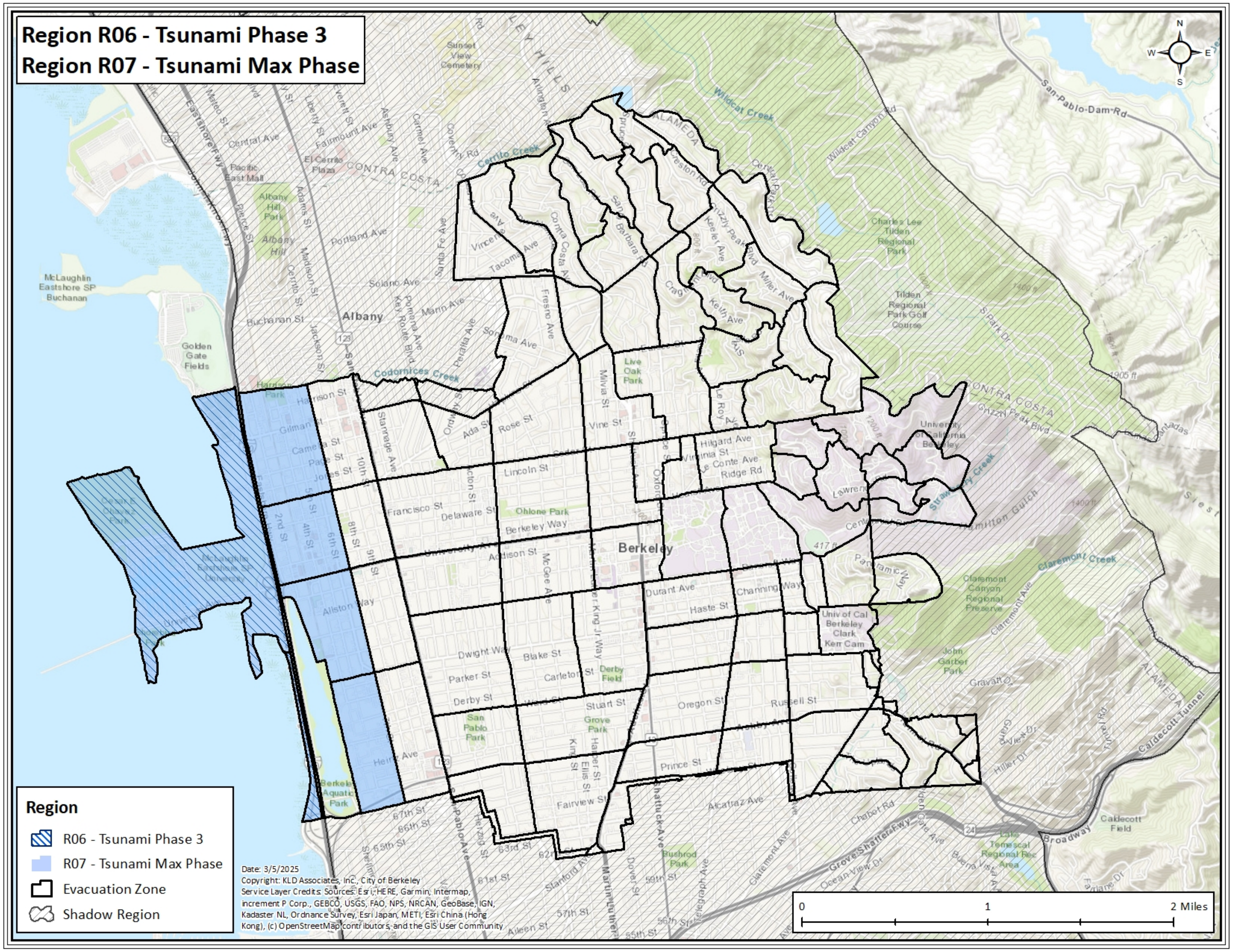


Figure E-8. Tsunami Phase 3 and Tsunami Max Phase

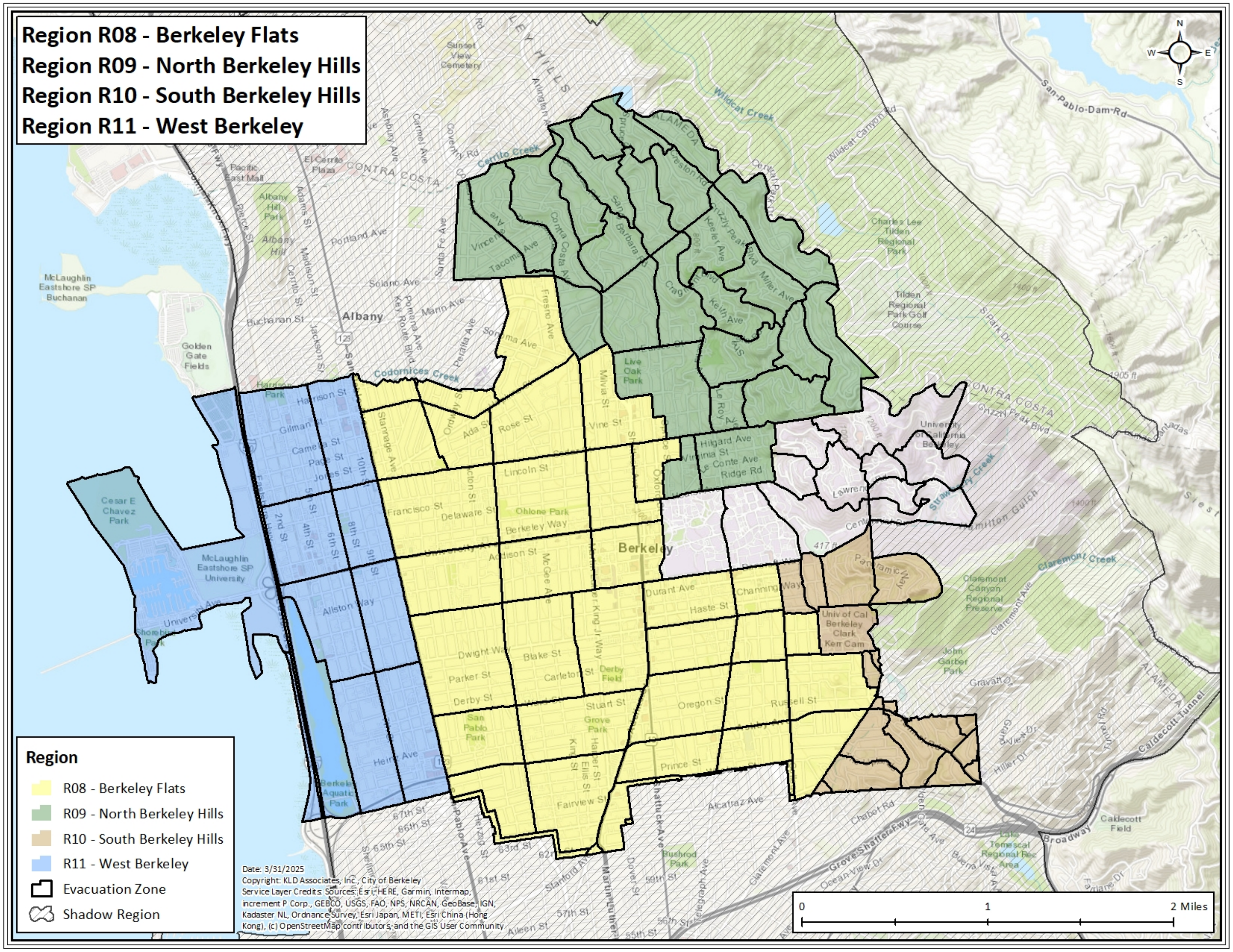


Figure E-9. Berkeley Flats, North Berkeley, South Berkeley and West Berkeley

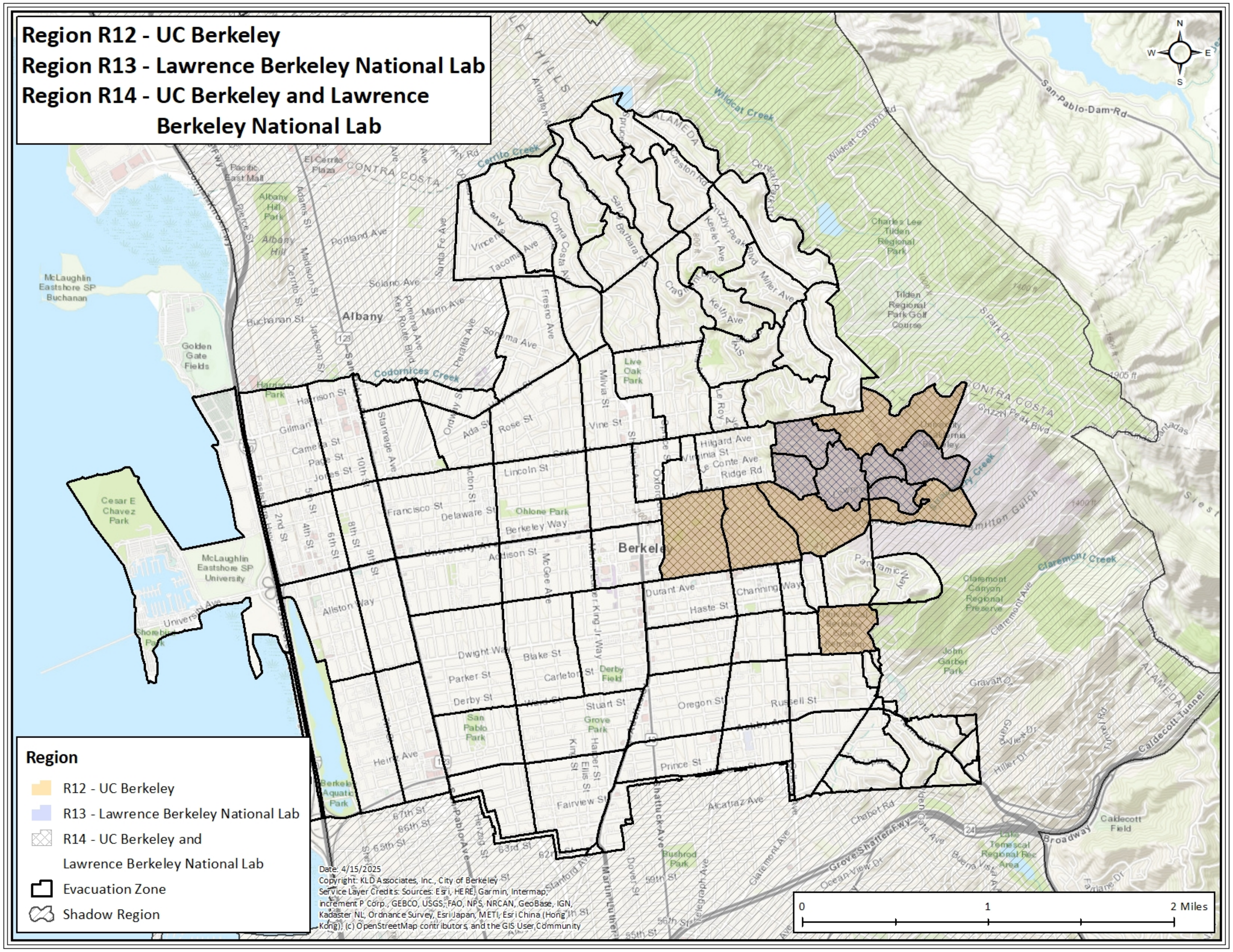


Figure E-10. UC Berkeley and Lawrence Berkeley National Lab

APPENDIX F

Patterns of Traffic Congestion During Evacuation

F. PATTERNS OF TRAFFIC CONGESTION DURING EVACUATION

This appendix provides patterns of traffic congestion during an evacuation. Traffic congestion, as the term is used here, is defined as Level of Service (LOS) F. LOS F is defined as follows (HCM 2022, page 5-5):

> The HCM uses LOS F to define operations that have either broken down (i.e., demand exceeds capacity) or have reached a point that most users would consider unsatisfactory, as described by a specified service measure value (or combination of service measure values). However, analysts may be interested in knowing just how bad the LOS F condition is, particularly for planning applications where different alternatives may be compared. Several measures are available for describing individually, or in combination, the severity of a LOS F condition:
>
> • *Demand-to-capacity ratios* describe the extent to which demand exceeds capacity during the analysis period (e.g., by 1%, 15%).
>
> • *Duration of LOS F* describes how long the condition persists (e.g., 15 min, 1 h, 3 h).
>
> • *Spatial extent measures* describe the areas affected by LOS F conditions. They include measures such as the back of queue and the identification of the specific intersection approaches or system elements experiencing LOS F conditions.

All highway "links" which experience LOS F are delineated in these figures by a thick red line; all others are lightly indicated. Congestion develops around concentration of population and traffic bottlenecks. The congestion patterns are presented for the regions specified below for Scenario 4 (fall midweek midday) as it’s the scenario with highest vehicular demand and therefore greatest levels of congestion.

F.1 Citywide Evacuation (Region R01)

As is noted in Section 7, **Region R01 does not reflect a realistic emergency or disaster**. An event requiring simultaneous evacuation of all of Berkeley would have regional impacts to roadway and transportation systems that are far beyond the scope of this analysis.

Rather, Citywide evacuation was included in this document in order to stress Berkeley’s roadway network to identify areas of potential traffic congestion that may not have been apparent from other evacuation cases.

Figure F-1 displays congestion patterns just 15 minutes after the Evacuation Order. At this time, 8.1% of vehicles have begun their evacuation trip and 6% of evacuating vehicles have successfully evacuated Berkeley. Initial congestion patterns are developing, particularly in the eastern portion of the Berkeley Flats and surrounding the UC Berkeley campus. As vehicles begin to mobilize, the increased traffic volume is already exceeding the capacity of key roadways in this area. This localized congestion is potentially due to the convergence of multiple evacuation routes, clustered pre-timed signals and traffic calming devices, a series of one-way pairs, and the high density of residential areas adjacent to the university.

1 hour after the initial Evacuation Order, 54.6% of vehicles have begun their evacuation trip and 26.7% of evacuating vehicles have successfully evacuated Berkeley. As shown in Figure F-2, congestion has become fully developed, with near-gridlock conditions prevailing. The Berkeley Flats are now experiencing LOS F on virtually every major street, indicating severely congested flow. This widespread congestion extends into the Berkeley Hills area, impacting key thoroughfares such as Spruce Street, Grizzly Peak Boulevard, Boynton Avenue, and Marin Avenue, all of which are also operating at LOS F. The confluence of evacuating traffic from both the flats and the hills has resulted in a critical bottleneck, effectively impeding movement and significantly reducing the overall evacuation efficiency.

Two hours after the Evacuation Order, 96.7% of vehicles have begun their evacuation trip and 50.1% of evacuating vehicles have successfully evacuated Berkeley. Severe congestion persists, although a slight improvement is observed in the Berkeley Hills area, as shown in Figure F-3. However, the situation has escalated elsewhere, with Interstate 580 (I-580) and its associated ramps now operating at LOS F, effectively creating a major bottleneck for evacuees attempting to leave the area along this freeway. As drivers seek alternative routes, arterial streets such as San Pablo Avenue, Sacramento Street, and Shattuck Avenue are experiencing increased traffic volume. The inherent configuration of Berkeley's road network, characterized by predominantly north-south routes and limited east-west connectivity, exacerbates the congestion, restricting evacuation options and further hindering traffic flow. This constrained network design contributes significantly to the persistent gridlock and poses a considerable challenge to efficient evacuation.

Three hours after the Evacuation Order, nearly all (99.6%) vehicles have begun their evacuation trip and 72.7% of evacuating vehicles have successfully evacuated Berkeley. As shown in Figure F-4, the congestion begins to show some signs of differentiation. While the Berkeley Flats area continues to experience heavy congestion, particularly in the northern sections, conditions in the southeast are starting to improve. In the Berkeley Hills area, the dissipation of congestion continues, though several key arteries, including Woodmont Avenue, Grizzly Peak Boulevard, Spruce Street, Marin Avenue and Boynton Avenue, remain at LOS F, indicating persistent bottlenecks. On I-580, some sections are now operating at LOS C, a significant improvement. However, the ramps connecting to the interstate remain heavily congested and continue to function as the primary bottleneck, impeding the overall flow of evacuating traffic onto the interstate. This persistent ramp congestion suggests that access to and from one of the primary evacuation routes remains a critical bottleneck.

Four hours after the initial Evacuation Order, all evacuating vehicles have begun their evacuation trip and 89.7% of evacuating vehicles have successfully evacuated Berkeley. As shown in Figure F-5, a noticeable reduction in citywide congestion can be observed. LOS F conditions are now primarily concentrated within a defined area bounded by Dwight Way and Hopkins Street to the south and north, and Sacramento Street and Piedmont Avenue to the west and east. The presence of traffic calming devices, such as those on Fulton St, reduces the efficiency of the evacuation by slowing traffic down. In the Berkeley Hills, while general improvement is evident, Spruce Street continues to experience LOS E, indicating localized congestion. West of San Pablo Ave, roadways show significant improvement as all roadways in the area are operating at LOS C or better, particularly those providing access to I-580.

Four hours and 45 minutes after the Evacuation Order, 96.7% of evacuating vehicles have successfully evacuated Berkeley. Shattuck Avenue and Martin Luther King Jr Way continue to experience significant congestion between Ashby Avenue and Hopkins Street, as shown in Figure F-6. This persistent bottleneck is likely attributable to the pre-timed signal system present throughout these sections of the roadway. The fixed timing of these signals may not be adequately responding to the fluctuating traffic demands of the evacuation, creating inefficiencies and hindering traffic flow.

As shown in Figure F-7, 5 hours and 15 minutes after the Evacuation Order, the final pockets of congestion (LOS F) are on Cedar Street, Hearst Avenue and Shattuck Avenue while all other roads are operating at LOS D or better. The city is clear of congestion approximately 20 minutes later at 5 hours and 35 minutes after the Evacuation Order. This projected clearance time aligns with the overall evacuation time estimate.

F.2 1923 Fire Repeat (Region R02)

Figure F-8 shows the patterns of traffic congestion for a 1923 Fire Repeat at 1 hour and 2 hours after the Evacuation Order. One hour into the evacuation, the majority of the roads within the evacuated area are operating at LOS F conditions, especially surrounding UC Berkeley. Congested conditions develop between Dwight Way and Hopkins Ave and between Sacramento St and Grizzly Peak Blvd. All employees, visitors and college students who evacuate using personal vehicles mobilize within 1 hour after the Evacuation Order. Hence, the congestion that is present at 1 hour into the evacuation is largely caused by these vehicles. Only 20% of the population west of Sacramento St is evacuating for this Region, and for that reason the congestion within the Berkeley Flats is less significant.

Two hours after the Evacuation Order, the congestion near UC Berkeley lessens as the students and employees from the college have mobilized and evacuated. Congestion is present in other parts of the evacuated zones, which are still operating at LOS F conditions, specifically between Bancroft Way and Hopkins Ave and between Martin Luther King Jr Way and Gayley Rd. Congestion along Grizzly Peak Drive and Woodmont Ave has worsened as more residents are mobilizing within Berkeley Hills.

Figure F-9 shows the patterns of traffic congestion for 1923 Fire Repeat at 3 hours and 4 hours after the Evacuation Order. At 3 hours, Gayley Road and Hearst Ave near UC Berkeley are still operating at LOS F conditions within the Evacuation Zones. Both roads are clear of congestion 4 hours after the Evacuation Order. At 3 hours, Marin Ave, Hopkins St, Arlington Ave and Cedar St, which serve the majority of evacuating population leaving the area at risk are also still congested. One hour later at 4 hours after the Evacuation Order, the only road that is operating at LOS F conditions is Cedar St at the pretimed signalized intersection with Martin Luther King Jr Way, which clears of congestion 10 minutes later at 4 hours and 10 minutes.

F.3 1923 Fire Repeat Phased (Region R03)

Figure F-10 displays the patterns of traffic congestion for 1923 Fire Repeat (Phased) at 1 hour and 2 hours after the Evacuation Order. As discussed in Section 6, the residents that live closer to the proximity of the fire are ordered to evacuate first while other areas within the 1923 Fire Repeat Region are ordered to evacuate 90 (Phase b) and 180 minutes (Phase c) after. Since only the evacuations of residents are phased, but employees, college students and visitors in the entire area (including phase b and c) leave when evacuations are initially ordered, the congestion patterns near UC Berkeley are comparable between Figure F-10 and Figure F-8. However, congestion that is closer in proximity to the eastern boundary of Berkeley (closer to Tilden Park) is more pronounced in the phased region due evacuees from outside of Phase a entering Phase a, as is discussed in Section 7.

As shown in Figure F-11Figure F-11, since phase c does not start until 3 hours after the Evacuation Order, the congestion patterns at 3 hours are significantly improved as the demand is distributed over a long period of time, allowing the roadway network to process the demand more effectively. LOS F still exists near UC Berkeley. However, Berkeley Hills roadways are operating at LOS D or better as shown in Figure F-11Figure F-11. Even though residents from phase c are still mobilizing 4 hours after the Evacuation Order, they face little to no congestion leaving the area as all roads within the zones ordered to evacuate are operating at LOS C or better. All phase c evacuees are fully mobilized at 6 hours and 15 minutes after the Evacuation Order. All congestion clears 5 hours and 20 minutes. Because phase c is delayed by 180 minutes, the initial evacuation congestion has cleared by the time phase c is fully mobilized.

F.4 Panoramic Hill Fire (Region R04)

Figure F-12 displays the patterns of traffic congestion for a Panoramic Hill Fire 30 minutes and 1 hour after the Evacuation Order. Congestion within Panoramic Hill is minimal, operating at LOS C or better. As discussed in Section 10, even though Panoramic Hill only has one egress route, evacuees are mobilizing over a long period of time (over 3 hours), hence, the roadway network within the area being ordered to evacuate does not get overwhelmed trying to process the demand. Outside of Panoramic Hill and the evacuated area, near the Channing Way traffic circle, roadways operate at LOS F. The diverter on Derby St between Warring St and College Ave, is problematic for this area as evacuees can't travel westbound on Derby St to reach College Ave. At this point, vehicles on Derby St southbound are essentially forced to continue on Derby St to the congested intersection with Claremont Ave. Thirty minutes later, at 1 hour after the Evacuation Order, congestion persists near the traffic circle on Piedmont Ave and Channing Way. It should be noted that since the fire origin, travel direction and rate of spread is not modeled, Claremont Avenue was modeled as a viable evacuation route. At 1 hour after the evacuation order, this roadway experiences congested conditions due to the low-capacity geometric bends (i.e., hairpin turns) along this path.

Figure F-13 displays the patterns of traffic congestion for Panoramic Hill Fire 1 hour and 30 minutes and 2 hours after the Evacuation Order. Piedmont Ave to Warring St, to Derby St to Belrose Ave to Claremont Blvd is operating at LOS F conditions at 1 hour and 30 minutes after the Evacuation Order. This congestion is caused by the limited connections in this area. Once evacuees pass the intersection with Dwight Ave on Piedmont Ave, they are essentially forced to stay on Warring St/Derby St/Belrose Ave/Claremont Blvd, as there is only one connection (Forest Ave) to College Ave and other roadways leaving this area. Congestion along these roads clears 30 minutes later, 2 hours after the Evacuation Order.

F.5 Fire Zones 2 & 3 (Region R05)

As is discussed in Section 7, it is unlikely that there would be a simultaneous evacuation of Fire Zones 2 and 3 (the Berkeley hills) in association with a particular emergency or disaster. This region is included to help analyze impacts of the Berkeley Hills from administrative changes that could affect development in the area.

Figure F-14 displays the patterns of traffic congestion for Fire Zones 2 & 3 at 1 hour and 2 hours after the Evacuation Order. One hour into the evacuation, the majority of the roads within the Evacuation Zones are operating at LOS F conditions including Grizzly Peak Blvd, Euclid Ave, Spruce St, Marin Ave, La Loma Ave, Gayley Rd, and Arlington Ave. Outside of the evacuated area, roadways in proximity to UC Berkeley are also congested. Even though the UC Berkeley campus is not ordered to evacuate, 20% of evacuees are assumed to voluntary evacuate, so the demand exceeds the capacity causing LOS F conditions within this area. To the south, Ashby Rd/Tunnel Rd is heavily congested as it is the highest capacity roadway within the South Berkeley Hills. Two hours into the evacuation, congestion in South Berkeley Hills and UC Berkeley have dissipated somewhat. However, the North Berkeley Hills is still heavily congested. Roads within this area are windy and narrow, resulting in slower speeds and lower capacities. The roundabout that is along Channing Way and Piedmont Ave is slowing down traffic, causing congestion southbound along Piedmont Ave in this area. The five-legged roundabout on Marin Ave is also proving to be a bottleneck as traffic along competing movements attempt to merge into the roundabout at the same time.

Figure F-15 displays the patterns of traffic congestion for Fire Zones 2 & 3 at 2 hours and 30 minutes and 3 hours after the Evacuation Order. The last remnants of congestion within the evacuated area are present along Piedmont Ave/Warring Ave, Euclid Ave, Hearst Ave, Henry St, Spruce St, Grizzly Peak Blvd, and Woodmont Ave. Thirty minutes later, at 3 hours after the Evacuation Order, most of this congestion has cleared. Piedmont Ave is operating at LOS D or better at this time, and all congestion clears 15 minutes later (3 hours and 15 minutes after the Evacuation Order).

F.6 Tsunami Warning Phase 3 (Region R06)

Figure F-16 displays the patterns of traffic congestion for Tsunami Warning Phase 3 at 30 minutes and 1 hour after the Evacuation Order. Just 30 minutes after the Evacuation Order, University Ave and I-580 are already operating at LOS F conditions. University Ave and Frontage Rd are the only two egress routes for this region. Even though Frontage Road is operating at LOS D or better, the traffic circle that gives access to I-580 (near Gilman St) is operating at LOS F at this time. Thirty minutes later, one hour after the Evacuation Order, University Ave is clear of congestion within the region. However, congestion along Frontage Rd (near Gilman St and Ashby Ave) worsens due to low capacity on the traffic circle to the north and the merge between Ashby Ave and Frontage Rd to the south. Traffic along I-580 has also worsened as evacuees utilize this roadway as their primary evacuation route out of the area.

Figure F-17 displays the patterns of traffic congestion for Tsunami Warning Phase 3 at 1 hour and 30 minutes and 2 hours and 30 minutes after the Evacuation Order. I-580 is still heavily congested at 1 hour and 30 minutes into the evacuation, operating at LOS F, but this congestion clears 2 hours and 30 minutes after the Evacuation Order. At both times, Frontage Road is clear of congestion. Even though there are still evacuees mobilizing until 3 hours and 30 minutes after the Evacuation Order, all congestion clears by 2 hours and 30 minutes from the Evacuation Order.

F.7 Tsunami Warning Max Phase (Region R07)

Figure F-18 displays the patterns of traffic congestion for Tsunami Warning Max Phase at 30 minutes and 1 hour after the Evacuation Order. Evacuees in Region R07 can use I-580, University Ave, Gilman St, Ashby Ave and Seventh/Sixth St to leave the evacuated area. All of these roads experience some level of congestion (LOS F conditions) at 30 minutes after the Evacuation Order. Thirty minutes later, at 1 hour after the Evacuation Order, congestion along University Ave and Seventh/Sixth St worsens while congestion along Gilman St dissipates.

Figure F-19 displays the patterns of traffic congestion for Tsunami Warning Max Phase at 1 hour 30 minutes and 2 hours after the Evacuation Order. Congestion has significantly dissipated at 1 hour and 30 minutes after the Evacuation Order. The Ashby Rd on-ramp to I-580 is operating at LOS F conditions. The on-ramp is a capacity restriction in this area as Ashby Ave merges down to a single lane from 2-lanes. The speeds are also lower as the on-ramp is a cloverleaf-style ramp. Frontage Rd northbound experiences congestion as well due to the yield control and right turn movement at the traffic circle at Gilman St. I-580, and many of its on-ramps, experience LOS F conditions as well. An hour later, at 2 hours and 30 minutes after the Evacuation Order, congestion within the region has almost entirely dissipated, except along I-580 southbound, which clears 5 minutes later at 2 hours and 35 minutes. Even though there are still evacuees mobilizing until 3 hours and 30 minutes after the Evacuation Order, all congestion is clear within 2 hours and 35 minutes after the Evacuation Order.

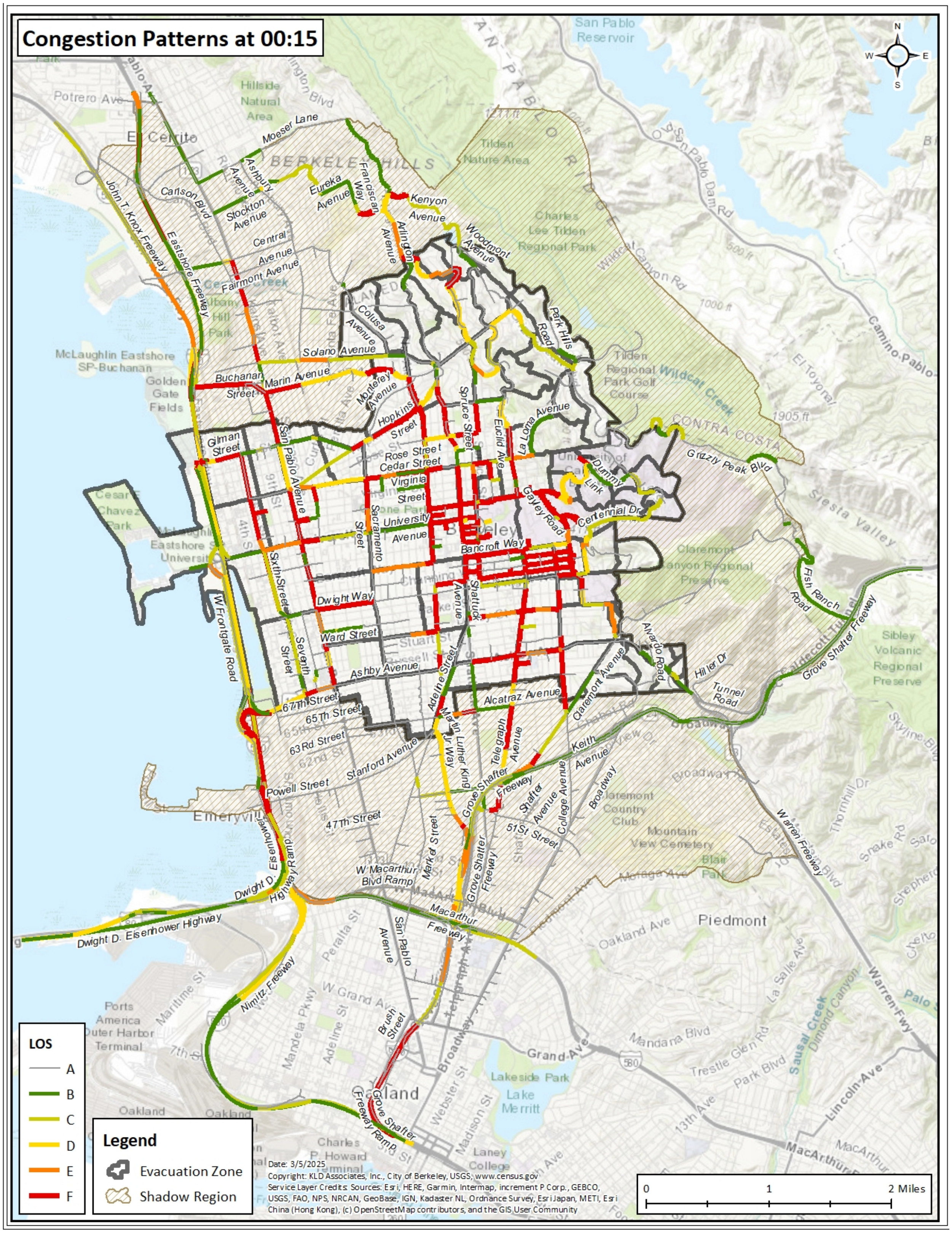


Figure F-1. Region R01 Congestion Patterns 15 Minutes after the Evacuation Order

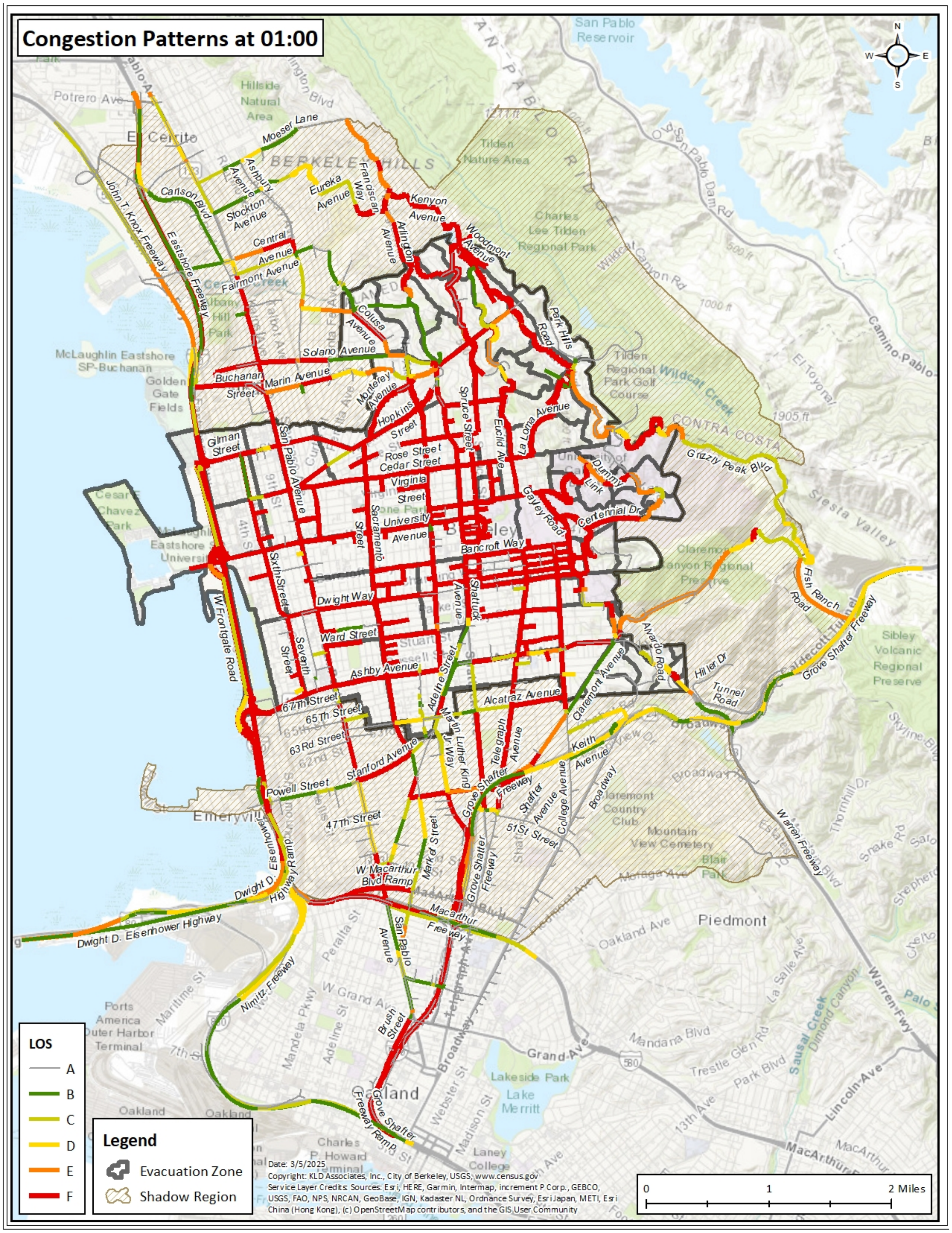


Figure F-2. Region R01 Congestion Patterns 1 Hour after the Evacuation Order

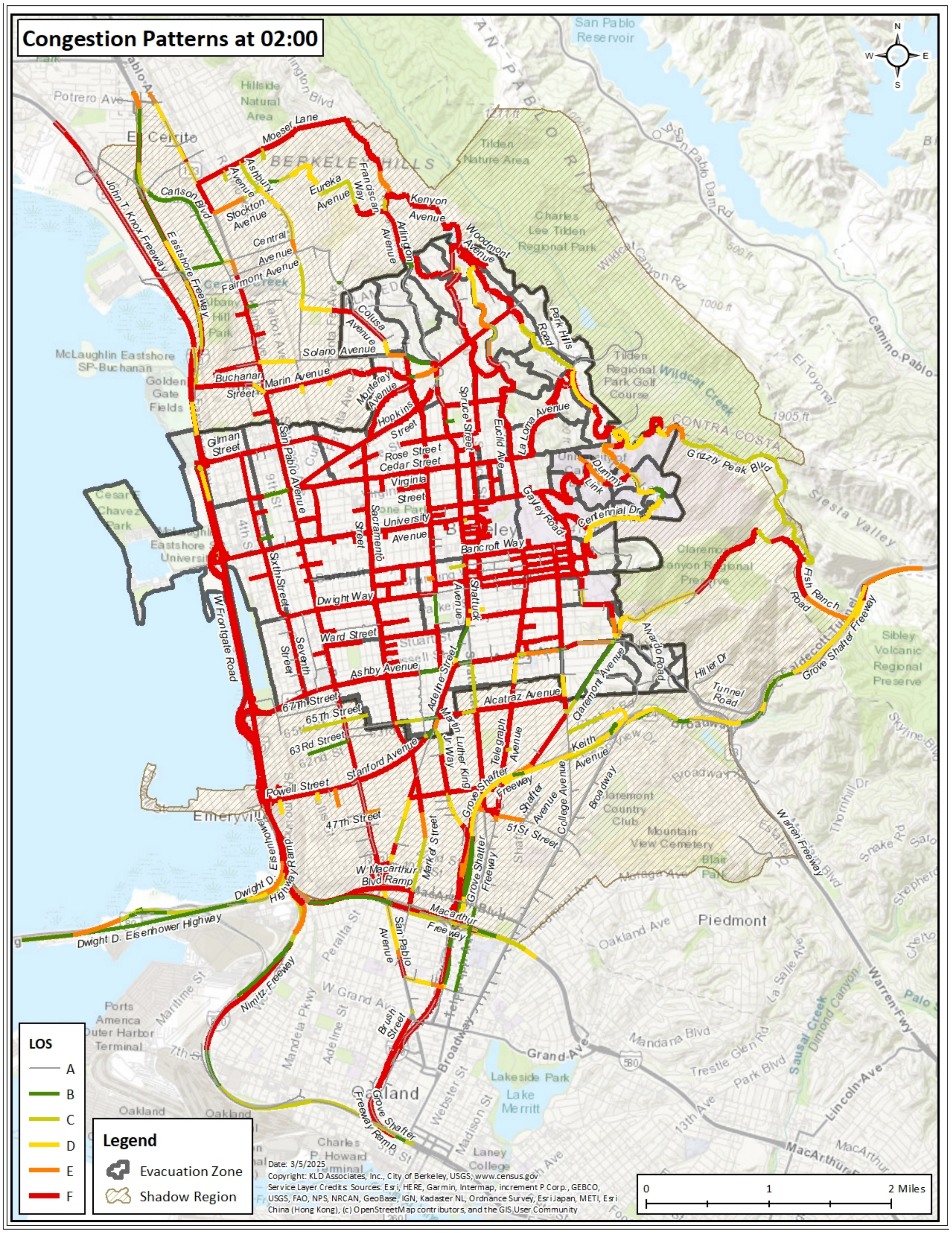


Figure F-3. Region R01 Congestion Patterns 2 Hours after the Evacuation Order

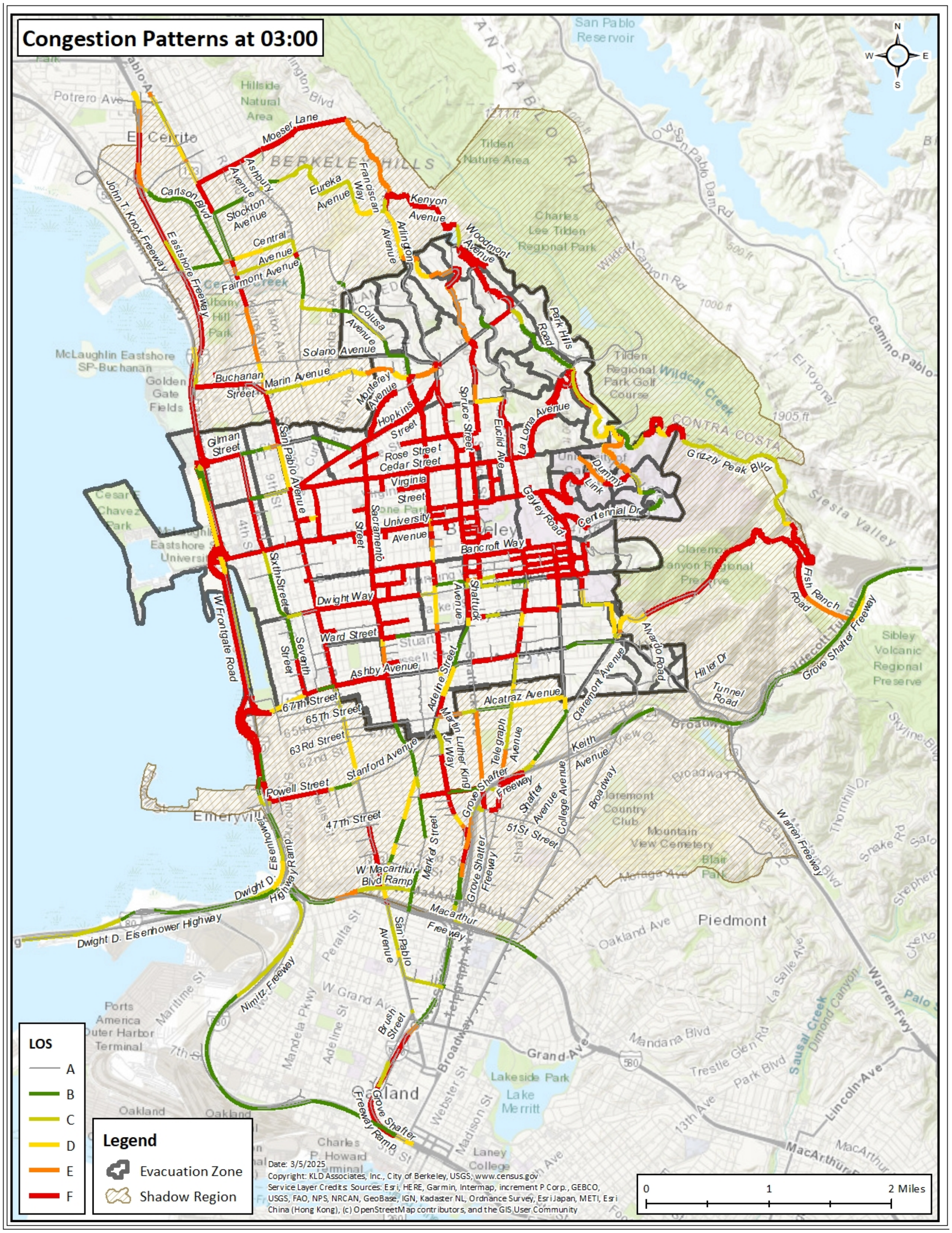


Figure F-4. Region R01 Congestion Patterns 3 Hours after the Evacuation Order

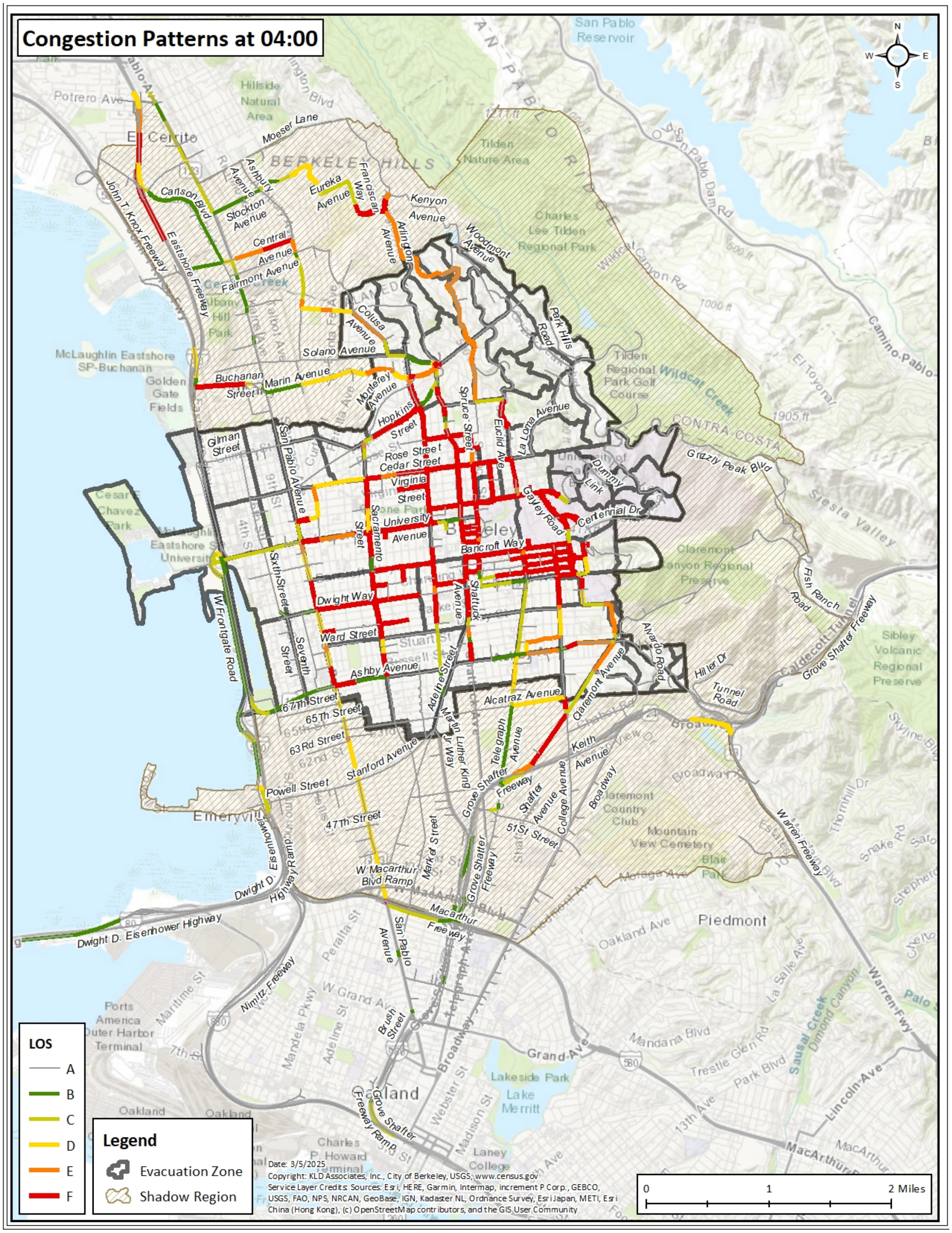


Figure F-5. Region R01 Congestion Patterns 4 Hours after the Evacuation Order

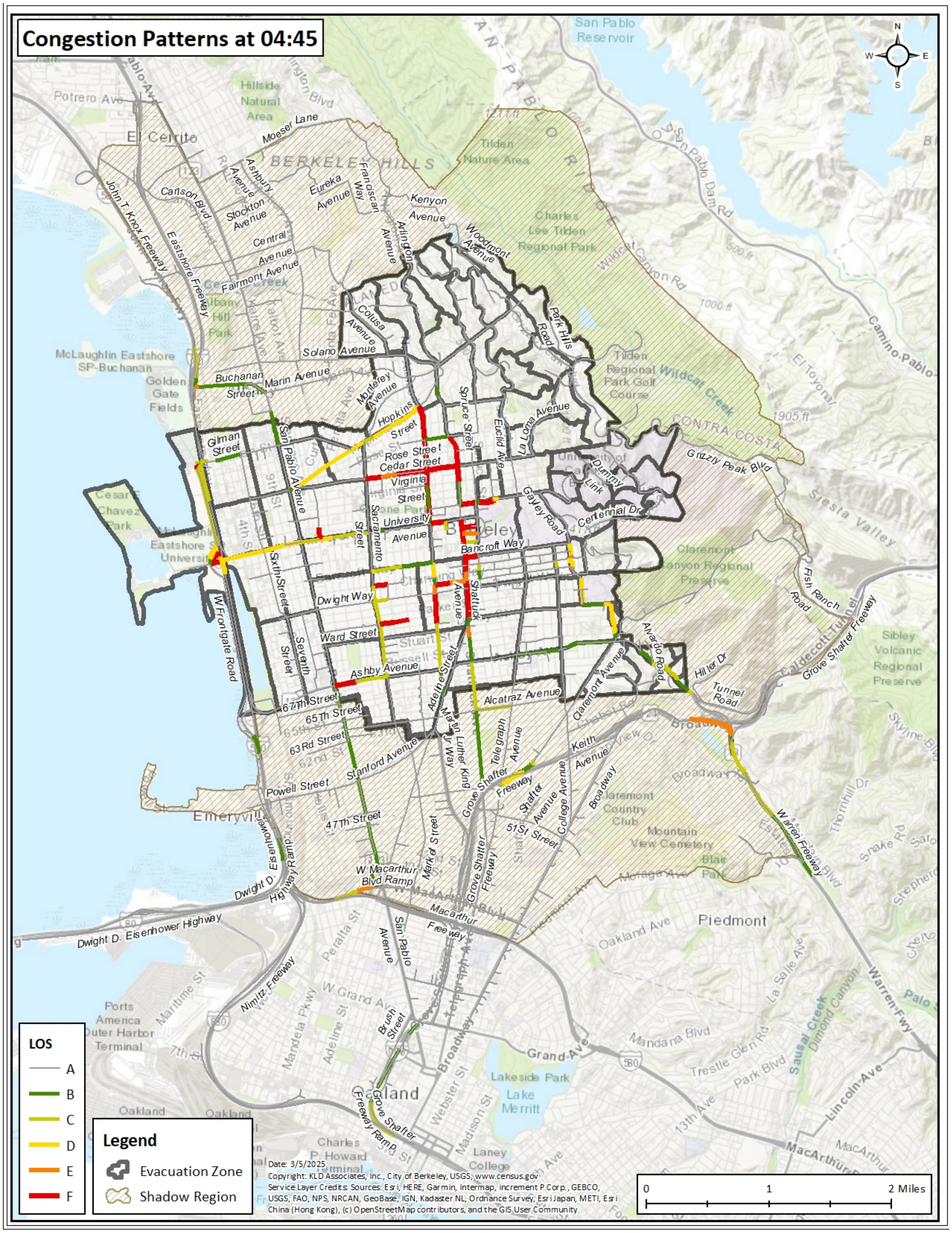


Figure F-6. Region R01 Congestion Patterns 4 Hours and 45 Minutes after the Evacuation Order

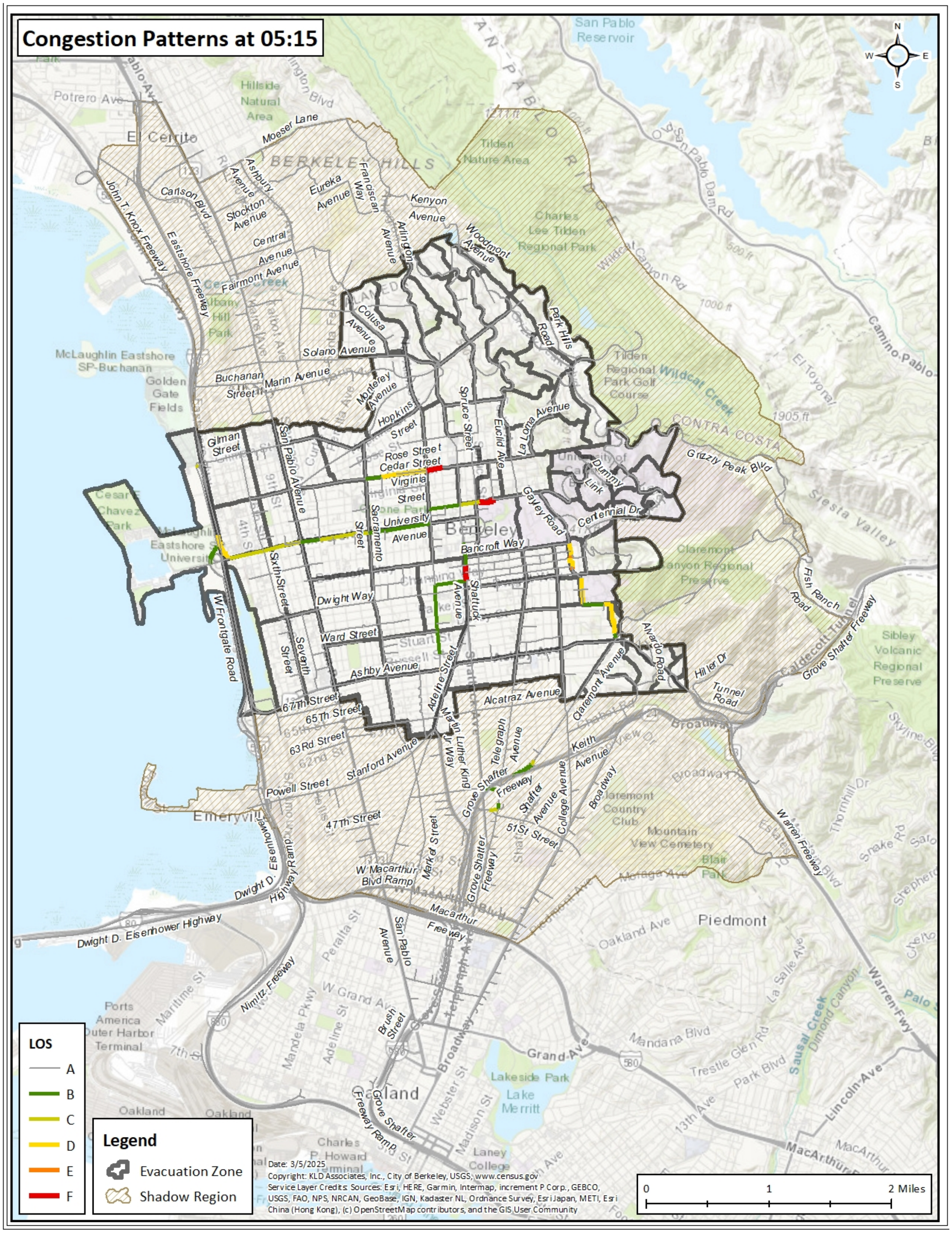


Figure F-7. Region R01 Congestion Patterns 5 Hours and 15 Minutes after the Evacuation Order

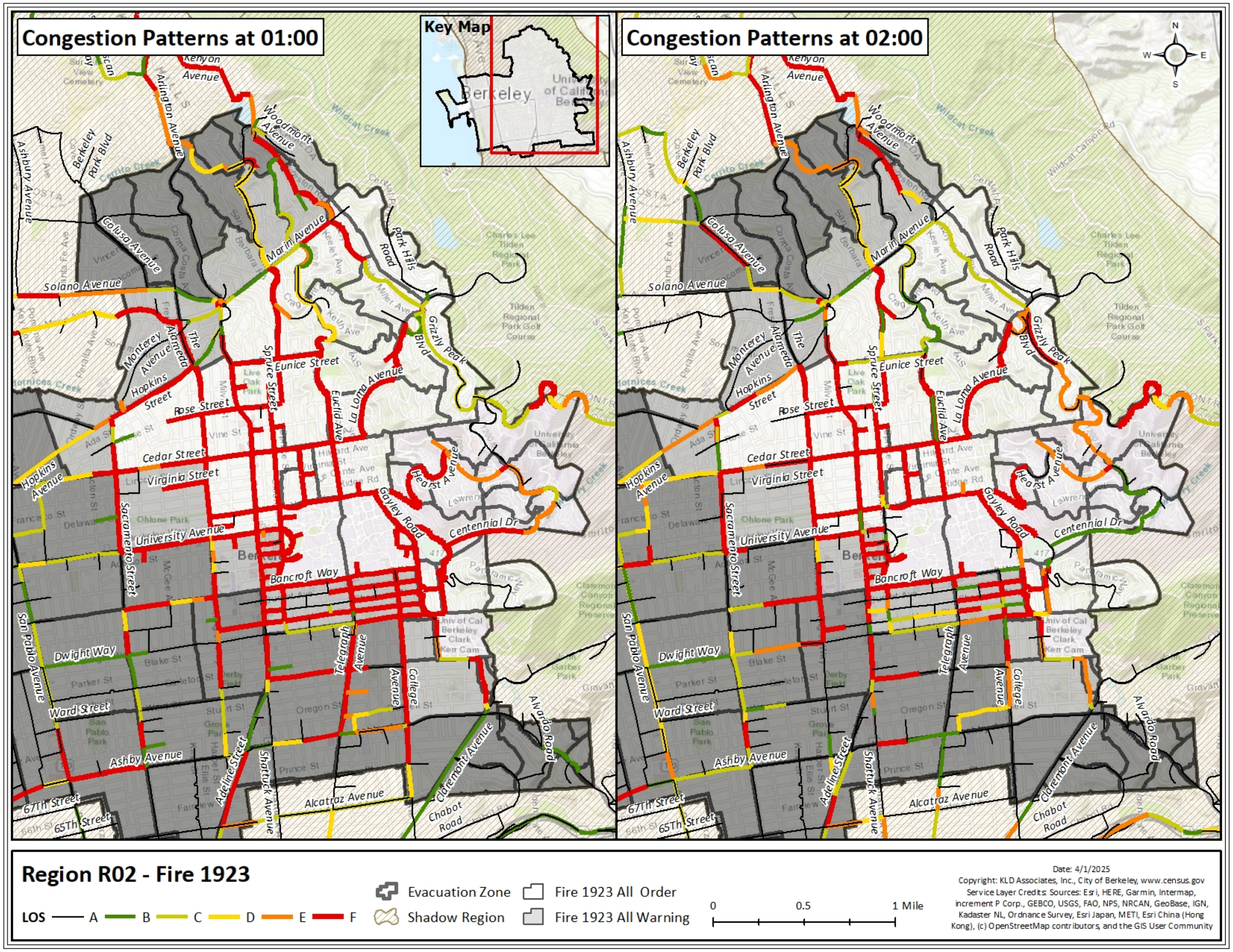


Figure F-8. Region R02 Congestion Patterns 1 Hour and 2 Hours after the Evacuation Order

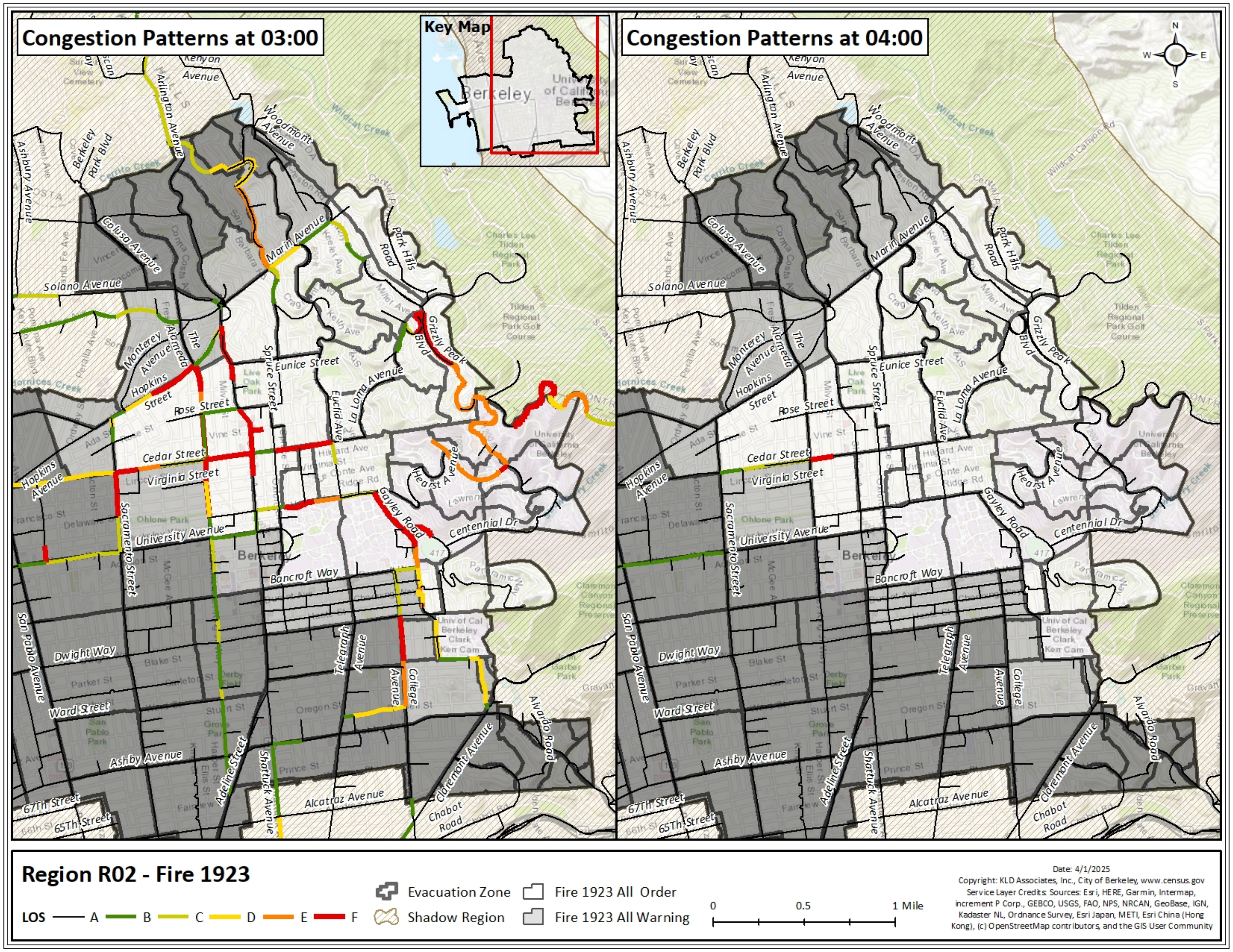


Figure F-9. Region R02 Congestion Patterns 3 Hours and 4 Hours after the Evacuation Order

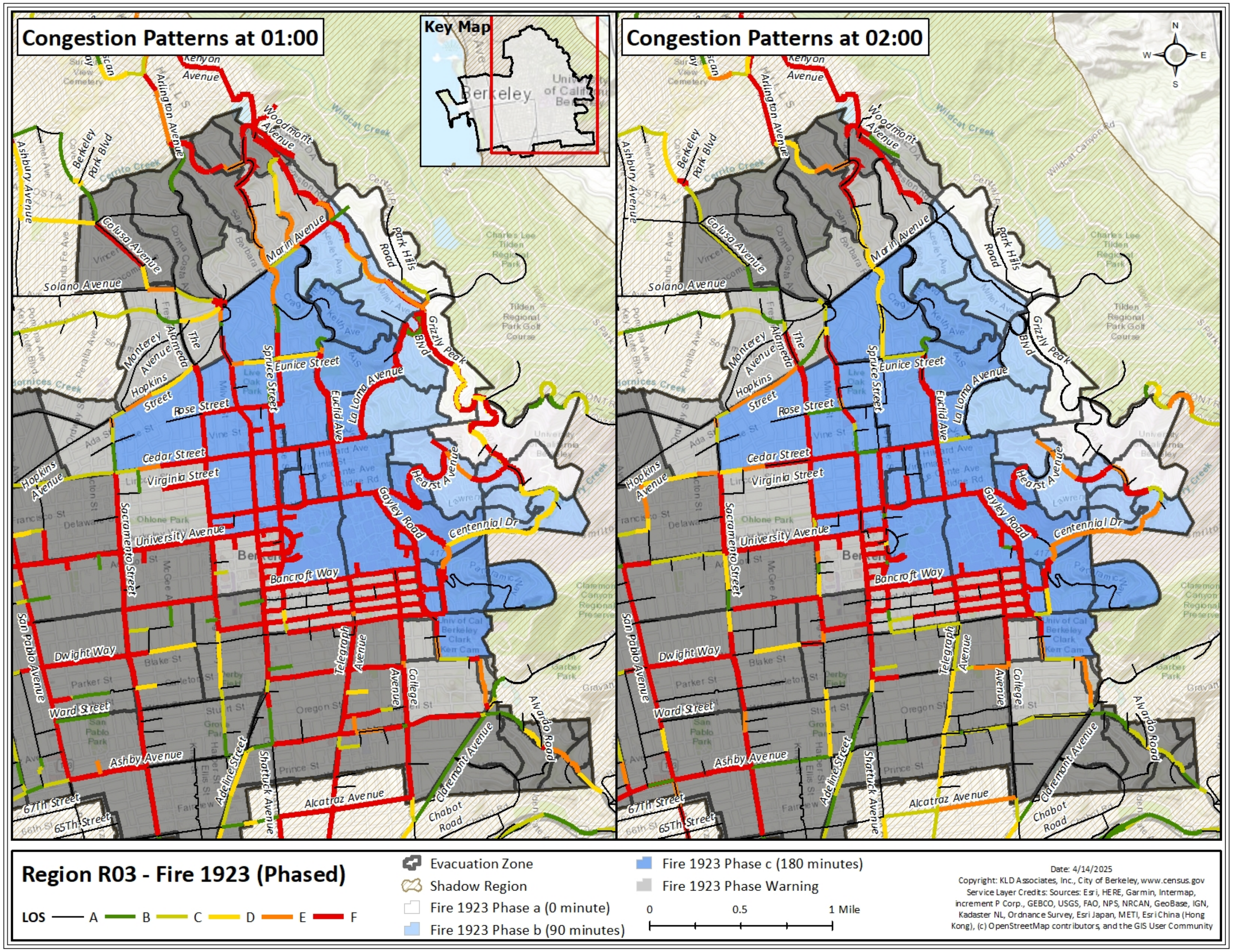


Figure F-10. Region R03 Congestion Patterns 1 Hour and 2 Hours after the Evacuation Order

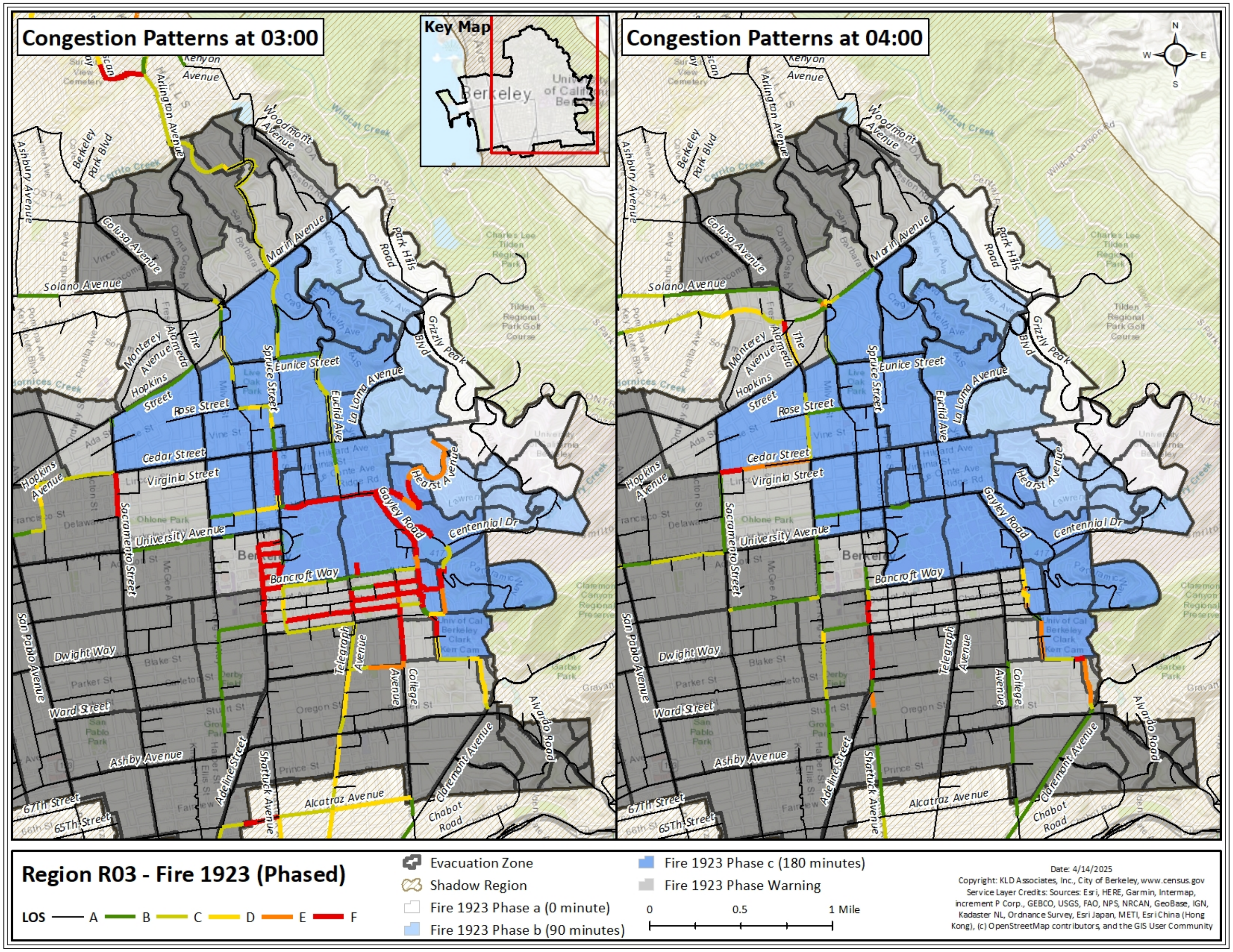


Figure F-11. Region R03 Congestion Patterns 3 Hours and 4 Hours after the Evacuation Order

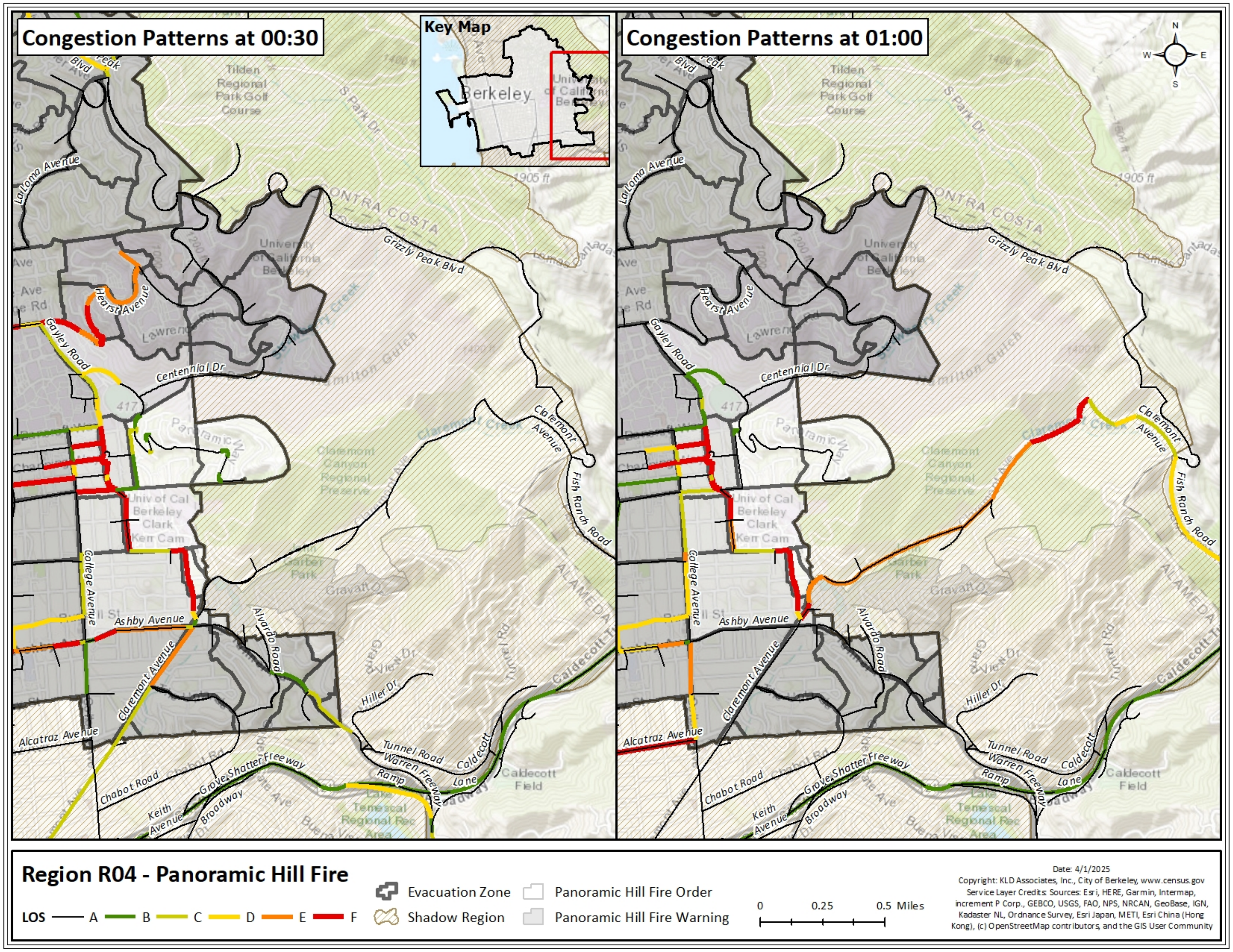


Figure F-12. Region R04 Congestion Patterns 30 Minutes and 1 Hour after the Evacuation Order

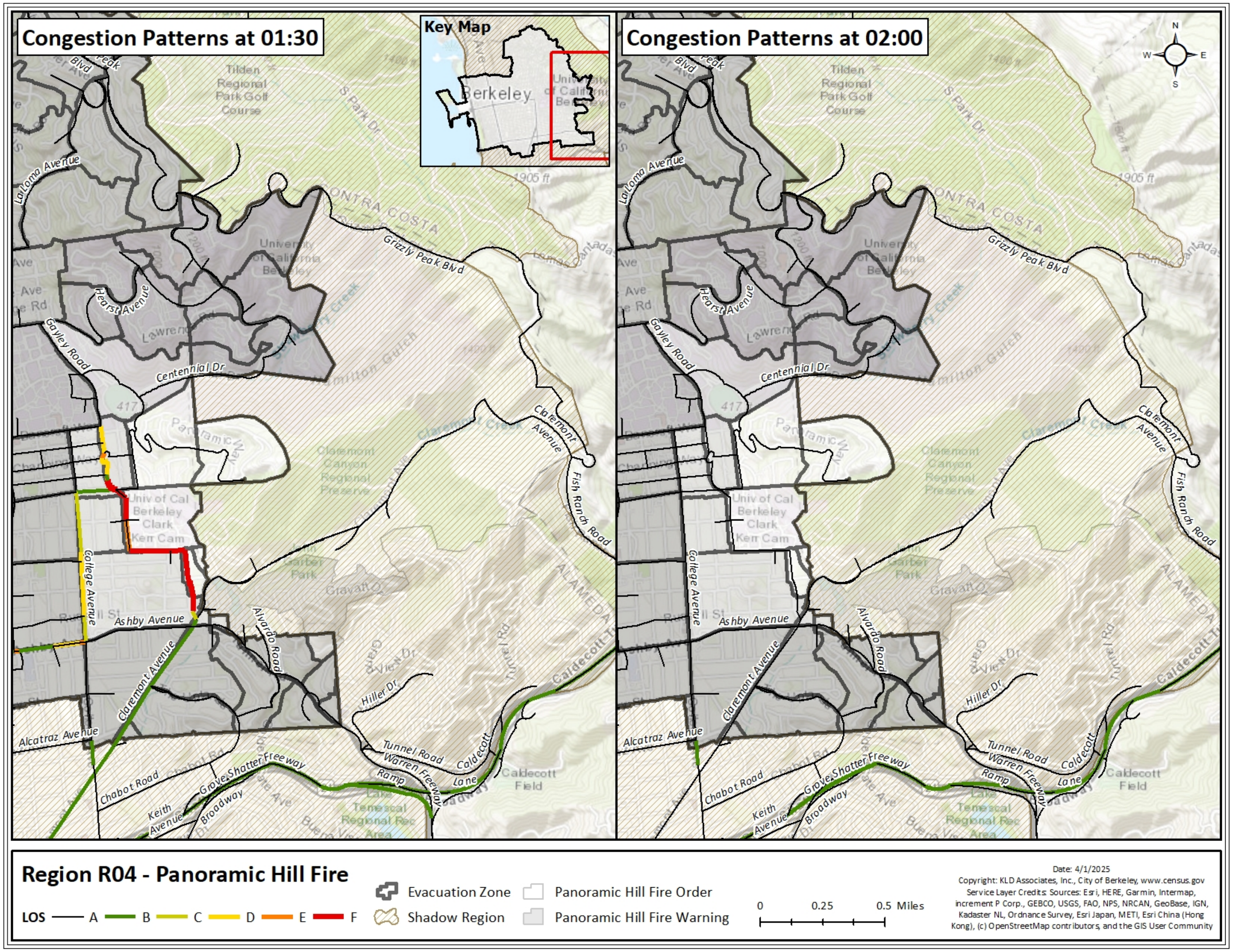


Figure F-13. Region R04 Congestion Patterns 1 Hour and 30 Minutes and 2 Hours after the Evacuation Order

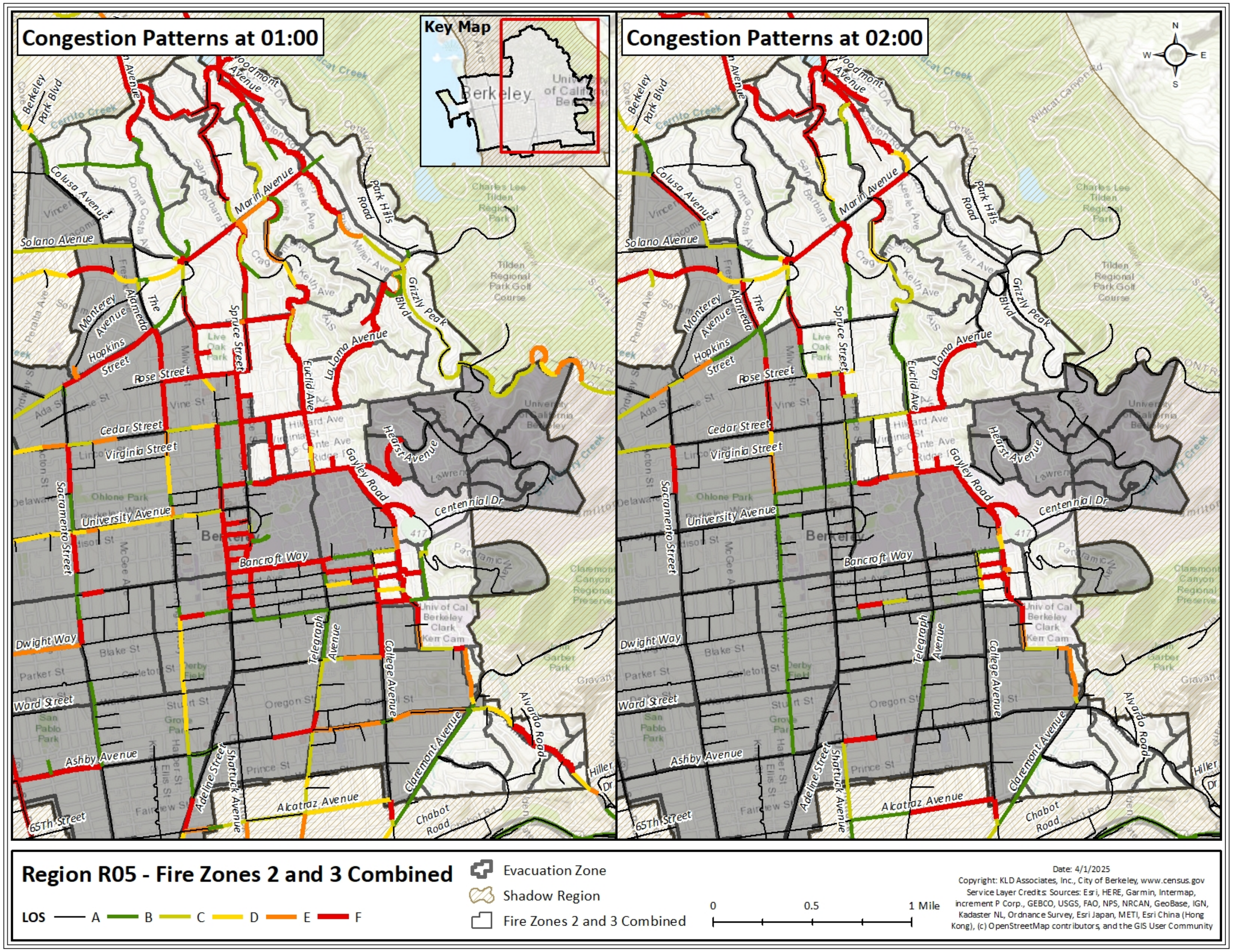


Figure F-14. Region R05 Congestion Patterns 1 Hour and 2 Hours after the Evacuation Order

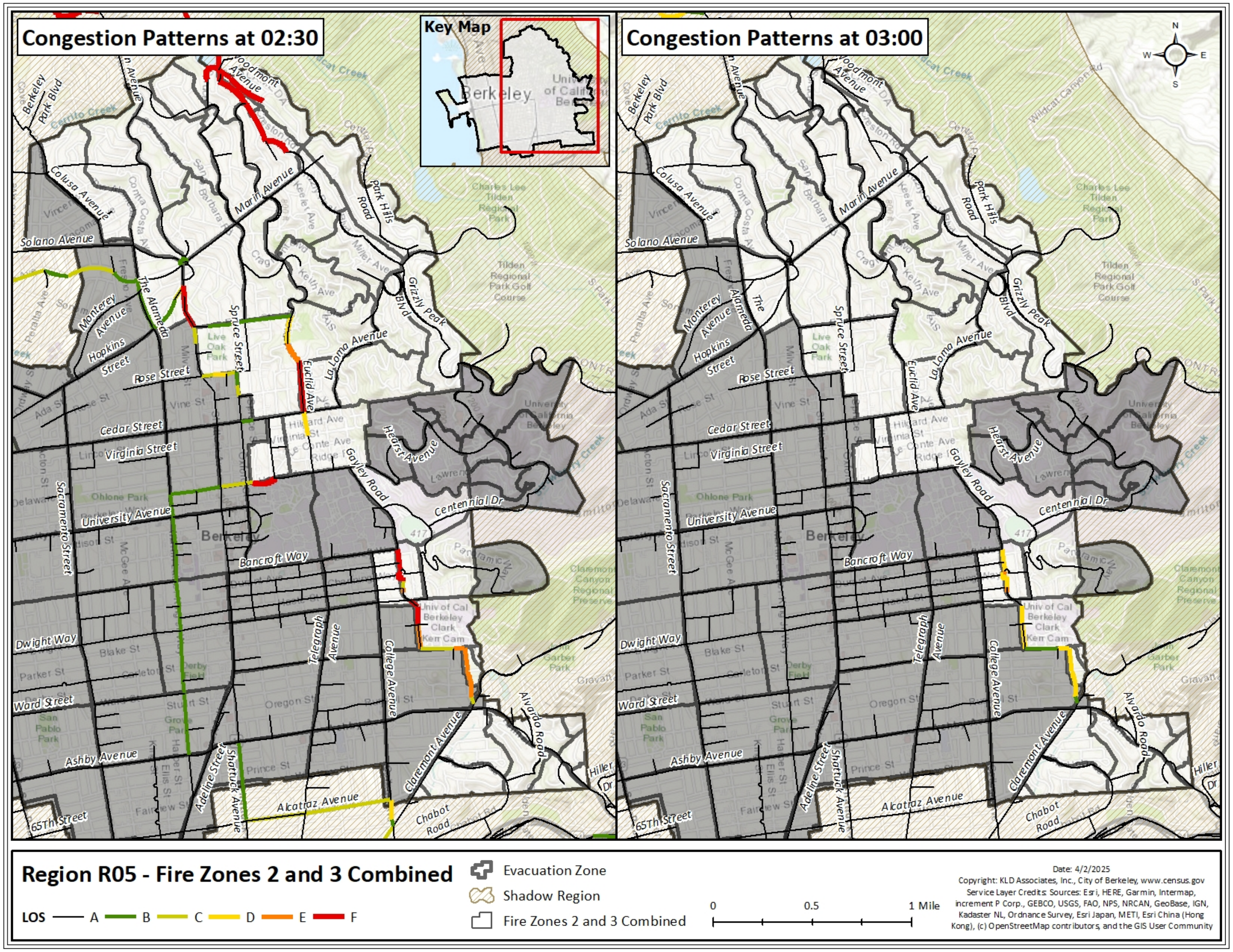


Figure F-15. Region R05 Congestion Patterns 2 Hours and 30 minutes and 3 Hours after the Evacuation Order

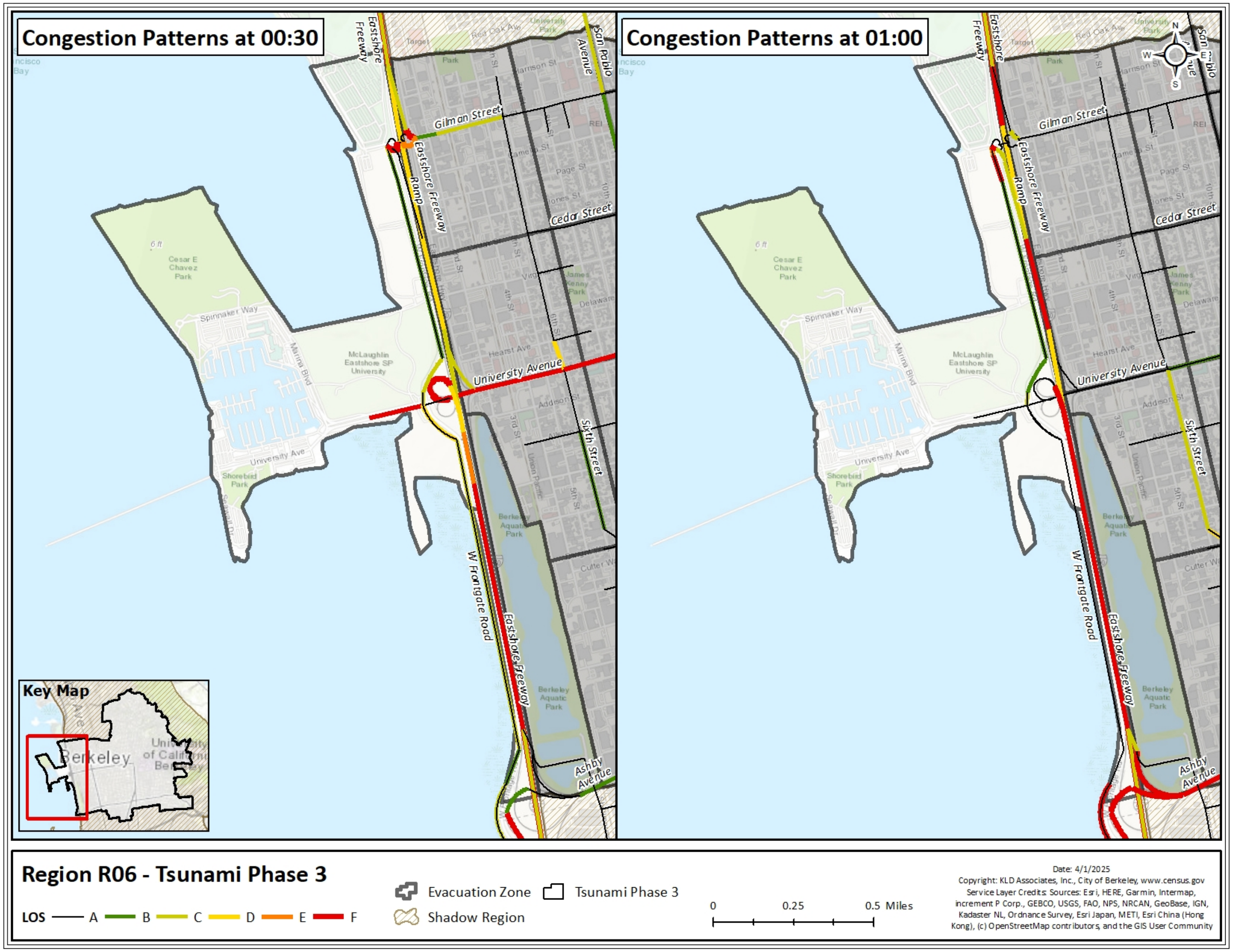


Figure F-16. Region R06 Congestion Patterns 30 Minutes and 1 Hour after the Evacuation Order

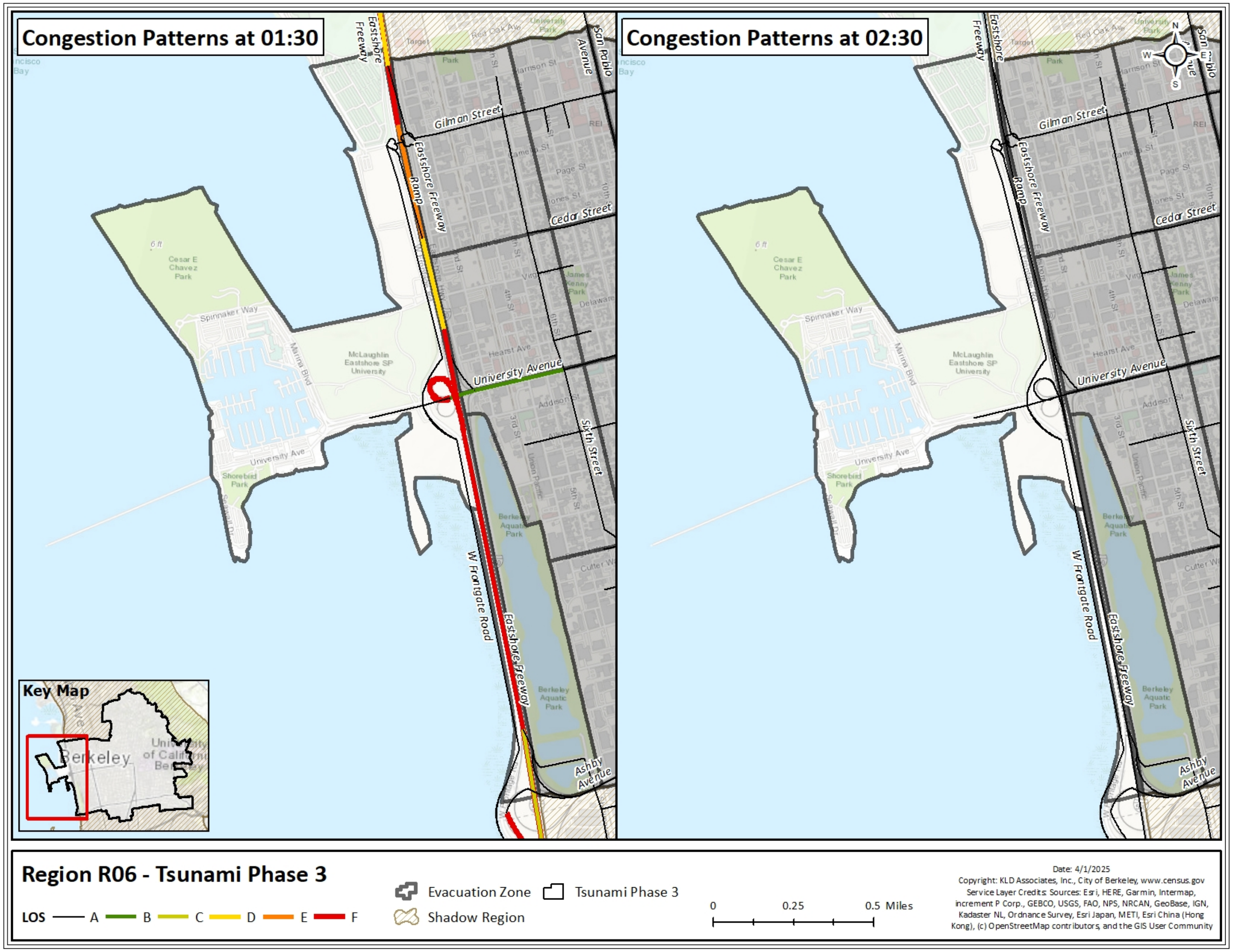


Figure F-17. Region R06 Congestion Patterns 1 Hour and 30 Minutes and 2 Hours and 30 Minutes after the Evacuation Order

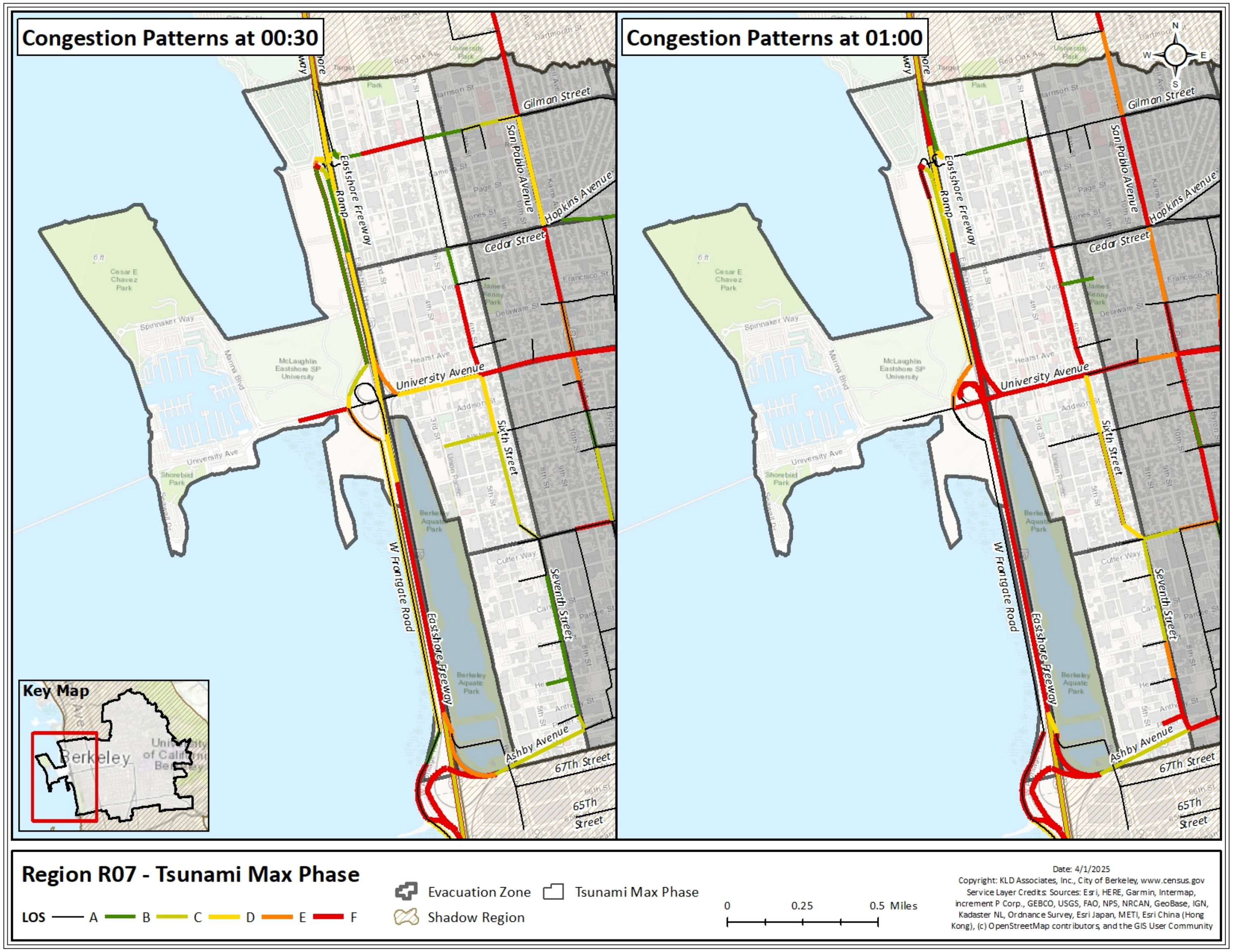


Figure F-18. Region R07 Congestion Patterns 30 Minutes and 1 Hour after the Evacuation Order

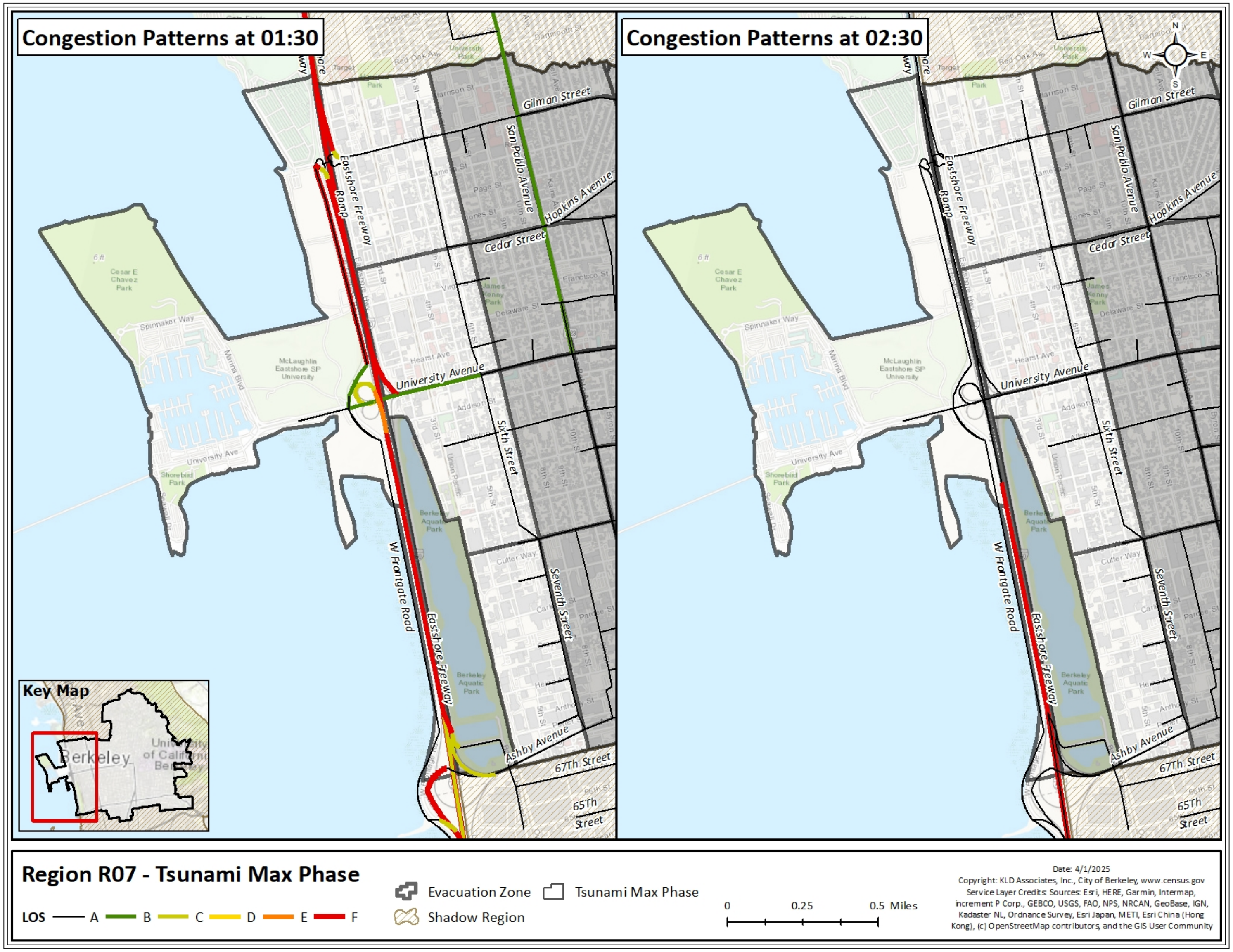


Figure F-19. Region R07 Congestion Patterns 1 Hour and 30 Minutes and 2 Hours and 30 Minutes after the Evacuation Order

APPENDIX G

Traffic Calming Devices, Traffic Signals, and Existing Street Network Characteristics Posing Challenges to Evacuation

G. TRAFFIC CALMING DEVICES (TCDS), TRAFFIC SIGNALS AND EXISTING STREET NETWORK CHARACTERISTICS POSING CHALLENGES TO EVACUATION

Appendix F provides patterns of traffic congestion during various evacuation cases. The figures in Appendix F were analyzed to identify problem areas, which are explored here in additional detail. This Appendix specifically identifies the impacts to evacuation traffic flow from traffic calming devices (TCDs), pre-timed traffic signals, and other attributes of Berkeley's roadway network or built and natural environment within the identified problem areas.

G.1 TCDs in DYNEV

Figure G-1 shows the TCDs within the City of Berkeley as of January 14, 2025. As discussed in Section 1.3, the traffic simulation model was developed based on the data collected during the field survey which was conducted in May 2023. The existing traffic calming devices (TCDs) were modeled within the network based on their impact to speed and capacity. Below is a summary of how each TCD broadly impacts the simulation of evacuating vehicles:

- Diverters are represented as disconnected links and nodes, effectively blocking routing paths and reflecting their function in preventing through traffic. (This is also applicable for sections of roadway that are for cyclists only.)
- Traffic circles, often functioning as all-way stops within the city, are assigned low capacities (approximately 900 vehicles per hour per lane) due to the inherent delays associated with stopping or yielding.
- Vertical deflection, like speed humps or bumps, are modeled by reducing link speeds as the driver safely navigates them, thereby lowering the effective capacity of those road segments.
- Rectangular rapid flashing beacons (RRFB) and pedestrian hybrid beacons (PHB) only influence vehicle behavior if the surveyor cautiously reduced speed at these locations, otherwise, they are disregarded.[1]
- Horizontal deflection affecting only the shoulder or parking lane, such as bulb outs, dedicated bike lanes, and median crossings are also excluded from the model, unless they encroach on travel lanes.

It should be noted that the impact of TCDs on fire apparatus and emergency vehicle response times is being conducted as a separate work effort. The scope of this study is limited to evacuating vehicles and the impacts of these TCDs on evacuation is discussed herein.

[1] Note that RRFB and PHB are not technically traffic calming devices but are described here because in Berkeley RRFB have been used as part of the City's draft traffic calming toolbox.

G.2 Traffic Calming Devices, Traffic Signals, and Other Street Network Characteristics Posing Challenges to Evacuation

Appendix F identifies patterns of traffic congestion expected for various evacuation regions and cases. This Appendix highlights particular roadway constraints and traffic calming devices with notable impacts across various evacuation cases studied.

This section identifies the specific traffic calming devices, traffic signals, and other street network characteristics posing challenges to evacuation, with the goal of identifying opportunities to improve traffic flow in evacuations. Traffic calming devices, by design, reduce vehicle speeds for pedestrian safety, reduce vehicle volumes on residential streets, and/or disrupt network connectivity for vehicles. Consequently, simulation results indicate drivers will have a strong preference for routes devoid of TCDs, which allow for higher speeds, have greater capacities, and have greater route choice availability. This preference, coupled with limited evacuation directions (in order to leave the city, drivers are essentially limited to an evacuation northbound or southbound), concentrates demand onto a reduced set of roadways. This concentrated demand results in congestion with both macroscopic impacts, increasing the overall time to clear the hazard area, as well as impacts to individual evacuees, whose time on the roadway increases.

Section 10 identifies improvements to evacuation traffic flow from a widescale transition to actuated/adaptive traffic signals. This section highlights pre-timed signals with notable impacts across various evacuation cases studied, so that they may be considered for prioritization in a shift to actuated/adaptive signals.

The existing characteristics of the road network are noted to provide a comprehensive analysis of the challenges to evacuation traffic flow. Some are assumed to be fixed, such as preexisting facilities and parks; others are noted as traffic design elements that could be improved for evacuation traffic flow.

Affected Area: South and West of UC Berkeley Campus

As shown in Figure F-2 through Figure F-5, Figure F-8, Figure F-10, and somewhat in Figure F-14, congestion is pronounced in areas of the city to the south and immediate west of the UC Berkeley campus. The area is bounded as follows: Piedmont Ave (east), Dwight Way (south), Shattuck Avenue (west), and University Ave-Oxford St-Bancroft Way (north). This is a result of the following:

<u>Traffic Calming</u>

- Between University and Dwight, there are only two roadways (Addison St and Allston Way) that provide a direct westbound connection for vehicles to access Sacramento St.
    - The diverter at Channing Way and Roosevelt Ave breaks the connection along Channing Way between the two arterials.
    - Addison St and Allston Way are the only roadways that provide the direct westbound connection to Sacramento Street, and they have numerous traffic circles with low capacities (that operate as all way stop intersections) between

Shattuck Ave and Sacramento Ave.

- Fulton St is not a viable southbound option for traffic in Downtown Berkeley and Southside due to diverters that block traffic from traveling southbound.
- Ellsworth St is not a desirable southbound option for traffic in Downtown Berkeley and Southside due to numerous traffic circles that lower the capacity of these roadways.

Traffic Signals

- Pretimed signals along Shattuck Ave exacerbate traffic in this area as vehicles are not efficiently processed through the signals in the north-south direction. This can be seen in Figure F-1 through Figure F-6, Figure F-8, Figure F-10, Figure F-11, and Figure F-14.
- Pretimed signals along Cedar St at the intersections with Sacramento St, Martin Luther King Jr Way, Shattuck Ave and Oxford St and the pretimed signals along Haste St westbound at Dana St, Ellsworth St and Fulton St also prevent efficient traffic flow westbound. This congestion resulting from the pretimed signals along Cedar St can be visually seen in Figure F-5 though Figure F-11.

Existing Street Network Characteristics

- Between University and Dwight, there are only two roadways that provide a direct westbound connection (Addison St and Allston Way) for vehicles to access Sacramento St.
    - Berkeley High School breaks Bancroft Way between Milvia St and Martin Luther King Jr Way.
    - Haste St intersects Martin Luther King Jr Way at a T-intersection and does not continue westbound to connect into Sacramento St.
- The limited desirable westbound connections force traffic south from Downtown Berkeley and Southside to funnel either northbound along Arlington Ave or Oxford St or southbound along Shattuck Ave, Telegraph Ave, College Ave, and Warring St/Derby St/Belrose Ave/Claremont Blvd to evacuate the area.

Affected Area: North of Ohlone Park

The portion of the city that lies between Sacramento St, Cedar St, Martin Luther King Jr Way, and Ohlone Park are in a unique situation for evacuation. This area is limited in the number of outbound paths to choose from.

Traffic Calming

- Between Sacramento Street and Martin Luther King Jr Way, only one street (California St) connects Ohlone Park with Cedar Street.
    - Diverters along Virginia St/McGee Ave and Grant St make northbound evacuation difficult for parts of this area.

Existing Street Network Characteristics

- Roadway design forces westbound traffic to go northbound on Sacramento St at every intersection except Lincoln, which is stop controlled.

- Ohlone Park blocks southbound egress out of this area.
- All eastbound routes meet with Martin Luther King Jr Way at stop signs.
- Southbound traffic must first go northbound to Cedar or go eastbound to Martin Luther King Jr Way (and wait for a break in traffic).
- Between Sacramento Street and Martin Luther King Jr Way, only one street (California St) connects Ohlone Park with Cedar Street. Edith St and Josephine St both stop at Virginia St and do not continue south.

This area is one of the last to clear in an evacuation of the entire city as shown in Figure F-6.

Affected Area: South and West of Clark Kerr Campus

As shown for the Panoramic Fire case (Figure F-12 and Figure F-13), the portion of the city that lies between Ashby Ave (south), College Ave (west), Dwight Way (north), and Warring St/Derby St/Bellrose Ave/Claremont Blvd (east) is also limited in the number of outbound paths to choose from.

Traffic Calming

- The diverter at Piedmont Ave and Parker St prevents traffic from traveling westbound.
- The diverter at Piedmont Ave and Derby St prevents traffic from traveling westbound.
- The diverter at the intersection with Derby St/Tanglewood Rd prohibits traffic from utilizing Tanglewood Rd to access Claremont Ave.
- The diverter at Avalon Ave and Claremont Ave prohibits vehicles from Avalon Ave from accessing Claremont Ave. As such, traveling further south on Bellrose Ave, Claremont Blvd/Garber St and Avalon Ave do not provide westbound or eastbound connections.
- Due to the diverter at Piedmont Ave/Russell St, traffic cannot access College Ave via Russell St.
- Traffic could travel on Claremont Blvd to Forest Ave. The speed table along Forest Ave has a low capacity of this roadway.

Existing Street Network Characteristics

- Evacuees traveling southbound along Piedmont Ave are limited in options once they pass the intersection with Dwight Way.
- Traveling eastbound on any road does not provide a way out of the area.

Affected Area: Lawrence Berkeley National Lab (LBNL)

As discussed in Section 7.3.9, during the midweek during the day, the heavy flow of traffic leaving LBNL combined with the daily background and shadow evacuating traffic in areas just west of LBNL overwhelms the intersection of Gayley Rd/LaLoma Ave and Hearst Ave.

Traffic Signals

- The intersection of Gayley Rd/LaLoma Ave and Hearst Ave is a pretimed traffic signal. Conversion to an actuated signal may provide better throughput at this intersection for an evacuation of LBNL.

G.3 Recommendations

This analysis highlights the TCDs, traffic signals, and existing street network characteristics with potential to reduce overall network capacity and to locally impede flow of evacuees in large-scale evacuations.

TCDs in particular are vital for pedestrian safety, as well as reduction of speed and traffic volume on neighborhood streets.

For existing infrastructure, the City should develop and implement a citywide connectivity and capacity strategy, potentially integrating approaches such as actuated or adaptive signal timing and replacing TCDs with removable/retractable options. As part of proposed infrastructure changes, City should develop and implement a methodology to conduct a comprehensive capacity analysis, considering peak evacuation demand (as is presented in Appendix F and G of this document), should be conducted. This analysis will attempt to ensure that infrastructure changes will not result in new evacuation bottlenecks, as increased traffic volume of diverting vehicles is redistributed in the roadway network. This proactive approach will attempt to ensure that strategies to improve connectivity and increase roadway capacity do not create downstream impacts.

For future infrastructure, it is strongly recommended that the City develop and implement a methodology to evaluate and consider evacuation efficiency and roadway capacity during the planning and implementation phases of future roadway infrastructure development, including TCD installations. Simulation modeling could be employed to assess the impact of proposed roadway infrastructure development, including TCDs, on evacuation times and congestion levels under emergency scenarios.

In addition to exploring these impacts for evacuation contexts, impacts to first responder response times should also be assessed in daily traffic environments to better understand the full impact of TCDs and other traffic calming measures. This effort is currently underway.

Section 11.3.2 identifies traffic signal improvements that could improve evacuation flow.

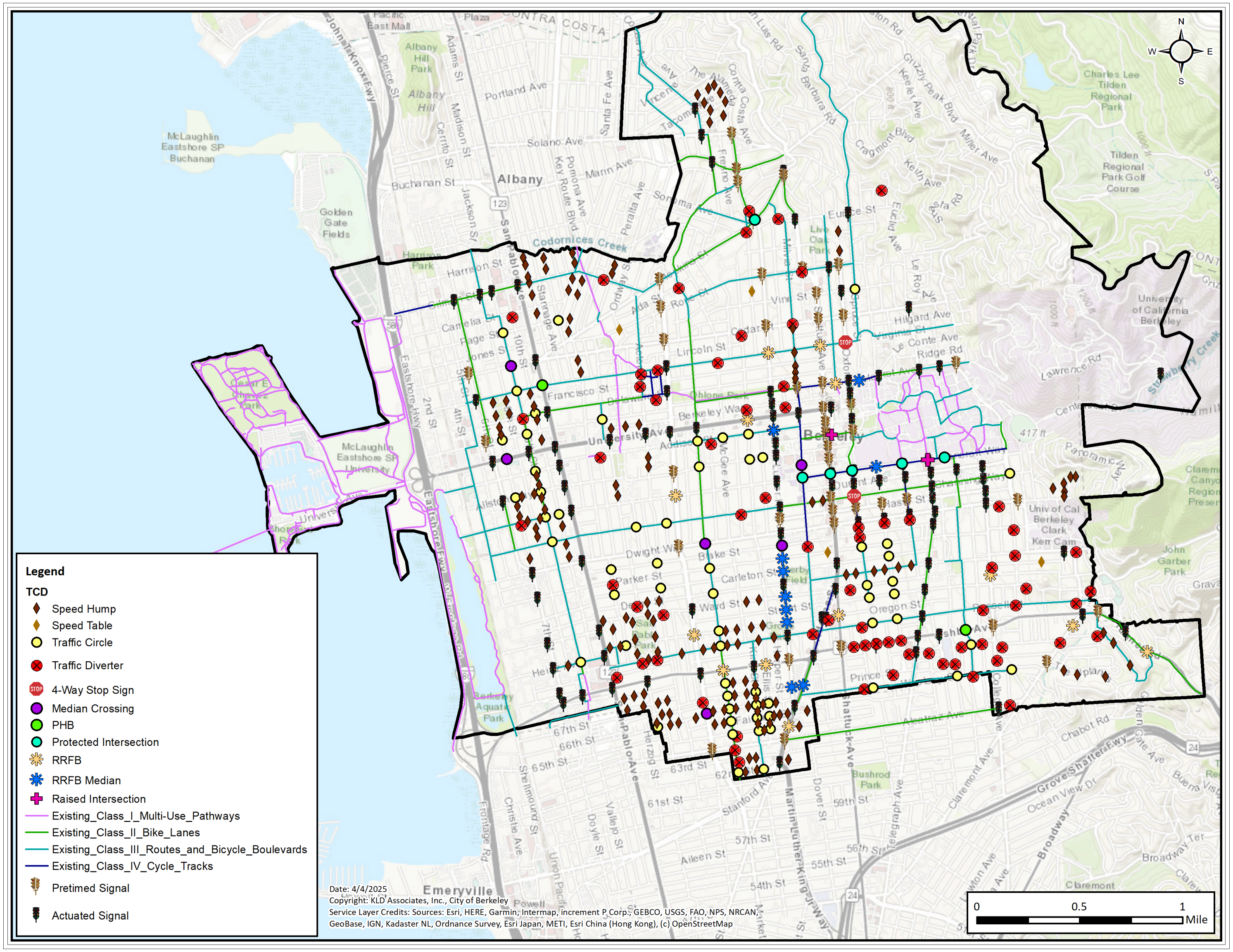


Figure G-1. Traffic Calming Devices, Traffic Signals, and Existing Street Network Characteristics

APPENDIX H

Region Specific Facility and Transit Dependent Population Data

H. REGION SPECIFIC FACILITY AND TRANSIT DEPENDENT POPULATION DATA

This appendix provides a list of special facility and transit dependent population data for Region R01 through Region R07. The following Sections explain how these numbers are derived for each population group that could be transit dependent:

- Visitors – Section 3.3
- Employees – Section 3.4
- Medical Facilities – Section 3.5.1
- Schools/Preschools/Day Care Centers – Section 3.6.1
- Colleges – Section 3.6.2
- Transit Dependent Residents – Section 3.7
- People Requiring Specialized Transportation Assistance – Section 3.8

Table H-1. Facility and Transit Dependent Population by Region

Region Number	Region Name	Facility Name	Facility Type	Total Population	Transit Dependent Population
R01	Citywide Evacuation	Various locations throughout the region	Transient Attractions	44,192	13,258
		Various locations throughout the region	Major Employers	25,341	9,046
		Various locations throughout the region	Transit Dependent Residents	1,686	1,686
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	348	348
		Alta Bates Summit Medical Center - Alta Bates Campus	Medical Facility	183	183
		Alta Bates Summit Medical Center - Herrick Campus	Medical Facility	58	58
		Ashby Care Center	Medical Facility	29	29
		Berkeley Pines Care Center	Medical Facility	32	32
		Chaparral House	Medical Facility	42	42
		Elegance Berkeley	Medical Facility	47	47
		Elmwood Care Center	Medical Facility	77	77
		Kyakameena Care Center	Medical Facility	60	60
		New Bridge Foundation	Medical Facility	45	45
		Redwood Gardens Apartments	Medical Facility	168	168
		Silverado Memory Care Center	Medical Facility	87	87
		Ala Costa Ctr. For The Developmentally Disabled	Preschool/Day Care Center	58	10
		American International Montessori School	Preschool/Day Care Center	117	20
		Aquatic Park School	Preschool/Day Care Center	77	13
		Arbor Preschool East	Preschool/Day Care Center	22	4
		Bahia School Age Program	Preschool/Day Care Center	65	11
		Berkeley Hills Nursery School	Preschool/Day Care Center	40	7
		Berkeley International Montessori School	Preschool/Day Care Center	21	4
		Berkeley Little School	Preschool/Day Care Center	42	7
		Berkeley Montessori School	Preschool/Day Care Center	119	20
		Berkeley Rose Waldorf School	Preschool/Day Care Center	24	4
		Berkeley Special Education Preschool	Preschool/Day Care Center	90	15
		Berkeley YMCA EHS - Vera Casey	Preschool/Day Care Center	26	4
		Berkeley YMCA Head Start - South YMCA	Preschool/Day Care Center	94	16

Region Number	Region Name	Facility Name	Facility Type	Total Population	Transit Dependent Population
R01	Citywide Evacuation	Berkeley YMCA Head Start - West YMCA	Preschool/Day Care Center	86	15
		Beth El Nursery School	Preschool/Day Care Center	74	13
		BUSD - Franklin Preschool	Preschool/Day Care Center	192	33
		BUSD - Hopkins Street	Preschool/Day Care Center	140	24
		BUSD - King Child Development Center	Preschool/Day Care Center	108	18
		Cedar Creek Montessori School	Preschool/Day Care Center	40	7
		Centro Vida Bilingual Childcare Center	Preschool/Day Care Center	64	11
		Child Education Center	Preschool/Day Care Center	107	18
		Childrens Community Center	Preschool/Day Care Center	52	9
		Congregation Beth Israel-Gan Shalom	Preschool/Day Care Center	32	5
		Congregation Netivot Shalom	Preschool/Day Care Center	30	5
		Cornerstone Children's Center	Preschool/Day Care Center	112	19
		Dandelion Nursery School, Inc	Preschool/Day Care Center	24	4
		Dolma Child Care Center	Preschool/Day Care Center	14	2
		Duck's Nest - Berkeley	Preschool/Day Care Center	91	15
		Ecole Bilingue De Berkeley	Preschool/Day Care Center	426	72
		Ephesian Children's Center	Preschool/Day Care Center	36	6
		Global Montessori International School	Preschool/Day Care Center	90	15
		Golden Gate Learning Center	Preschool/Day Care Center	57	10
		Hearts Leap Beginnings	Preschool/Day Care Center	40	7
		Hearts Leap ICRI Preschool	Preschool/Day Care Center	70	12
		Hearts Leap North	Preschool/Day Care Center	45	8
		Jewish Community Ctr of The East Bay-Berkeley	Preschool/Day Care Center	75	13
		Kids In Motion	Preschool/Day Care Center	70	12
		Little Beans Preschool	Preschool/Day Care Center	40	7
		Little Elephant Montessori, Inc.	Preschool/Day Care Center	24	4
		Mi Mundo Preschool	Preschool/Day Care Center	29	5
		Model School Comprehensive Humanistic Learning Ctr	Preschool/Day Care Center	63	11
		Mustard Seed Preschool	Preschool/Day Care Center	66	11
		Nia House Learning Center	Preschool/Day Care Center	94	16
		Pixar Child Development Center	Preschool/Day Care Center	108	18
		Rosemarie's Motivational Preschool	Preschool/Day Care Center	22	4

Region Number	Region Name	Facility Name	Facility Type	Total Population	Transit Dependent Population
R01	Citywide Evacuation	Shu Ren International School	Preschool/Day Care Center	179	30
		St. John's Child Care Center	Preschool/Day Care Center	45	8
		Step One School	Preschool/Day Care Center	108	18
		Sunshine Preschool (CEID)	Preschool/Day Care Center	45	8
		The Monteverde School	Preschool/Day Care Center	30	5
		The New School of Berkeley	Preschool/Day Care Center	48	8
		The New School Of Berkeley-Schoolage	Preschool/Day Care Center	45	8
		Through the Looking Glass Early Head Start	Preschool/Day Care Center	24	4
		UCB - Clark Kerr Campus Children's Center	Preschool/Day Care Center	29	5
		UCB - Clark Kerr Preschool	Preschool/Day Care Center	29	5
		UCB - Dwight Way Center	Preschool/Day Care Center	42	7
		UCB - Harold E. Jones Child Study Ctr/Childcare	Preschool/Day Care Center	56	10
		UCB - Haste Street Child Development Center	Preschool/Day Care Center	92	16
		VIA Nova Children's School	Preschool/Day Care Center	45	8
		Woolly Mammoth Childcare & Preschool	Preschool/Day Care Center	69	12
		Acupuncture and Integrative Medicine College-Berkeley	School	153	0
		Bayhill High School	School	73	12
		Berkeley Arts Magnet at Whittier School	School	407	69
		Berkeley City College	School	6,519	174
		Berkeley High School	School	3,427	583
		Berkeley Rose Waldorf School	School	97	16
		Berkeley School of Theology	School	65	0
		Berkeley Technology Academy	School	36	6
		Berkwood Hedge School	School	128	22
		Black Pine Circle School	School	347	59
		California Jazz Conservatory	School	88	0
		Church Divinity School of the Pacific	School	122	0
		Cragmont Elementary School	School	331	56
		Dominican School of Philosophy & Theology	School	100	0
		East Bay School for Boys	School	105	18
		Emerson Elementary School	School	323	55
		Escuela Bilingue Internacional School	School	324	55

Region Number	Region Name	Facility Name	Facility Type	Total Population	Transit Dependent Population
R01	Citywide Evacuation	Graduate Theological Union	School	275	0
		Institute of Buddhist Studies	School	53	0
		Jesuit School of Theology	School	112	0
		John Muir Elementary School	School	306	52
		Longfellow Arts and Technology Middle School	School	504	86
		Malcolm X Elementary School	School	552	94
		Martin Luther King Middle School	School	1,007	171
		Maybeck High School	School	121	21
		Oxford Elementary at West Campus	School	256	44
		Pacific Boychoir Academy	School	30	5
		Pacific Lutheran Theological Seminary	School	50	0
		Pacific School of Religion	School	139	0
		Rosa Parks Environmental Science School	School	442	75
		Ruth Acty Elementary School	School	433	74
		School of the Madeleine	School	337	57
		Sylvia Mendez Elementary School	School	409	70
		The Berkeley School	School	236	40
		The Crowden School	School	75	13
		The Elmwood Academy	School	100	17
		The Wright Institute	School	638	0
		Thousand Oaks Elementary School	School	382	65
		University of California - Berkeley	School	44,075	2,289
		VIA Center	School	20	3
		Walden Center & School	School	84	14
		Washington Elementary School	School	416	71
		Willard Middle School	School	669	114
		Zaytuna College	School	43	0
			REGION TOTAL:	**141,006**	**30,382**

Region Number	Region Name	Facility Name	Facility Type	Total Population	Transit Dependent Population
R02	Fire 1923 Evacuation Order	Various locations throughout the region	Transient Attractions	9,342	2,803
		Various locations throughout the region	Major Employers	15,362	5,484
		Various locations throughout the region	Transit Dependent Residents	525	525
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	108	108
		New Bridge Foundation	Medical Facility	45	45
		Redwood Gardens Apartments	Medical Facility	168	168
		Berkeley Hills Nursery School	Preschool/Day Care Center	40	7
		Berkeley Montessori School	Preschool/Day Care Center	119	20
		Beth El Nursery School	Preschool/Day Care Center	74	13
		BUSD - Hopkins Street	Preschool/Day Care Center	140	24
		Childrens Community Center	Preschool/Day Care Center	52	9
		Hearts Leap North	Preschool/Day Care Center	45	8
		Jewish Community Ctr of The East Bay-Berkeley	Preschool/Day Care Center	75	13
		Mustard Seed Preschool	Preschool/Day Care Center	66	11
		The New School of Berkeley	Preschool/Day Care Center	48	8
		The New School of Berkeley-Schoolage	Preschool/Day Care Center	45	8
		UCB - Clark Kerr Campus Children's Center	Preschool/Day Care Center	29	5
		UCB - Clark Kerr Preschool	Preschool/Day Care Center	29	5
		Bayhill High School	School	73	12
		Berkeley Arts Magnet at Whittier School	School	407	69
		Church Divinity School of the Pacific	School	122	0
		Dominican School of Philosophy & Theology	School	100	0
		Graduate Theological Union	School	275	0
		Jesuit School of Theology	School	112	0
		Martin Luther King Middle School	School	1,007	171
		Pacific Lutheran Theological Seminary	School	50	0
		Pacific School of Religion	School	139	0
		School of the Madeleine	School	337	57
		University of California - Berkeley	School	44,075	2,289
		Zaytuna College	School	43	0

Region Number	Region Name	Facility Name	Facility Type	Total Population	Transit Dependent Population
R02	**Fire 1923 Evacuation Warning**	Various locations throughout the region	Transient Attractions	4,265	1,280
		Various locations throughout the region	Major Employers	1,156	413
		Various locations throughout the region	Transit Dependent Residents	270	270
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	56	56
		Berkeley Little School	Preschool/Day Care Center	42	7
		Cornerstone Children's Center	Preschool/Day Care Center	112	19
		Dandelion Nursery School, Inc	Preschool/Day Care Center	24	4
		St. John's Child Care Center	Preschool/Day Care Center	45	8
		The Monteverde School	Preschool/Day Care Center	30	5
		UCB - Dwight Way Center	Preschool/Day Care Center	42	7
		UCB - Harold E. Jones Child Study Ctr/Childcare	Preschool/Day Care Center	56	10
		UCB - Haste Street Child Development Center	Preschool/Day Care Center	92	16
		Berkeley City College	School	6,519	174
		Berkeley High School	School	3,427	583
		California Jazz Conservatory	School	88	0
		Cragmont Elementary School	School	331	56
		East Bay School for Boys	School	105	18
		Emerson Elementary School	School	323	55
		Institute of Buddhist Studies	School	53	0
		Maybeck High School	School	121	21
		Pacific Boychoir Academy	School	30	5
		Ruth Acty Elementary School	School	433	74
		The Crowden School	School	75	13
		The Wright Institute	School	638	0
			REGION TOTAL:	**66,681**	**6,669**

Region Number	Region Name	Facility Name	Facility Type	Total Population	Transit Dependent Population
R03a	**Fire 1923 Phase a Evacuation Order**	Various locations throughout the region	Transient Attractions	1,423	427
		Various locations throughout the region	Transit Dependent Residents	64	64
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	13	13
		Pacific Lutheran Theological Seminary	School	50	0
R03a	**Fire 1923 Phase a Evacuation Warning**	Various locations throughout the region	Transient Attractions	2,377	713
		Various locations throughout the region	Transit Dependent Residents	175	175
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	36	36
		Berkeley Hills Nursery School	Preschool/Day Care Center	40	7
			REGION TOTAL:	**4,178**	**1,435**
R03b	**Fire 1923 Phase b Evacuation Order**	Various locations throughout the region	Transient Attractions	3,347	1,004
		Various locations throughout the region	Transit Dependent Residents	207	207
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	43	43
		Berkeley Hills Nursery School	Preschool/Day Care Center	40	7
		Pacific Lutheran Theological Seminary	School	50	0
R03b	**Fire 1923 Phase b Evacuation Warning**	Various locations throughout the region	Transient Attractions	2,772	832
		Various locations throughout the region	Major Employers	3,028	1,081
		Various locations throughout the region	Transit Dependent Residents	175	175
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	36	36
		Church Divinity School of the Pacific	School	122	0
		Graduate Theological Union	School	275	0
		Jesuit School of Theology	School	112	0
		Pacific School of Religion	School	139	0
		Zaytuna College	School	43	0
			REGION TOTAL:	**10,389**	**3,385**
R03c	**Fire 1923 Phase c Evacuation Order**	Various locations throughout the region	Transient Attractions	9,342	2,803
		Various locations throughout the region	Major Employers	15,362	5,484
		Various locations throughout the region	Transit Dependent Residents	525	525
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	108	108

Region Number	Region Name	Facility Name	Facility Type	Total Population	Transit Dependent Population
R03c	Fire 1923 Phase c Evacuation Order	New Bridge Foundation	Medical Facility	45	45
		Redwood Gardens Apartments	Medical Facility	168	168
		Berkeley Hills Nursery School	Preschool/Day Care Center	40	7
		Berkeley Montessori School	Preschool/Day Care Center	119	20
		Beth El Nursery School	Preschool/Day Care Center	74	13
		BUSD - Hopkins Street	Preschool/Day Care Center	140	24
		Childrens Community Center	Preschool/Day Care Center	52	9
		Hearts Leap North	Preschool/Day Care Center	45	8
		Jewish Community Ctr of The East Bay-Berkeley	Preschool/Day Care Center	75	13
		Mustard Seed Preschool	Preschool/Day Care Center	66	11
		The New School of Berkeley	Preschool/Day Care Center	48	8
		The New School of Berkeley-Schoolage	Preschool/Day Care Center	45	8
		UCB - Clark Kerr Campus Children's Center	Preschool/Day Care Center	29	5
		UCB - Clark Kerr Preschool	Preschool/Day Care Center	29	5
		Bayhill High School	School	73	12
		Berkeley Arts Magnet at Whittier School	School	407	69
		Church Divinity School of the Pacific	School	122	0
		Dominican School of Philosophy & Theology	School	100	0
		Graduate Theological Union	School	275	0
		Jesuit School of Theology	School	112	0
		Martin Luther King Middle School	School	1,007	171
		Pacific Lutheran Theological Seminary	School	50	0
		Pacific School of Religion	School	139	0
		School of the Madeleine	School	337	57
		University of California - Berkeley	School	44,075	2,289
		Zaytuna College	School	43	0
R03c	Fire 1923 Phase c Evacuation Warning	Various locations throughout the region	Transient Attractions	4,265	1,280
		Various locations throughout the region	Major Employers	1,156	413
		Various locations throughout the region	Transit Dependent Residents	270	270
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	56	56
		Berkeley Little School	Preschool/Day Care Center	42	7
		Cornerstone Children's Center	Preschool/Day Care Center	112	19

Region Number	Region Name	Facility Name	Facility Type	Total Population	Transit Dependent Population
R03c	Fire 1923 Phase c Evacuation Warning	Dandelion Nursery School, Inc	Preschool/Day Care Center	24	4
		St. John's Child Care Center	Preschool/Day Care Center	45	8
		The Monteverde School	Preschool/Day Care Center	30	5
		UCB - Dwight Way Center	Preschool/Day Care Center	42	7
		UCB - Harold E. Jones Child Study Ctr/Childcare	Preschool/Day Care Center	56	10
		UCB - Haste Street Child Development Center	Preschool/Day Care Center	92	16
		Berkeley City College	School	6,519	174
		Berkeley High School	School	3,427	583
		California Jazz Conservatory	School	88	0
		Cragmont Elementary School	School	331	56
		East Bay School for Boys	School	105	18
		Emerson Elementary School	School	323	55
		Institute of Buddhist Studies	School	53	0
		Maybeck High School	School	121	21
		Pacific Boychoir Academy	School	30	5
		Ruth Acty Elementary School	School	433	74
		The Crowden School	School	75	13
		The Wright Institute	School	638	0
			REGION TOTAL:	**91,385**	**14,956**

Region Number	Region Name	Facility Name	Facility Type	Total Population	Transit Dependent Population
R04	**Panoramic Hill Fire Evacuation Order**	Various locations throughout the region	Transient Attractions	757	227
		Various locations throughout the region	Transit Dependent Residents	80	80
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	16	16
		Redwood Gardens Apartments	Medical Facility	168	168
		UCB - Clark Kerr Campus Children's Center	Preschool/Day Care Center	29	5
		UCB - Clark Kerr Preschool	Preschool/Day Care Center	29	5
R04	**Panoramic Hill Fire Evacuation Warning**	Various locations throughout the region	Transient Attractions	1,090	327
		Various locations throughout the region	Major Employers	172	61
		Various locations throughout the region	Transit Dependent Residents	127	127
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	26	26
		St. John's Child Care Center	Preschool/Day Care Center	45	8
		The Monteverde School	Preschool/Day Care Center	30	5
		Emerson Elementary School	School	323	55
		Maybeck High School	School	121	21
		The Wright Institute	School	638	0
			REGION TOTAL:	**3,651**	**1,131**

Region Number	Region Name	Facility Name	Facility Type	Total Population	Transit Dependent Population
R05	Fire Zones Fire Zones 2 and 3 Combined	Various locations throughout the region	Transient Attractions	8,851	2,655
		Various locations throughout the region	Major Employers	172	61
		Various locations throughout the region	Transit Dependent Residents	668	668
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	138	138
		New Bridge Foundation	Medical Facility	45	45
		Redwood Gardens Apartments	Medical Facility	168	168
		Arbor Preschool East	Preschool/Day Care Center	22	4
		Berkeley Hills Nursery School	Preschool/Day Care Center	40	7
		Beth El Nursery School	Preschool/Day Care Center	74	13
		Childrens Community Center	Preschool/Day Care Center	52	9
		Dandelion Nursery School, Inc	Preschool/Day Care Center	24	4
		Kids In Motion	Preschool/Day Care Center	70	12
		Step One School	Preschool/Day Care Center	108	18
		UCB - Clark Kerr Campus Children's Center	Preschool/Day Care Center	29	5
		UCB - Clark Kerr Preschool	Preschool/Day Care Center	29	5
		Church Divinity School of the Pacific	School	122	0
		Cragmont Elementary School	School	331	56
		Dominican School of Philosophy & Theology	School	100	0
		Graduate Theological Union	School	275	0
		Jesuit School of Theology	School	112	0
		John Muir Elementary School	School	306	52
		Pacific Lutheran Theological Seminary	School	50	0
		Pacific School of Religion	School	139	0
		The Wright Institute	School	638	0
		Zaytuna College	School	43	0
			REGION TOTAL:	**12,606**	**3,920**

Region Number	Region Name	Facility Name	Facility Type	Total Population	Transit Dependent Population
R06	**Tsunami Phase 3**	Various locations throughout the region	Transient Attractions	1,944	583
		Various locations throughout the region	Major Employers	126	45
		Various locations throughout the region	Transit Dependent Residents	32	32
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	7	7
			REGION TOTAL:	**2,109**	**667**
R07	**Tsunami Max Phase**	Various locations throughout the region	Transient Attractions	4,077	1,223
		Various locations throughout the region	Major Employers	3,547	1,266
		Various locations throughout the region	Transit Dependent Residents	111	111
		Various locations throughout the region	People Requiring Specialized Transportation Assistance	23	23
		Aquatic Park School	Preschool/Day Care Center	77	13
		Duck's Nest - Berkeley	Preschool/Day Care Center	91	15
		Golden Gate Learning Center	Preschool/Day Care Center	57	10
		VIA Center	School	20	3
			REGION TOTAL:	**8,003**	**2,664**