CITY OF BERKELEY

2014 LOCAL HAZARD MITIGATION PLAN

JUNE 1, 2014

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2014 Local Hazard Mitigation Plan

June 1, 2014

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Executive Summary

Berkeley is a vibrant and unique community. But every aspect of the city – its economic prosperity, social and cultural diversity, and historical character – could be dramatically altered by a serious earthquake or fire. While we cannot predict or protect ourselves against every possible hazard that may strike the community, we can anticipate many impacts and take steps to reduce the harm they will cause. We can make sure that tomorrow's Berkeley continues to reflect our current values.

The City and community members have been working together for years to address certain aspects of the risk – such as strengthening structures, distributing disaster supply caches, and enforcing vegetation management measures to reduce fire risk. The 2004 Disaster Mitigation Plan formalized this process, ensuring that these activities continued to be explored and improved over time. Over many years, this constant focus on disasters has made Berkeley, its residents and businesses, much safer.

This 2014 Local Hazard Mitigation Plan continues this ongoing process to evaluate the risks that different hazards pose to Berkeley, and to engage the community in dialogue to identify the most important steps that the City and its partners should pursue to reduce these risks.

The federal Disaster Mitigation Act of 2000 called for all communities to prepare mitigation plans. The City adopted a plan that met the requirements of DMA 2000 on June 22, 2004. This is the 2014 update to that plan, which ensures that Berkeley will remain eligible to apply for mitigation grants before disasters, and to receive federal mitigation funding and additional State recovery funding after disasters.

Risks in Berkeley

A sound disaster resilience program must be founded on reliable information about the types and scale of damage that different hazards could cause. To develop the 2004 Disaster Mitigation plan, the City conducted detailed research on four major natural and two major "manmade" hazards present in Berkeley. These hazards were earthquake, wildland-urban interface fire, landslide, flood, hazardous materials release, and terrorism. Since that time, new maps and data depicting the extent and possible impacts from tsunami and climate change have become available. In 2011, the City added these hazards to the list.

As in 2004, earthquake and wildland-urban interface fire are the two hazards of greatest concern. These hazards have the potential for catastrophic impacts to Berkeley.

Hazards of Greatest Concern

Earthquake

We do not know when the next major earthquake will strike Berkeley, the United States Geological Survey calculated that there is a 63 percent chance that a 6.7 magnitude earthquake will strike the Bay Area by 2038, and a 31 percent chance that that earthquake will occur on the Hayward/Rogers Creek Fault system, which runs directly through Berkeley.[i] The 1994 Northridge earthquake was also magnitude 6.7, and caused $28 billion in losses.

A catastrophic earthquake on the Hayward Fault would cause very violent shaking and three types of ground failure in Berkeley. Liquefaction is likely in the westernmost parts of the city.

Liquefaction can destroy pavements and dislodge foundations. Surface fault rupture could occur along the Fault, causing displacements of up to several feet. Landslides are expected in the Berkeley hills during the next earthquake, particularly if the earthquake occurs during the rainy winter months. Landslide movement could range from a few inches to tens of feet; ground surface displacements as small as a few inches are enough to break typical foundations.

In a 6.9 magnitude earthquake on the Hayward Fault, the City estimates that over 600 housing units in Berkeley will be completely destroyed and 20,000 more will be damaged. One thousand to 4,000 families may need temporary shelter. Depending on the disaster scenario, one hundred people could be killed in Berkeley alone, and many more would be injured. Commercial buildings, utilities, and public roads will be disabled or destroyed. The earthquake could also spark numerous fires at a time when water systems may not be functioning. This plan estimates that building damage in Berkeley alone could exceed $1.8 billion, out of a multi-billion dollar regional loss, with losses to business activities and infrastructure adding to this figure. Low-income housing units are expected to be damaged at a higher rate than other residences. Other types of housing, such as condominiums, may replace them when land owners rebuild. This could lead to profound demographic shifts in Berkeley.

Wildland-Urban Interface Fire

Berkeley is vulnerable to a wind-driven fire starting along the city's eastern border. The fire risk facing the people and properties in the eastern hills is compounded by the area's mountainous topography, limited water supply, minimal access and egress routes, and location, overlaid upon the Hayward Fault. Berkeley's flatlands are also exposed to a fire that spreads west from the hills. The flatlands are densely-covered with old wooden buildings housing low-income and vulnerable populations, including isolated seniors, persons with disabilities and students.

The high risk of wildland-urban interface (WUI) fire in Berkeley was clearly demonstrated in the 1991 Tunnel Fire, which destroyed 62 homes in Berkeley and more than 3,000 in Oakland. In 1923, an even more devastating fire burned through Berkeley. It began in the open lands of Wildcat Canyon to the northeast and, swept by a hot September wind, penetrated residential north Berkeley and destroyed nearly 600 structures, including homes, apartments, fraternities and sororities, a church, a fire station and a library. The fire burned downhill all the way to Shattuck Avenue in central Berkeley[ii]. If a fire today burned that same area, 3,000 structures would be destroyed, with losses for buildings alone exceeding $3 billion. Destruction of contents in all of the homes and businesses burned could increase the losses by another $600 million. Depending on the speed of the fire spread, lives of Berkeley residents could also be lost. Many established small businesses, homes, and multi-family apartment buildings, particularly student housing, would be completely destroyed, changing the character of Berkeley forever.

Natural Hazards of Concern

This plan identified three additional natural hazards of concern: rainfall-induced landslide, flood, and tsunami. These hazards could cause significant damage and losses in Berkeley. However, unlike earthquake and WUI fire, their impacts are likely to be smaller, and confined to specific areas.

Berkeley has a number of deep-seated landslides that continuously move, with the rate of movement affected by rainfall and groundwater conditions. Significant localized areas of the

Berkeley hills face risk from landslide, and a major slide could endanger lives and impact scores of properties, utilities and infrastructure.

Floods also could damage property and cause significant losses in Berkeley. Flooding can occur when stormwater exceeds the capacity of a creek channel, or the capacity of the storm drain system. Creek flooding in Berkeley has the potential to affect about 675 structures, mainly in the western, industrial area of the city. It is unlikely that floodwaters will reach higher than three feet, but damages to homes, businesses, and their contents could total almost $150 million. With few properties covered by flood insurance, these costs would be borne primarily by Berkeley residents and businesses.

Tsunamis, though rare inside the San Francisco Bay, can occur from large offshore Subduction style earthquakes around the Pacific Rim. Small, local tsunamis can also result from offshore strike-slip Faults such as parts of the San Andreas Fault of the Peninsula and the Hayward Fault through San Pablo Bay. The March 2011 Japan earthquake generated a devastating tsunami, which reached the Bay Area and caused minor damage to docks and floats in the Berkeley Marina. A larger tsunami could impact much more of Berkeley's western shores. Buildings, infrastructure, and roadways could be damaged, and debris and hazardous materials could cause post-tsunami fires. Deaths are possible if individuals choose not to evacuate hazardous areas, do not understand tsunami warnings, or are unable to evacuate.

Manmade Hazards of Concern

This plan addresses climate change, hazardous materials release, and terrorism as Berkeley's three manmade hazards of concern.

Like regions across the globe, the San Francisco Bay Area is experiencing and will continue to increasingly experience the impacts of the changing climate. By 2100, average temperatures in the San Francisco Bay Area will increase up to 11° F. In 2100, Berkeley will have 6-10 additional heat waves each year, which will disproportionately impact the elderly, children under five, and the low-income community members.

Climate change will also cause additional extreme rainfall events, which will lead to more flooding. San Francisco Bay sea-levels will rise up to 55" by 2100, impacting infrastructure and community members in west Berkeley. Climate change impacts will also exacerbate the natural hazards of concern outlined in this plan. Rising sea levels will increase Berkeley's exposure to earthquake liquefaction, tsunami inundation, and flooding. Increases in precipitation and severe storms will make flooding more frequent, and will increase the landslide risk in the hills. California's water security will be reduced, and drought will become a more persistent issue.

Over the last twenty years, Berkeley has seen a more than 90 percent reduction in the number of facilities with extremely hazardous materials. The City carefully tracks hazardous materials within its borders, and works closely with companies using large amounts of potentially dangerous materials. The City has identified fifteen facilities in Berkeley with sufficiently large quantities of toxic chemicals to pose a high risk to the community. Hazardous materials also travel through Berkeley by truck and rail. Natural hazards identified in the plan could trigger the release of hazardous materials.

It is not possible to estimate the probability of a terrorist attack. Experts prioritize terrorism readiness efforts by identifying critical sites and assessing these sites' vulnerability to terrorist

attack. City officials are currently working with State and regional groups to prevent and prepare for terrorist attacks.

Disaster Resilience

Managing risk requires government and its partners to identify and evaluate risks, and implement and maintain policies, practices and projects to reduce those risks. Many innovative Berkeley initiatives are increasing our community's disaster resilience:

- The City has strengthened its ability to serve the community during and after disasters by seismically upgrading or replacing buildings that house critical City functions. Since 2004, Berkeley has strengthened or replaced its City Hall, all seven fire stations, all five libraries, its public works maintenance building, and its animal shelter.
- The Berkeley Unified School District, supported by voter-approved bonds, has strengthened all public schools.
- Over 90% of Berkeley's 700 unreinforced masonry buildings have been retrofitted or demolished since a City mandate began in 1991.
- Berkeley was the first city in the nation to inventory the community's soft-story buildings. In December 2013, City Council adopted an ordinance requiring soft-story buildings with five or more units to be retrofitted within five years. .
- Berkeley has also developed innovative programs to encourage building owners to strengthen their own structures. The City has distributed over $9 million through the Transfer Tax Rebate Program, which reduces the real estate transfer tax to building owners who perform seismic safety work.
- Four different programs contribute to vegetation management citywide, removing thousands of tons of potential fire fuels each year.
- The City enforces several programs to reduce Berkeley's fire hazard in the hills. These include strict building and fire code provisions, as well as more restrictive local amendments for new and renovated construction, along with vegetation control inspections in high-risk properties.
- The Disaster Cache Program incentivizes community-building for disaster readiness. To date, the City has awarded 87 caches of disaster response equipment to neighborhoods, congregations, and UC Berkeley Panhellenic groups that have undertaken disaster readiness activities.
- The City recently hired two positions tasked specifically with increasing disaster readiness in Berkeley's vulnerable and underserved populations.
- Berkeley's 2009 Climate Action Plan has served as a model for jurisdictions across the nation. The Climate Action Plan also guides the City's new climate adaptation strategy.

These programs, and many others, place Berkeley as a leader in disaster management. Long-term maintenance and improvements to these programs will help to protect the Berkeley community in our next disaster.

Mitigation Strategy

Berkeley aims to be a resilient community that can survive, recover from, and thrive after a disaster, while maintaining its unique character and way of life. Berkeley envisions a community in which the people, buildings, and infrastructure, in and serving Berkeley, are resilient to disasters; City government provides critical services in the immediate aftermath of a devastating event of any kind; and basic government and commercial functions resume within thirty days of a damaging earthquake or other significant event.

For many years, the City has pursued initiatives to identify and mitigate Berkeley's hazard vulnerabilities. In 2014, the City is continuing this effort: this plan outlines a five-year strategic plan to bring Berkeley closer to that vision. This plan identifies three disaster mitigation approaches to increase Berkeley's resilience:

1. The City will evaluate and strengthen all City-owned structures, particularly those needed for critical services, to ensure that the community can be served adequately after a disaster.
2. The City will establish and maintain incentive programs and standards to encourage local residents and businesses to upgrade the hazard-resistance of their own properties.
3. The City will actively engage other local and regional groups to collaboratively work towards mitigation actions that help maintain Berkeley's way of life and its ability to be fully functional after a disaster event.

This plan has four objectives for reducing disaster risk in Berkeley:

A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, and their secondary impacts.

B. Increase the ability of the City government to serve the community during and after hazard events by mitigating risk to key city functions such as response, recovery and rebuilding.

C. Protect Berkeley's unique character and values from being compromised by hazard events.

D. Encourage mitigation activities to increase the disaster resilience of institutions, private companies and lifeline systems that are essential to Berkeley's functioning.

Actions specified in the 2014 mitigation strategy were inspired by multiple elements of the City's General Plan, and specified through collaborative planning processes among City staff and key institutional partners. 2014 mitigation actions are presented in *high*, *medium*, and *low* priority categories. Generally, *high* and *medium* priority actions address Berkeley's hazards of greatest concern—earthquake and wildland-urban interface fire. *High* and *medium* priority actions can be completed in the five-year time frame covered by this strategy. Implementation of *medium* and *low* actions is dependent on outside sources of funding becoming available. Resource availability will strongly influence the pace of achievements.

High Priority Actions:

- Perform appropriate seismic and fire safety analysis based on current and future use for all City-owned facilities and structures.
- Strengthen or replace City buildings in the identified prioritized order as funding is available.
- Implement Phase Two of the Soft-Story Retrofit Program, mandating retrofit of soft-story residences.
- Complete the ongoing program to retrofit all remaining non-complying Unreinforced Masonry (URM) buildings.
- Reduce hazard vulnerabilities in Berkeley buildings.
- Reduce fire risk in existing development through fire code updates and enforcement.
- Reduce fire risk in existing development through vegetation management.
- Collect, analyze and share information with the Berkeley community about Berkeley hazards and associated risk reduction techniques.
- Ensure that the City provides leadership and coordination of the private sector, public institutions, and other public bodies in disaster mitigation.
- Work with EBMUD to ensure an adequate water supply during emergencies and disaster recovery.
- Manage and promote pedestrian evacuation routes in Fire Zones 2 and 3.
- Mitigate climate change impacts by integrating climate change research and adaptation planning into City operations and services.

Medium Priority Actions:

- Develop an Energy Assurance Plan for City operations.
- Improve the disaster-resistance of the natural gas delivery system to increase public safety and to minimize damage and service disruption following a disaster.
- Rehabilitate the City's stormwater system to reduce local flooding caused by inadequate storm drainage.
- Define and mitigate Berkeley's tsunami hazard.
- Reduce Berkeley's vulnerability to extreme heat events and associated hazards.
- Reduce Berkeley's vulnerability to severe storms and associated hazards.
- Collaborate with local, State, regional and federal partners to increase the security of Berkeley's water supply from climate change impacts.
- Maintain City participation in the National Flood Insurance Program.
- Streamline the zoning permitting process to rebuild residential and commercial structures following disasters.

Low Priority Actions:

- Mitigate the impacts of sea-level rise in Berkeley.
- Explore legislation to require hazardous materials stored in the flood zones to be elevated or otherwise protected from floodwaters.

Berkeley has developed effective processes to implement, track and update the status of its disaster mitigation activities. The City Manager's Office directs implementation and tracking of mitigation activities; funded actions will be inserted into departmental work plans each year.

Department heads task staff members with projects. Lead staff identified in each action will meet together at the beginning of each calendar year to address their progress on the actions that comprise Berkeley's mitigation strategy. Staff will also present progress on mitigation strategy implementation to the Disaster and Fire Safety Commission on an annual basis. Staff will conduct a complete review and update of the plan, including the hazard analysis and mitigation strategy, once every five years.

Summary of Changes to Section 3: Hazard Analysis

As part of the 2004 plan update, this 2014 plan includes an updated analysis of Berkeley's hazards and their potential impacts. Hazard vulnerabilities identified in Section 3 guide the mitigation strategy presented in Section 1.

General Changes and Updates

The 2014 plan contains numerous updates to facts, figures and descriptions. The City has incorporated the newest-available hazard data, including impact maps for particular scenarios. The City and its partners have provided additional descriptions, details and definitions to explain the science of these hazards and their potential impacts.

Advances in GIS mapping technology have enabled the City to present maps that help to visualize information. The City has overlaid multiple related hazards with Berkeley's buildings and infrastructure to demonstrate structural hazard exposure and vulnerabilities.

Institutional community partners have updated information regarding their vulnerabilities to the described hazards, as well as significant mitigation activities that they have completed, in progress, or planned for the coming five years.

Within the historical section for each hazard, the City has added information about any instances of the hazard affecting Berkeley since 2004. Throughout the plan, the City has updated 2004 financial loss estimates for inflation.

Appendix A describes Berkeley's progress on the hazard mitigation actions identified in 2004. It also identifies where and how the City incorporated select 2004 actions and activities into this 2014 plan.

Hazards Described in the 2014 Plan

The 2014 plan now specifically highlights Berkeley's two hazards of greatest concern as earthquake and wildland-urban interface (WUI) fire. These two hazards are underscored because of their history in Berkeley, our community's extensive exposure and many vulnerabilities to these hazards, and the cascading impacts that could result from one of these hazards.

For the first time, the plan identifies tsunami and climate change as hazards of concern.

Significant changes and updates to the analysis of each hazard are described below:

Earthquakes (Section 3.3)

- Three new Hayward Fault earthquake scenario maps illustrate the Bay Area's exposure to seismic shaking, and Berkeley's exposure to liquefaction and seismically-triggered landslides.
- A new map overlays the areas of Berkeley potentially exposed to liquefaction, fault rupture and earthquake-induced landslides. The City has overlaid Berkeley's vulnerable structures on this base map, demonstrating where vulnerable buildings have been constructed on ground that could possibly liquefy, rupture or slide in an earthquake.
- The City addresses seismically-triggered landslides, their cause and their potential impacts in additional detail. The 2014 plan also contains a new scenario map for seismically-triggered landslide.
- The 2014 plan addresses fire following earthquake in greater detail: the plan describes significant fires resulting from past earthquakes, causes of fire following earthquake, and how earthquake impacts can impede firefighting efforts and promote fire spread. The estimated number of fires following a scenario earthquake has been updated based on new scientific research, from five ignitions to 6-12[iii] ignitions in the first day.
- The seismic stability of City-owned and leased buildings has been updated to reflect significant retrofit efforts since 2004. (This information is provided in greater detail in *Appendix B: List of City Owned and Leased Buildings*.)
- The City has updated the plan to describe Berkeley's progress on mitigating earthquake vulnerabilities in soft-story buildings. Data gathered through the City's 2005 soft-story ordinance (Phase I) are used to describe the ordinance's impacts on retrofit activities, as well as the current number and locations of soft-story buildings in Berkeley.
- The City describes locations and seismic vulnerabilities to gas systems in greater detail. Pacific Gas & Electric natural gas transmission lines, and Kinder Morgan's jet fuel/diesel pipelines are overlaid on the seismic hazard planning zone map to illustrate their potential earthquake liquefaction exposure.
- Earthquake risk and loss estimates have been updated to include data from a 2008 catastrophic earthquake incident scenario. The 2008 report uses a more severe scenario earthquake than the City used to establish risk and loss estimates in 2004. The 2008 scenario also includes additional information about potential impacts to partner systems at a greater level of detail than was available for the 2004 plan.

Wildland-Urban Interface Fire (Section 3.4)

- This plan redefines Berkeley's 2004 "wildfire" hazard as the "wildland-urban interface" fire hazard. The "WUI" term more specifically describes the fire hazard present in the Berkeley hills, in which natural and built environments meet and intermix. This change of perspective and associated terminology aligns Berkeley's 2014 plan with the State of California Hazard Mitigation Plan.

- The 2014 plan describes the potential for a WUI fire to spread to Berkeley's flatlands, clarifying that WUI fire is a citywide concern. The 2014 plan provides additional detail on the particular vulnerabilities of Panoramic Hill residents and visitors.
- The City has provided information about Berkeley's four vegetation management programs reducing Berkeley's fire risk, and its partnership with the Berkeley Path Wanderers Association to maintain and improve the rustic paths in the hills, which also serve as pedestrian evacuation routes.

Rainfall-Triggered Landslide (Section 3.5)

- Rainfall-triggered landslide is addressed separately of earthquake-induced landslide. Additional information has been provided to describe rainfall-triggered landslide and debris flow, and Berkeley's exposure and vulnerabilities to historic or recent deep-seated landslides.

Floods (Section 3.6)

- The floods section has been rewritten for clarity. The 2014 plan also provides additional information about floods caused by storm drain overflow. Hydraulic models created in 2011 identify key intersections in Berkeley that are exposed to flooding from storm drain overflow.

Tsunami (Section 3.7)

- Tsunami is a newly-introduced hazard of concern for the 2014 plan. The tsunami section describes recent tsunami events and their impacts on Berkeley. It outlines the latest information about the tsunami hazard within the San Francisco Bay, and provides an inundation map showing Berkeley's tsunami exposure. The City identifies populations, businesses, roadways, City buildings and other infrastructure within the tsunami inundation zone, and discusses potential evacuation challenges.

Climate Change (Section 3.8)

- Climate change is a newly-introduced hazard of concern for the 2014 plan. The climate change section describes the anticipated impacts to Berkeley from climate change. It also outlines how climate change exacerbates other hazards identified in this plan. The City discusses potential impacts from sea-level rise on Berkeley's western coast, and maps areas in Berkeley that are vulnerable in 55-inch sea-level rise.

Hazardous Materials Release (Section 3.9)

- This plan provides greater detail regarding Berkeley's exposure and vulnerability to hazardous materials release. The City's classification system for Berkeley's hazardous materials sites is described.
- This section includes a map that visualizes sites with sufficiently large quantities of toxic chemicals to pose a high risk to the community, along with key transportation routes used for hazardous materials in Berkeley. This map also includes areas of Berkeley exposed to earthquake-induced ground failure and flooding. By layering this information, readers can visualize how Berkeley's natural hazards could cause a hazardous materials release.

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[1] Analyses by the US Geologic Survey (USGS) and California Earthquake Prediction Evaluation Council: http://pubs.usgs.gov/fs/2008/3027/fs2008-3027.pdf

[ii] City of Berkeley. *Fire Hazard Mitigation Plan*. February 25, 1992.

[iii] Estimation derived from Ch. 10, particularly Eqn. 10-1, of HAZUS Earthquake Tech Manual MR 4:

FEMA, 2003. Multi-hazard Loss Estimation Methodology, Earthquake Model, HAZUS-MH MR4 Technical Manual. Developed by: Department of Homeland Security, Federal Emergency Management Agency, Mitigation Division, Under a contract with: National Institute of Building Sciences Washington, D.C., p. 712.

1 Mitigation Strategy

Berkeley aims to be a disaster-resilient community that can survive, recover from, and thrive after a disaster while maintaining its unique character and way of life. Berkeley envisions a community in which the people, buildings, and infrastructure, in and serving Berkeley, are resilient to disasters; City government provides critical services in the immediate aftermath of a devastating event of any kind; and basic government and commercial functions resume within thirty days of a damaging earthquake or other significant event.

Disaster mitigation reduces or eliminates long-term risks to people and property from hazards and their effects, and/or provides passive protection at the time of disaster impact.[i] Disaster mitigation is a foundational element of disaster resilience.

Section 1 of this plan outlines Berkeley's mitigation strategy, and how it connects to Berkeley's disaster resilience vision. The strategy identifies and analyzes a comprehensive range of specific mitigation actions and activities being considered to reduce the effects of each hazard described in Section 3: Hazard Analysis. It is based on existing authorities, policies, programs, and resources described in Section 4 of this plan, as well as Berkeley's ability to expand on and improve these existing mitigation tools.

1.1 *Disaster Mitigation Approaches and Objectives*

Berkeley will focus on three approaches to disaster mitigation to reach this level of resilience:

1. The City will evaluate and strengthen all City-owned structures, particularly those needed for critical services, to ensure that the community can be served adequately after a disaster.
2. The City will establish and maintain incentive programs and standards to encourage local residents and businesses to upgrade the hazard resistance of their own properties.
3. The City will actively engage other local and regional groups to collaboratively work towards mitigation actions that help maintain Berkeley's way of life and its ability to be fully functional after a disaster event.

Four objectives guide the mitigation strategy:

A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquakes, wildfires, landslides, floods, tsunamis, climate change, and their secondary impacts.
B. Increase the ability of the City government to serve the community during and after hazard events by mitigating risk to key city functions such as response, recovery and rebuilding.
C. Protect Berkeley's unique character and values from being compromised by hazard events.
D. Encourage mitigation activities to increase the disaster resilience of institutions, private companies and lifeline systems that are essential to Berkeley's functioning.

1.1.1 Links to City Plans

This plan is part of an ongoing process to build Berkeley's disaster resilience. The Berkeley community has invested considerable financial investment in risk reduction activities, including planning for and implementing mitigation activities.

The City's long-standing commitment and approach to community safety and disaster resilience is demonstrated in the General Plan. The General Plan, revised in 2002, directly guides the objectives and actions in this plan. One of the General Plan's major goals is to make Berkeley a disaster-resilient community. Berkeley put significant effort into developing the City's Disaster Preparedness and Safety Element of the General Plan, and disaster issues are also addressed in other elements, including the Land Use, Environmental Management, Transportation and Urban Design and Preservation Elements. The objectives in this mitigation plan are guided by the major goals of the General Plan and the objectives of the Disaster Preparedness and Safety Element. Many of the actions in this plan are directly taken from the Disaster Preparedness and Safety Element. Section 1.2.4 *Details of Actions* identifies specific General Plan Policies guiding this mitigation strategy.

The Berkeley Climate Action Plan was written through a community-wide process and was adopted by City Council on June 2, 2009. The Plan outlines a vision, goals and policies to reduce community-wide greenhouse gas emissions by 33 percent below 2000 levels. Because climate change impacts can cause or exacerbate many of Berkeley's hazards of concern, the mitigation strategy has also been directly guided by the Climate Action Plan. Section 1.2.4 *Details of Actions* identifies the Climate Action Plan Policies guiding the mitigation strategy.

Section 1.2.4 *Details of Actions*, as well as Section 2: *Implementing, Monitoring and Updating the Plan* identify how the data, information, goals and actions from this mitigation plan are integrated into other planning mechanisms.

1.2 *Mitigation Actions*

This plan advocates 23 mitigation actions. Table 1.1 summarizes all of the actions, identifies the hazard(s) and mitigation objective(s) each action addresses, and indicates the assigned priority level of the action.

1.2.1 Identification of Actions

Plan actions were developed through a multi-step, broadly-inclusive process. The City convened an interdepartmental planning team, which reviewed the actions identified in the 2004 mitigation plan, as well as Berkeley's progress since 2004 on these actions. This Team then revised these actions, created new actions, and established priorities to guide Berkley's mitigation strategy for the next five years. At a meeting in October 2013, staff presented the 2014 actions to Institutional Community Partners from utilities, educational institutions, community-based organizations and other cities and government agencies. Partners offered feedback and identified opportunities for collaboration to further strengthen these actions. Staff revised actions and incorporated them into the 2014 First Draft Plan Update, which went through further public review before adoption.

Additional detail on the process used to identify 2014 actions is provided in Appendix C: *Plan Development Process*.

1.2.2 Prioritization of Actions

The City's Interdepartmental Planning Team assigned 2014 actions a *High, Medium* or *Low* priority level. Eight key factors were used to determine each action's priority:

1. Support of goals and objectives
2. Cost/benefit relationship
3. Funding availability
4. Hazards addressed
5. Public and political support
6. Adverse environmental impact
7. Environmental benefit
8. Timeline for completion

Institutional Community Partners, community members, City staff, Council members, commissioners, and other stakeholders reviewed these categorizations in City staff meetings, the Institutional Community Partner Meeting, commission meetings, and a City Council meeting.

Additional detail on the structure used to prioritize actions is provided in Appendix E: *Prioritization Structure*.

1.2.3 Overview of Mitigation Actions

Actions supporting Berkeley's mitigation strategy are outlined in the tables that follow, grouped by their priority level.

Table 1.1 High-Priority Actions in mitigation strategy

Name	Action	Hazards
Building Assessment	Perform appropriate seismic and fire safety analysis based on current and future use for all City-owned facilities and structures.	Earthquake Wildland-Urban Interface Fire Tsunami Landslide Floods Climate Change
Strengthen and Replace City Buildings	Strengthen or replace City buildings in the identified prioritized order as funding is available.	Earthquake Wildland-Urban Interface Fire Tsunami Landslide Floods Climate Change

Name	Action	Hazards
Soft-Story	Implement Phase Two of the Soft-Story Retrofit Program, mandating retrofit of soft-story residences.	Earthquake
URM	Complete the ongoing program to retrofit all remaining non-complying Unreinforced Masonry (URM) buildings.	Earthquake
Buildings	Reduce hazard vulnerabilities for non-City-owned buildings throughout Berkeley.	Earthquake Wildland-Urban Interface Fire Landslide Floods
Fire Code	Reduce fire risk in existing development through fire code updates and enforcement.	Wildland-Urban Interface Fire
Vegetation Management	Reduce fire risk in existing development through vegetation management.	Wildland-Urban Interface Fire
Hazard Information	Collect, analyze and share information with the Berkeley community about Berkeley hazards and associated risk reduction techniques.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change
Partnerships	Ensure that the City provides leadership and coordinate with the private sector, public institutions, and other public bodies in disaster mitigation.	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change
EBMUD	Work with EBMUD to ensure an adequate water supply during emergencies and disaster recovery.	Earthquake Wildland-Urban Interface Fire

Name	Action	Hazards
Hills Evacuation	Manage and promote pedestrian evacuation routes in Fire Zones 2 and 3.	Earthquake Wildland-Urban Interface Fire
Climate Change Integration	Mitigate climate change impacts by integrating climate change research and adaptation planning into City operations and services.	Climate Change

Table 1.2 Medium-Priority Actions in mitigation strategy

Name	Action	Hazards
Energy Assurance	Develop an Energy Assurance Plan for City operations.	Earthquake Wildland-Urban Interface Fire Tsunami Landslide Floods Climate Change
Gas Safety	Improve the disaster-resistance of the natural gas delivery system to increase public safety and to minimize damage and service disruption following a disaster.	Earthquake Wildland-Urban Interface Fire Landslide Tsunami
Stormwater System	Rehabilitate the City's stormwater system to reduce local flooding caused by inadequate storm drainage.	Earthquake Floods Landslide Tsunami Climate Change
Tsunami	Define and mitigate Berkeley's tsunami hazard.	Tsunami
Extreme Heat	Reduce Berkeley's vulnerability to extreme heat events and associated hazards.	Climate Change
Severe Storms	Reduce Berkeley's vulnerability to severe storms and associated hazards.	Climate Change Flooding

Name	Action	Hazards
Water Security	Collaborate with local, State, regional and federal partners to increase the security of Berkeley's water supply from climate change impacts.	Climate Change
NFIP	Maintain City participation in the National Flood Insurance Program.	Floods
Streamline Rebuild	Streamline the zoning permitting process to rebuild residential and commercial structures following disasters.	Earthquake Floods Landslide Tsunami

Table 1.3 Low-Priority Actions in mitigation strategy

Name	Action	Hazards
Sea-Level Rise	Mitigate the impacts of sea-level rise in Berkeley.	Climate Change
HazMat Floods	Explore local legislation to require hazardous materials stored in the flood zones to be elevated or otherwise protected from floodwaters.	Floods Climate Change

1.2.4 Details of Actions

Mitigation actions identified by the Berkeley community are presented in the following pages. Actions are presented per their high, medium- or low-priority designation.

The following information is provided for each action:

- *Action Title*: Short title to identify the action
- *Action*: Proposed action
- *Proposed Activities*: Specific projects or efforts that support the action
- *Related Natural Hazard(s)*: Lists hazards whose impacts would be mitigated by the action
- *Associated LHMP Objective(s)*: Mitigation objectives that the action supports
- *Related Policies from the General Plan or Climate Action Plan*: General Plan or Climate Action Plan policies that the action supports
- *Special Environmental Concerns*: Particular considerations that will be taken into account when the action is implemented
- *Lead Organization(s) and Staff Lead(s)*: City departments and divisions, along with particular City staff positions that will lead implementation of the action
- *Priority*: High, Medium or Low priority assigned to the action using criteria outlined in Appendix E: *Prioritization Structure*
- *Timeline*: Timeline and milestones to implement the action
- *Additional Resources Required*: Identifies if funding is not yet available to complete the action
- *Potential Funding Sources*: Identifies potential funding sources to complete the action. Includes all sources that could possibly fund any element of the action: staff time, vendor contracts, equipment purchase, etc. **Funding allocations are made through the Citywide budget process. Listing a specific potential funding source <u>does not</u> commit resources to the action.**
    - *Activity Type(s)*: If the action could be eligible for federal mitigation grant funding, identifies federally-defined activity type for grant purposes

Appendix A: *2004 Actions* documents progress on 2004 actions.

1.2.4.1 High-Priority Actions

2014 **Building Assessment**	**Perform appropriate seismic and fire safety analysis based on current and future use for all City-owned facilities and structures.**
Proposed Activities	- First, complete analysis of structures supporting critical emergency response and recovery functions, and make recommendations for structural and nonstructural improvements. - Prioritize analysis of remaining structures based on occupancy and structure type, taking historic significance into consideration. Use analysis to make recommendations for structural and nonstructural improvements. - Integrate unsafe structures into a prioritized program for retrofit or replacement. - Develop emergency guidelines for buildings with structural deficiencies.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Tsunami Landslide Floods Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards. B. Increase City government's ability to serve the community during disaster response and recovery by mitigating risks to key buildings and infrastructure.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-10, Action B General Plan Policy S-20, Actions G and H General Plan Policy UD-7, Actions A and B General Plan Policy UD-12, Actions A and C
Lead Organization and Staff Lead	Public Works Department: Facilities Division Staff Lead: Facility Maintenance Superintendent
Priority	High

Timeline	Analysis of critical structures: December 2013 Analysis of remaining structures: Funding-dependent Emergency guideline development: Ongoing as identified
Additional Resources Required	Funding for analysis of remaining structures: Dependent upon progress of critical structure analysis Funding for emergency guideline development: consultant and staff time, dependent upon the number of identified buildings
Potential Funding Sources	Analysis of critical structures: multiple City funds Potential sources for other projects: City General Fund, grants, other City funds

2014 **Strengthen and Replace City Buildings**	**Strengthen or replace City buildings in the identified prioritized order as funding is available.**
Proposed Activities	- Seismically strengthen 2180 Milvia Civic Center - Replace the Center Street Garage - Seek funding to seismically strengthen or replace additional City buildings in a prioritized order
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Tsunami Landslide Floods Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards. B. Increase City government's ability to serve the community during disaster response and recovery by mitigating risks to key buildings and infrastructure. C. Protect Berkeley's unique character and values from being compromised by hazard events.
Related Policies	General Plan Policy S-20, Action H

from the General Plan or Climate Action Plan	General Plan Policy UD-12, Actions A and C
Special Environmental Concerns	All construction activities recommended in this action will preserve historic character of buildings, take measures to control air quality and limit noise during construction.
Lead Organization and Staff Lead	Public Works Department – Engineering Division Staff Lead: Supervising Civil Engineer
Priority	High
Timeline	2180 Milvia Civic Center retrofit by 2019 Center Street Garage replacement by 2019 Funding identification: Ongoing
Additional Resources Required	2180 Milvia Civic Center retrofit: $1 million Center Street Garage replacement: $30 million (est.) Old City Hall retrofit: $30 million Veterans Memorial Building retrofit: $20 million
Potential Funding Sources	Legislative Pre-Disaster Mitigation grant funding Pre-Disaster Mitigation Grant Program (PDM) Hazard Mitigation Grant Program (HMGP) General Fund City-Issued Bonds
Activity Type(s)	Mitigation: Structural Retrofitting of existing buildings Mitigation: Nonstructural retrofitting of existing buildings and facilities

2014 **Soft-Story**	**Implement Phase Two of the Soft-Story Retrofit Program, mandating retrofit of soft-story residences.**
Proposed Activities	- Develop and publish Framework Guidelines calibrating, delineating and detailing technical requirements to be used for building retrofits. - Inform impacted property owners of the requirement to retrofit their building - Designated project manager will: • Prepare handouts and correspondence • Respond to inquiries from owners, tenants, engineers, contractors and realtors about the mandatory program, compliance procedures and

	requirements - Investigate and adopt financial, procedural, and land use incentives to facilitate retrofit. • The Rent Board will review requests for pass-through of capital improvement expenses for seismic retrofits. They will determine on a case-by-case basis if rent increases to tenants can be approved. • Explore establishment of a loan program to assist landlords who cannot access financing to retrofit their buildings. - Review plan submittals for soft-story seismic retrofits - Issue permits and perform field inspections - Remove retrofitted buildings from the Soft-Story Inventory - Review appeals to accommodate unique circumstances preventing owners from meeting program requirements; consider time extensions, etc.
Related Natural Hazard(s)	Earthquake
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards. C. Protect Berkeley's unique character and values from being compromised by hazard events.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-20, Actions B, C, D, E, and F General Plan Policy S-15, Action A
Special Environmental Concerns	All building upgrade activities will include efforts to minimize impacts to existing residential and commercial tenants, and historic resources.
Lead Organization and Staff Lead	Planning Department – Building and Safety Division Staff Lead: Program and Administration Manager
Priority	High
Timeline	January 2017: Deadline for soft-story owners to submit a permit application for retrofit January 2019: Final deadline for soft-story retrofit completion (2 years after permit application)

Additional Resources Required	Additional $20-30k required for structural engineering firm to develop Framework Guidelines
Potential Funding Sources	City General Fund Permit Service Center Enterprise Fund Rental Housing Safety Program Fund

2014 **URM**	**Complete the ongoing program to retrofit all remaining non-complying Unreinforced Masonry (URM) buildings.**
Proposed Activities	- Begin by working with owners of remaining potentially hazardous URM buildings to obtain structural analyses of their buildings and to undertake corrective mitigation measures to improve seismic resistance or to remove the buildings and replace them with safer buildings. - Apply available legal remedies, including but not limited to citations, to owners who fail to comply with the URM ordinance. - Maintain program notification to building occupants and owners.
Related Natural Hazard(s)	Earthquake
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-20, Action A
Special Environmental Concerns	All building upgrade activities will include efforts to minimize impacts to existing residential and commercial tenants, and historic resources.
Lead Organization and Staff Lead	Planning Department - Building and Safety Division Staff Lead: Program and Administration Manager
Priority	High
Timeline	Engage all remaining URM building owners by January 2015 Complete all remaining URM retrofits/demolitions by

	January 2019
Additional Resources Required	No additional resources required
Potential Funding Sources	Permit Service Center Enterprise Fund Rental Housing Safety Program Fund

2014 **Buildings**	**Reduce hazard vulnerabilities for non-City-owned buildings throughout Berkeley.**
Proposed Activities	- Periodically update and adopt the California Building Standards Code with local amendments to incorporate the latest knowledge and design standards to protect people and property against known seismic, fire, flood and landslide risks in both structural and non-structural building and site components. - Explain requirements and provide guidance to owners of potentially hazardous structures to facilitate retrofit.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Floods
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards. C. Protect Berkeley's unique character and values from being compromised by hazard events.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-15, Action A General Plan Policy S-20, Actions D and E General Plan Policy UD-7, Actions A and B General Plan Policy UD-12, Actions A and C
Special Environmental Concerns	All building upgrade activities will include efforts to minimize impacts to existing residential and commercial tenants, and historic resources.
Lead Organization and Staff Lead	Planning Department – Building and Safety Division Staff lead: Building Official
Priority	High

Timeline	Enactment of 2013 Building Code: January 1, 2014 Enactment of 2016 Building Code: January 1, 2017 Technical assistance: Ongoing
Additional Resources Required	No additional resources required
Potential Funding Sources	Permit Service Center Enterprise Fund

2014 **Fire Code**	**Reduce fire risk in existing development through fire code updates and enforcement.**
Proposed Activities	- Periodically update and adopt the Berkeley Fire Code with local amendments to incorporate the latest knowledge and design standards to protect people and property against known risks in both structural and non-structural building and site components. - Maintain Fire Department efforts to reduce fire risk through inspections: • Annual inspections in all Fire Zones • Hazardous Fire Area inspections • Multi-unit-residential building inspections in all Fire Zones - Create a standard for written vegetation management plans for major construction projects in Fire Zones 2 and 3. - Evaluate inspection procedures and adjust inspection cycle annually based on changing climatic conditions.
Related Natural Hazard(s)	Wildland-Urban Interface Fire
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards. C. Protect Berkeley's unique character and values from being compromised by hazard events.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-21: Fire Preventative Design Standards, Action A General Plan Policy S-23: Property Maintenance, Action B General Plan Policy UD-7, Actions A and B

	General Plan Policy UD-12, Actions A and C
	Climate Action Plan – Adaptation, Goal 1D, Action 3
Lead Organization and Staff Lead	Fire Department – Division of Fire Prevention Staff Lead: Deputy Fire Chief (Fire Marshal)
Priority	High
Timeline	Fire Code Adoption: Complete by January 2014 and January 2017
	Inspections: Ongoing
	Vegetation Management Standard: 1-2 years
	Inspection system evaluation: Ongoing
Additional Resources Required	No additional resources required
Potential Funding Sources	City General Fund

2014 **Vegetation Management**	**Reduce fire risk in existing development through vegetation management.**
Proposed Activities	- Maintain Fire Fuel Chipper Program - Maintain Fire Fuel Abatement Program on Public Land - Maintain Fire Fuel Debris Bin Program - Maintain Weekly Curbside Plant Debris Collection - Pursue external funding to increase education and awareness of vegetation management standards for fire fuel reduction
Related Natural Hazard(s)	Wildland-Urban Interface Fire
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-23, Action A.
Special Environmental	All activities occurring in biologically sensitive areas will include measures to protect sensitive habitats and species.

Concerns	
Lead Organization and Staff Lead	Department of Parks Recreation and Waterfront – Parks Division Fire Fuel Chipper Program Staff Lead: Senior Forestry Supervisor Fire Fuel Abatement Program on Public Land Staff Lead: Senior Landscape Supervisor Department of Public Works – Zero Waste Division (Fire Fuel Debris Bin Program and Weekly Curbside Plant Debris Collection) Staff Lead: Zero Waste Manager Fire Department – Division of Support Services (Funding for education) Staff Lead: Deputy Fire Chief (Fire Marshal)
Priority	High
Timeline	Ongoing
Additional Resources Required	Fire Fuel Chipper Program: Additional resources required, amount to be determined Fire Fuel Abatement Program on Public Land: Additional resources required, amount to be determined Fire Fuel Debris Bin Program and Weekly Curbside Plant Debris Collection: No additional resources required
Potential Funding Sources	City General Fund Refuse Fee City Parks Tax Fund 450 Pre-Disaster Mitigation Grant Program (PDM) Hazard Mitigation Grant Program (HMGP) Assistance to Firefighters Grant
Activity Type(s)	Mitigation: Hazardous Fuels Reduction

2014 **Hazard Information**	**Collect, analyze and share information with the Berkeley community about Berkeley hazards and associated risk reduction techniques.**
Proposed Activities	- Track changes in hazard risk using the best-available information and tools. - Collect and share up-to-date hazard maps identifying

	areas subject to heightened risk from hazards. - Partner with the Association of Bay Area Governments to incorporate Berkeley's vulnerabilities onto regionally-managed hazard maps. - Publicize financial and technical assistance resources for risk reduction.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards. B. Increase City government's ability to serve the community during disaster response and recovery by mitigating risks to key buildings and infrastructure. C. Protect Berkeley's unique character and values from being compromised by hazard events. D. Encourage mitigation activities to increase the disaster resilience of institutions, private companies and lifeline systems that are essential to Berkeley's functioning.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-13: Hazards Identification, Action A General Plan Policy S-19: Risk Analysis, Action A General Plan Policy UD-12, Actions A and C Climate Action Plan: Adaptation Action A
Lead Organization and Staff Lead	Fire Department – Office of Emergency Services Lead Staff: Emergency Services Coordinator Office of Energy and Sustainable Development (Climate Change Hazards) Lead Staff: Climate Action Coordinator
Priority	High

Timeline	Ongoing
Additional Resources Required	No additional resources required
Potential Funding Sources	General Fund Measure GG Special Revenue Fund

2014 **Partnerships**	**Ensure that the City provides leadership and coordinate with the private sector, public institutions, and other public bodies in disaster mitigation.**
Proposed Activities	- Support and encourage efforts undertaken by key lifeline providers to plan for and finance seismic retrofit and other disaster-resistance measures, including: • Utility providers • Transportation agencies • Communication providers • Healthcare facilities - Coordinate with and encourage mitigation actions of: • Institutions serving the Berkeley community • Berkeley organizations and nonprofits • Other partners whose actions affect the Berkeley community
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards. B. Increase City government's ability to serve the community during disaster response and recovery by mitigating risks to key buildings and infrastructure. C. Protect Berkeley's unique character and values from being compromised by hazard events. D. Encourage mitigation activities to increase the

	disaster resilience of institutions, private companies and lifeline systems that are essential to Berkeley's functioning
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-5 The City's Role in Leadership and Coordination, Actions A and B General Plan Policy UD-7, Actions A and B General Plan Policy UD-12, Actions A and C General Plan Policy S-12 Utility and Transportation Systems, Action A
Lead Organization and Staff Lead	City Manager's Office (Advocacy) Staff Lead: Deputy City Manager Fire Department – Office of Emergency Services (Coordination) Staff Lead: Office of Emergency Services Captain
Priority	High
Timeline	Ongoing
Additional Resources Required	To be determined
Potential Funding Sources	City General Fund Measure GG Special Revenue Fund

2014 **EBMUD**	**Work with EBMUD to ensure an adequate water supply during emergencies and disaster recovery.**
Proposed Activities	- Coordinate with EBMUD regarding plans to install a new 48-inch pipeline parallel to the existing north-south water main in 2015-2016. - Explore project approaches with EBMUD to expedite replacement of problem pipelines in Berkeley neighborhoods exposed to wildland-urban interface fire and seismic ground failure. - Coordinate with EBMUD to ensure that pipeline replacement projects and upgrades are coordinated with the City's five-year street paving program.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and

	businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards. D. Encourage mitigation activities to increase the disaster resilience of institutions, private companies and lifeline systems that are essential to Berkeley's functioning.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-12: Utility and Transportation Systems, Action A
Special Environmental Concerns	All activities occurring in biologically sensitive areas will include measures to protect sensitive habitats and species.
Lead Organization and Staff Lead	Department of Public Works – Engineering Division Staff Lead: City Engineer
Priority	High
Timeline	Ongoing
Additional Resources Required	No additional funding required
Potential Funding Sources	City General Fund and Other City Funds Pre-Disaster Mitigation Grant Program (PDM) Hazard Mitigation Grant Program (HMGP)
Activity Type(s)	Mitigation: Infrastructure Retrofit

2014 **Hills Evacuation**	**Manage and promote pedestrian evacuation routes in Fire Zones 2 and 3.**
Proposed Activities	- Ensure that all public pathways and associated signage are maintained to identify and provide safe and accessible pedestrian evacuation routes from the hill areas. - Update City maps of all emergency access and evacuation routes to include pedestrian pathways. - Coordinate with UC Berkeley and Berkeley Lab to ensure that evacuation route options account for paths on UC and Berkeley Lab property. - Publicize up-to-date maps of all emergency access and evacuation routes.

Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-1 Response Planning, Action B General Plan Policy S-22 Fire Fighting Infrastructure, Action A General Plan Policy T-28 Emergency Access, Actions B and C
Special Environmental Concerns	All activities occurring in biologically sensitive areas will include measures to protect sensitive habitats and species.
Lead Organization and Staff Lead	Department of Public Works – Engineering Division (Maintenance) Public Works Staff Lead: Associate Civil Engineer Information Technology GIS Division (Mapping) IT Staff Lead: GIS Coordinator Fire Department Office of Emergency Services (Outreach) Fire-OES Staff Lead: Emergency Services Coordinator
Priority	High
Timeline	Maintenance: Ongoing Mapping: 1 year to include pathways in public maps, then ongoing updates Publicizing Maps: Ongoing
Additional Resources Required	No additional resources required
Potential Funding Sources	City General Fund Measure GG Special Revenue Fund

2014 **Climate Change Integration**	**Mitigate climate change impacts by integrating climate change research and adaptation planning into City operations and services.**
Proposed Activities	- Determine staffing needs to monitor research and oversee integration of climate change adaptation into City operations and services - Develop and implement a process to integrate adaptation planning into City operations. Activities include: • Integrate climate change adaptation actions into the Citywide Work Plan • Integrate climate change adaptation considerations into templates for staff reports to City Council and City commissions • Train City staff on the basic science and impacts of climate change and on climate adaptation strategies • Develop a staff recognition and award program to encourage staff to integrate climate change considerations into City projects and programs
Related Natural Hazard(s)	Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards.
Related Policies from the General Plan or Climate Action Plan	• Climate Action Plan – Adaptation, Goal 1A • Climate Action Plan – Community Outreach and Empowerment, Goal 1A • Climate Action Plan – Implementation, Monitoring and Reporting, Goals 2, 3 and 4
Lead Organization and Staff Lead	City Manager's Office through Sustainability Working Group (Process Management) Staff Lead: Deputy City Manager Planning Department – Office of Energy and Sustainable Development (Support) Staff Lead: Climate Action Coordinator
Priority	Medium
Timeline	Staffing: 2-3 years

	Work Plan Integration: 1 year Council/Commission Report Integration: 1 year Funding Mechanisms: 2-3 years Staff Training: 2-3 years
Additional Resources Required	To be determined
Potential Funding Sources	City General Fund Permit Service Center Enterprise Fund

1.2.4.2 Medium-Priority Actions

2014 **Energy Assurance**	**Develop an Energy Assurance Plan for City operations.**

Proposed Activities	- Develop a plan to assist the City of Berkeley to prepare for, respond to, and recover from disasters that include energy emergencies.
	  • Identify the key City facilities that support emergency operations.
	  • Estimate those facilities' energy supply and demand during emergencies to assess those facilities' vulnerabilities to power loss.
	  • Identify potential actions to mitigate those vulnerabilities (e.g., photovoltaic-supplemented emergency generation, energy efficiency activities, and/or mobile charging stations).
	- Integrate energy assurance actions into Citywide planning processes.

Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards.

	B. Increase City government's ability to serve the community during disaster response and recovery by mitigating risks to key buildings and infrastructure.
Related Policies from the General Plan or Climate Action Plan	General Plan - Disaster Preparedness and Safety Element: Objective 1 General Plan Policy S-8: Continuity of Operations Climate Action Plan – Chapter 4, Goal 5: Increase Energy Efficiency and Renewable Energy Use in Public Buildings – Policies 5a and 5b
Lead Organization and Staff Lead	Fire Department – Office of Emergency Services (Plan Development and Gap Analysis) Staff Lead: Emergency Services Coordinator Planning Department – Office of Energy and Sustainable Development (Energy Profile) Staff Lead: Sustainability Outreach Specialist Department of Public Works – Facilities Division (City Infrastructure) Staff Lead: Facility Maintenance Superintendent
Priority	Medium
Timeline	Plan Development: 1 year Project implementation: To be determined
Additional Resources Required	No additional resources required to develop plan. Resources required to implement plan proposals is to be determined.
Potential Funding Sources	City General Fund Measure GG Special Revenue Fund Various State funds

2014 **Gas Safety**	**Improve the disaster-resistance of the natural gas delivery system to increase public safety and to minimize damage and service disruption following a disaster.**
Proposed Activities	- Work with the Public Utilities Commission, utilities, and oil companies to strengthen, relocate, or otherwise safeguard natural gas and other pipelines where they extend through areas of high liquefaction potential, cross potentially active faults, or traverse potential landslide areas, or areas that may settle differentially during an

	earthquake. - Establish a program to provide free automatic gas shutoff valves to community members who attend disaster readiness training. Provide subsidized permit fee waivers for low-income homeowners.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Tsunami
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards. D. Encourage mitigation activities to increase the disaster resilience of institutions, private companies and lifeline systems that are essential to Berkeley's functioning.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-12, Action C
Special Environmental Concerns	All activities occurring in biologically sensitive areas will include measures to protect sensitive habitats and species.
Lead Organization and Staff Lead	Fire Department – Office of Emergency Services Staff Lead: Office of Emergency Services Captain (Coordination) Staff Lead: Associate Management Analyst (Shutoff Valve Program)
Priority	Medium
Timeline	Coordination: Ongoing Gas Valve Shutoff Program: July 2014
Additional Resources Required	No additional resources required
Potential Funding Sources	City General Fund Measure GG Special Revenue Fund

2014 **Stormwater System**	**Rehabilitate the City's stormwater system to reduce local flooding caused by inadequate storm drainage.**
Proposed Activities	- Complete the hydraulic analysis of watersheds in the city to predict areas of insufficient capacity. - Seek funding to perform system capacity and disaster resistance improvements.
Related Natural Hazard(s)	Earthquake Floods Landslide Tsunami Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-26, Actions B and C
Special Environmental Concerns	Any non-emergency construction work on the storm drain system will take steps to minimize impacts to riparian habitat.
Lead Organization and Staff Lead	Public Works Department – Engineering Division Staff Lead: Associate Civil Engineer
Priority	Medium
Timeline	Complete the hydraulic analysis: funding-dependent System improvements: funding-dependent
Additional Resources Required	Complete the hydraulic analysis: $200,000 System improvements: $208 million
Potential Funding Sources	City General Fund, bonds Urban Greening Project Grants (Prop. 84) Stormwater–Flooding Management Projects Grants (Prop. 1E) Pre-Disaster Mitigation Grant Program (PDM) Hazard Mitigation Grant Program (HMGP)
Activity Type(s)	Mitigation: Infrastructure Retrofit

2014	**Define and mitigate Berkeley's tsunami hazard.**
Tsunami	
Proposed Activities	- Collaborate with the California Office of Emergency Services to define Berkeley's different areas of inundation for different tsunami scenarios. - Collaborate with the California Office of Emergency Services, the California Geological Survey, and the Federal Emergency Management Agency to document and explore potential tsunami hazard mitigation measures for Berkeley's maritime communities.
Related Natural Hazard(s)	Tsunami
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-13: Hazards Identification General Plan Policy S-19: Risk Analysis, Action A
Special Environmental Concerns	All activities occurring in biologically sensitive areas will include measures to protect sensitive habitats and species.
Lead Organization and Staff Lead	Fire Department – Office of Emergency Services (Scenarios) Staff Lead: Emergency Services Coordinator Parks, Recreation and Waterfront Department – Marina Division (Mitigation Measures) Staff Lead: Waterfront Manager
Priority	Medium
Timeline	Scenarios: 2 years Mitigation Measures: To be determined
Additional Resources Required	Scenarios: No additional resources required Mitigation Measures: To be determined
Potential Funding Sources	City General Fund Measure GG Special Revenue Fund

2014 **Extreme Heat**	**Reduce Berkeley's vulnerability to extreme heat events and associated hazards.**
Proposed Activities	- Monitor and support regional and State-level efforts to forecast the impact of climate change on temperatures and incidence of extreme heat events in Berkeley and the region, and integrate extreme heat event readiness into City operations and services. - Create and maintain shading by sustaining municipal tree planting efforts and continuing to maintain the health of existing trees. - Continue to implement energy efficiency ordinances for existing residential and commercial buildings to improve building comfort, including in extreme weather conditions, and to reduce energy use.
Related Natural Hazard(s)	Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards.
Related Policies from the General Plan or Climate Action Plan	Climate Action Plan - Adaptation Goal 1, Policies A and D General Plan Policy EM-29: Street and Park Trees
Lead Organization and Staff Lead	Planning Department – Office of Energy and Sustainable Development (Monitor Impacts) Staff Lead: Climate Action Coordinator Department of Parks, Recreation and Waterfront – Parks Division (Tree Planting) Staff Lead: Parks Superintendent
Priority	Medium
Timeline	Other Activities: Ongoing
Additional Resources Required	Scientific monitoring: No additional resources required Tree planting: Dependent on State Grant
Potential Funding Sources	City General Fund State Grant City Parks Tax Fund 450

2014 **Severe Storms**	**Reduce Berkeley's vulnerability to severe storms and associated hazards.**
Proposed Activities	- Support and monitor research on climate change impacts on local rainfall patterns and incidences of severe storms. - Integrate considerations of severe storms into City operations and services: • Use development review to ensure that new development does not contribute to an increase in flood potential. • Complete the hydraulic analysis of watersheds in the city to predict areas of insufficient capacity. • Design public improvements such as streets, parks and plazas, for retention and infiltration of stormwater by diverting urban runoff to bio-filtration systems such as greenscapes. • Continue to encourage use of permeable surfaces and other techniques as appropriate in both greenscape and hardscape areas for retention and infiltration of stormwater. • Continue to encourage the development of green roofs by providing local outreach and guidelines consistent with the Building Code.
Related Natural Hazard(s)	Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards.
Related Policies from the General Plan or Climate Action Plan	Climate Action Plan - Adaptation Goal 1, Policies A and C General Plan Policy S-27 New Development
Special Environmental Concerns	Public infrastructure improvements will utilize appropriate environmental review processes.
Lead Organization and Staff Lead	Planning Department – Office of Energy and Sustainable Development Staff Lead: Climate Action Coordinator (Monitor Research) Staff Lead: Sustainability Outreach Specialist (Green Roof outreach)

	Planning Department – Land Use Planning Division (Development Review) Staff Lead: Division Director Department of Public Works – Engineering Division (Watershed Management Plan, Permeable Surfaces, Public Improvements) Staff Lead: Supervising Civil Engineer
Priority	Medium
Timeline	Ongoing
Additional Resources Required	To be determined
Potential Funding Sources	City General Fund Permit Service Center Enterprise Fund Measure M Bond Funds Pre-Disaster Mitigation Grant Program (PDM) Hazard Mitigation Grant Program (HMGP)
Activity Type(s)	Mitigation: Infrastructure Retrofit

2014 **Water Security**	**Collaborate with local, State, regional and federal partners to increase the security of Berkeley's water supply from climate change impacts.**
Proposed Activities	- Support efforts by the U.S. Forest Service and its partners to improve water security through restoration of the Headwaters Forest and Mokelumne River. - Encourage water recycling and gray water use through the distribution of outreach materials and local guidelines that are consistent with the Building Code. - Encourage the use of water conservation technologies and techniques in the design of new buildings and landscapes, such as waterless urinals and cisterns, through the development of local guidelines that are consistent with the Building Code. - Partner with East Bay Municipal Utility District (EBMUD) to provide and market incentives for residents, businesses and institutions to conserve water. - Partner with agencies such as EBMUD and StopWaste.org to encourage private property owners and public agencies (including the City government) to use sustainable landscaping techniques that require less water

	and energy to maintain.
Related Natural Hazard(s)	Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards. D. Encourage mitigation activities to increase the disaster resilience of institutions, private companies and lifeline systems that are essential to Berkeley's functioning.
Related Policies from the General Plan or Climate Action Plan	Climate Action Plan - Adaptation Goal 1, Policy B General Plan Policy EM-25: Groundwater General Plan Policy EM-26: Water Conservation General Plan Policy EM-31: Landscaping
Lead Organization and Staff Lead	City Manager's Office via Sustainability Working Group (Partner Support) Staff Lead: Deputy City Manager Planning Department – Office of Energy and Sustainable Development Staff Lead: Climate Action Coordinator (Community Awareness) Staff Lead: Sustainability Outreach Specialist (Water Recycling/Incentives) Staff Lead: Sustainability Coordinator (Guidelines and Landscaping)
Priority	Medium
Timeline	Ongoing
Additional Resources Required	No additional resources required
Potential Funding Sources	City General Fund Permit Service Center Enterprise Fund

2014 **NFIP**	**Maintain City participation in the National Flood Insurance Program.**
Proposed Activities	- Continue to update and revise flood maps for the City. - Continue to incorporate FEMA guidelines and suggested activities into City plans and procedures for managing flood hazards.
Related Natural Hazard(s)	Floods
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards. B. Increase City government's ability to serve the community during disaster response and recovery by mitigating risks to key buildings and infrastructure. D. Encourage mitigation activities to increase the disaster resilience of institutions, private companies and lifeline systems that are essential to Berkeley's functioning.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-28 Flood Insurance, Actions B and C
Special Environmental Concerns	All activities occurring in biologically sensitive areas will include measures to protect sensitive habitats and species. Any non-emergency construction work on the storm drain system will take steps to minimize impacts to riparian habitat. All activities will take steps to minimize impacts to historic resources to the extent feasible.
Lead Organization and Staff Lead	Public Works – Engineering Division Staff Lead: Supervising Civil Engineer
Priority	Medium
Timeline	Ongoing
Additional Resources Required	No additional resources required

2014 **Streamline Rebuild**	**Streamline the zoning permitting process to rebuild residential and commercial structures following disasters.**
Proposed Activities	- Explore a Zoning Amendment to BMC 23C.04.100 that streamlines the Zoning permitting process to allow industrial and commercial buildings, and multiple-family dwellings to rebuild by right following disasters. Consider different treatment for buildings in high-risk areas, such as: • Imposing higher standards of building construction for rebuilding • Excluding buildings in these areas from the amendment - Define the standard for documentation of current conditions for residential and commercial property owners to rebuild by right (in conformity with current applicable codes, specifications and standards) following disasters. - Define the process for the City to accept and file this documentation. - Outreach to property owners about this documentation process.
Related Natural Hazard(s)	Earthquake Wildland-Urban Interface Fire Landslide Floods Tsunami
Associated LHMP Objective(s)	C. Protect Berkeley's unique character and values from being compromised by hazard events
Related Policies from the General Plan or Climate Action Plan	General Plan Policy LU-26: Neighborhood Commercial Areas General Plan Policy LU-27: Avenue Commercial Areas General Plan S-9: Pre-Event Planning, Action B General Plan policy UD-7, Action C
Lead Organization and Staff Lead	Planning Department – Land Use Planning Division Staff Lead: Division Director
Priority	Medium
Timeline	1 year
Additional	To be determined

Resources Required	
Potential Funding Sources	City General Fund Permit Service Center Enterprise Fund

1.2.4.3 Low-Priority Actions

2014 **Sea-Level Rise**	**Mitigate the impacts of sea-level rise in Berkeley.**
Proposed Activities	- Monitor and participate in regional and State-level research on projected sea-level rise in Berkeley and the region. - Develop guidelines, regulations, and development review procedures to protect new and existing public and private developments and infrastructure from floods due to expected sea-level rise.
Related Natural Hazard(s)	Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards.
Related Policies from the General Plan or Climate Action Plan	Climate Action Plan, Adaptation Policies A and C General Plan Goal 6: Make Berkeley a disaster-resistant community that can survive, recover from, and thrive after a disaster – Utilize Disaster-Resistant Land Use Planning General Plan Policy S-27: New Development General Plan Policy S-14: Land Use Regulation, Action E
Special Environmental Concerns	Policy changes to development regulations in areas exposed to sea-level rise will take steps to minimize impacts to coastal habitat and historic resources.
Lead Organization and Staff Lead	Planning Department – Office of Energy and Sustainable Development (Monitor Research/Integrate Considerations) Staff Lead: Climate Action Coordinator Planning Department – Land Use Planning Division (Development Regulations) Staff Lead: Division Director
Priority	Low

Timeline	To be determined
Additional Resources Required	To be determined
Potential Funding Sources	City General Fund Permit Service Center Enterprise Fund

2014 **HazMat Floods**	**Explore local legislation to require hazardous materials stored in the flood zones to be elevated or otherwise protected from floodwaters.**

Proposed Activities:	- Conduct cost/benefit evaluation to determine if hazardous materials should be elevated/protected in existing development in flood hazard zones:
	  • Assess potential impacts from hazardous materials release due to flooding
	  • Consult with federal, State and regional partners to identify legislative best practices and lessons learned
	  • Work with Berkeley Building Official to identify engineering solutions and potential permitting requirements for hazardous materials
	  • Identify potential costs to hazardous materials owners
	- If cost/benefit evaluation is positive, work with City Manager's Office and City Council to determine and implement path forward.
	- If cost/benefit is not positive, consider alternative methods of compliance such relocation or modification of business activities.

Related Natural Hazard(s)	Floods Climate Change
Associated LHMP Objective(s)	A. Reduce the potential for loss of life, injury and economic damage to Berkeley residents and businesses from earthquake, wildland-urban interface fire, landslide, flood, tsunami, climate change, and the cascading impacts of these hazards.
Related Policies from the General Plan or Climate Action Plan	General Plan Policy S-13 Hazards Identification, Action A
Special	All activities occurring in biologically sensitive areas will

Environmental Concerns:	include measures to protect sensitive habitats and species.
Lead Organization and Staff Lead:	Planning Department – Toxics Management Division Staff Lead: Hazardous Materials Specialist II
Priority:	Low
Timeline:	Complete assessment of existing legislation: January 2014 Complete Cost-benefit evaluation for assessment by City Manager's Office: To be determined
Additional Resources Required:	To be determined
Potential Funding Sources:	Existing Certified Unified Program Agency (CUPA) Funding for emergency planning.

[i] This mitigation plan does not focus on disaster preparedness actions, which are undertaken to facilitate response to a disaster once it has occurred. Preparedness actions include planning response mechanisms, purchasing equipment to use in emergency response, or conducting drills. The City has strong plans and programs focused on emergency response and disaster preparedness activities, such as the Community Emergency Response Team program and the Emergency Operations Plan. These plans and programs are coordinated with, but separate from, this mitigation plan.

2 Implementing, Monitoring and Updating the Plan

This Plan will be well-integrated into the City's existing plans and planning mechanisms. Upon its adoption, it will be an appendix to the City's Disaster Preparedness and Safety Element of the City's General Plan.

On June 25, 2013, the City Council adopted the FY 2014 and FY 2015 Biennial Budget, which includes the Citywide Work Plan. Many actions outlined in this Mitigation Strategy have already been integrated into the Citywide Work Plan.

For upcoming budget cycles, the City's newly-established Chief Resilience Officer (CRO) position in the City Manager's Office[i] will be responsible for working with Department leaders to further incorporate funded actions from this Mitigation Strategy into the Citywide Work Plan. City staff indicated under "Lead Organizations and Staff Leads" will be responsible for further developing the project plans, schedules and budgets outlined for actions in the Mitigation Strategy.

Additionally, each year, the City assesses potential capital improvement projects and available funding as it implements its Five-Year Capital Improvement Plan. Capital improvement actions in this Plan will be assessed as part of this annual process.

Implementation of many of these actions will be dependent on outside funding sources.

2.1 *Implementing Actions and Reporting on Progress*

The CRO will coordinate monitoring, evaluation and updates to the mitigation plan on an annual basis within the five-year cycle. Lead staff identified in each action will meet with the CRO at the beginning of each calendar year to address the City's overall progress on this Mitigation Strategy. In these meetings, staff will:

- Provide qualitative and quantitative performance data related to actions
- Identify any necessary changes to existing Plan actions
- Identify new Plan actions to be incorporated into the Strategy

The City's Disaster and Fire Safety Commission will serve as the advisory body for implementation of this Plan. This group was created by ordinance to advise the City Council on disaster-related issues. All meetings of this Commission are held in public. Staff will present progress on mitigation strategy implementation to this group on an annual basis.

The City will maintain the www.CityofBerkeley.info/Mitigation website and the Mitigation@CityofBerkeley.info email address. Community members will be able to submit feedback during the implementation of this plan through this website and email address. Additionally, community members are able to write and mail or hand-deliver feedback to the City Manager's Office at any time. The City will also use the website as one means of reporting implementation progress to the community.

2.2 *Updating the Plan*

Per federal regulations, this Plan must be updated once every five years. To ensure future compliance with these regulations, the 2018 mitigation strategy meeting will commence the comprehensive process to create the 2019 Plan update. This process will be similar to the annual

mitigation strategy update process defined above, but will be expanded to address all sections of the Plan:

1. City staff will consult with scientists and hazard experts to conduct a thorough evaluation and update of this Plan's hazard analysis. The update will include any new scientific research about Berkeley's hazards, the city's exposure and vulnerabilities, as well as a thorough review of all loss estimates.
2. City staff will measure and report progress on actions since the Plan's inception.
3. Items 1 and 2 together will inform the assessment of the updated mitigation strategy.
    - City staff will assess incomplete actions to determine if they should be removed, retained or rewritten
    - City staff will propose new actions for the updated Plan.
4. City staff will perform another community review process, including input opportunities for institutional community partners and individual members of the public.
5. City staff will incorporate appropriate public feedback and will conduct an outreach and adoption process, involving City commissions and City Council.

[i] The hiring process for the Chief Resilience Officer is currently underway and will be complete by July 1, 2014.

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3 Hazard Analysis

To become disaster resilient, a community must first understand the existing hazards and their potential impacts. Berkeley is exposed to a number of natural and human-caused hazards that vary in their intensity and impacts on the city. This mitigation plan addresses five high-probability natural hazards: earthquake, wildland-urban interface (WUI) fire, flood, landslide, and tsunami. Each of these hazards can occur independently or in combination, and can also trigger secondary hazards.

Although this plan is focused on natural hazards, three human-caused hazards of concern are also discussed: hazardous materials release, climate change,[1] and terrorism. They are included because of their likelihood of occurrence and the magnitude of their potential consequences.

For each of the natural hazards above, this plan describes:

1. The hazard itself;
2. Geographic areas of Berkeley that are exposed to the hazard;
3. Vulnerabilities to the hazard within each exposed area;
4. Cascading hazards created by the primary hazard; and
5. Probable damage and other impacts from the hazard.

The best available technical methods were used to estimate possible losses caused by various hazards. The City's detailed GIS databases, which include carefully gathered information about building types, natural features, and important property uses, were extensively used to characterize the city's hazards. HAZUS, an earthquake loss estimation program developed by FEMA, was used to estimate damage to buildings, economic losses, deaths and injuries, and shelter requirements after an earthquake. For other hazards, past calamitous events or studies by local specialists were used to estimate possible impacts to the community. The regional hazard mitigation plan developed by the Association of Bay Area Governments in 2010 contains additional information and analysis relevant to the city and informed portions of this update.

3.1 *Identification of Hazards*

3.1.1 Natural Hazards

The natural hazards included in this plan were first identified through a community-based process during the revision of the Disaster Preparedness and Safety Element of the City's General Plan, adopted in 2002. The General Plan is the result of four drafts, approximately 100 hours of public workshops, meetings, and hearings, almost 1,000 pages of policy suggestions submitted by Berkeley citizens, and the hard work and dedication of the Berkeley community and Berkeley Planning Commission[2]. Specialists

from the California Geological Survey, US Geological Survey, UC Berkeley, the Earthquake Engineering Research Institute (EERI), the Association of Bay Area Governments (ABAG) and many others worked with the city on programs and research that were incorporated in the Disaster Preparedness and Safety Element.

In 2014, tsunami was added to the mitigation plan. Newly-available maps and information for tsunamis now allow us to identify potential tsunami impacts, and to consider related mitigation actions.

3.1.2 Manmade Hazards

The focus of this mitigation plan is on natural hazards as emphasized in the Disaster Mitigation Act of 2000 (DMA 2000).[3] However, the plan addresses three manmade hazards—climate change, hazardous materials release and terrorism.

Climate change was specifically identified as a hazard of concern in the City's 2009 Climate Action Plan, and in 2014, climate change has been added to the mitigation plan. Newly-available maps and information now allow us to identify potential climate change impacts, and to consider related mitigation actions.

Hazardous materials release is addressed in this mitigation plan as a potential impact from a natural hazard. Terrorism is identified as a hazard of concern but is not analyzed in-depth. Other manmade hazards that could occur in Berkeley, such as ground water contamination, are not included in this plan, but may be addressed by other City programs in ongoing regulatory processes, such as activities of the Toxics Management Division.

The worst potential disaster that Berkeley could face involves multiple hazards being realized at the same time. A major earthquake could trigger significant landslides, spark fires and release toxic chemicals. If an earthquake occurred during the rainy winter season, landslides would be worsened and flooding could occur, exacerbated by damaged creek culverts and storm drains. City staff conducts planning and training to respond to challenging, multi-hazard events such as these. In addition to looking at each hazard individually, this plan explores how the hazards interact, and how mitigation activities for each hazard impact the overall disaster risk in Berkeley.

3.1.3 Public Health Impacts of Identified Hazards

The City's Public Health and Environmental Health Divisions have provided guidance on the public health impacts associated with hazards included in this plan. For example, drinking water quality is likely to be impaired after a major earthquake or flood, and air quality can be affected by a fire. Impure water and air have public health effects, and providing accurate and timely information and precautionary measures is a public health function.

The Public Health Division participated in the Bay Area Regional Risk-Based Assessment of public health impacts of a variety of hazards. The assessment for Berkeley

focused on the health impacts of a severe or moderate earthquake, a wildland/urban interface fire, and a moderate influenza pandemic. In addition to evaluating these categories of risk, the assessment focused on three sub-populations considered most vulnerable in a disaster: 1) seniors and homebound individuals with disabilities, 2) individuals with mental/behavioral health illness, and 3) UC Berkeley students in multi-unit residential housing. The assessment helps to inform our public health emergency preparedness and mitigation efforts. It also helped to engage our partners with recommendations for improving their own preparedness plans as they serve these most vulnerable populations.

3.1.4 Hazards Not Considered in the Plan

Other natural hazards that are extremely rare in Berkeley are not included in this plan; these include severe storms, which can produce prolonged low temperatures, heavy rainfall and hail; severe heat; high winds; and small tornados and waterspouts. This plan does not focus on these hazards because they are not as likely to occur or to create damage that is as serious as the hazards addressed in detail. California is not generally exposed to the large tornado events experienced in the Midwest. Berkeley's geographic location and moderate climate shelters it from prolonged storms and extremes of cold and heat. Ocean temperatures moderate the power of tropical storms, lessening the effects of low barometric pressure and storm surge. However, these hazards may become more prevalent in Berkeley with the changing climate.

Naturally-occurring communicable disease outbreaks (e.g. a flu pandemic; SARS) do pose a significant risk to the Berkeley community, but are not addressed in this plan. Mitigation activities for communicable disease are not yet well-defined, but they could include, for example, measures to assure a high baseline level of immunization in the community, both for routine childhood immunizations and for annual seasonal flu vaccination. The City's Public Health Division leads Berkeley's communicable disease and public health emergency preparedness planning, in conjunction with State and Bay Area local health departments.

3.2 *Components of the Hazards Analysis*

The analysis of hazards in this plan has the following components:

- Historical Events. Within recent history the city has experienced the effects of all hazards addressed in this plan. Descriptions of the impacts of these disasters help illustrate some of the types of damage they can cause.

- Hazard. Describes the ways that each hazard can damage the community, and maps the locations in Berkeley that are particularly prone to specific hazards, such as the "100-year" floodplain. Areas that could experience secondary hazards, such as liquefaction following earthquakes, are also discussed.

- Exposure and Vulnerability. This plan identifies the people, buildings and infrastructure that exist in hazard zones. Vulnerability refers to the susceptibility

to physical injury, harm, damage, or economic loss of the exposed people, buildings and infrastructure. City elements exposed to each hazard are listed and mapped, and their vulnerability is discussed.

- Risk and Loss Estimates. The expected damage to be caused by future hazard events is estimated quantitatively, when possible. For most hazards, specific figures are estimated for the damage and losses that could occur. Consequences of damage on city residents and visitors are explored.

SECTION A: HAZARDS OF GREATEST CONCERN

Earthquakes and wildland-urban interface (WUI) fires are the hazards of greatest concern to Berkeley. Both of these hazards have a relatively high likelihood of occurrence and the potential for widespread damage within the city and the greater east bay region. Berkeley is committed to reducing the impact of these hazards on the city, and therefore they are the primary focus of the mitigation actions identified in Section 4 of this plan.

3.3 *Earthquakes*

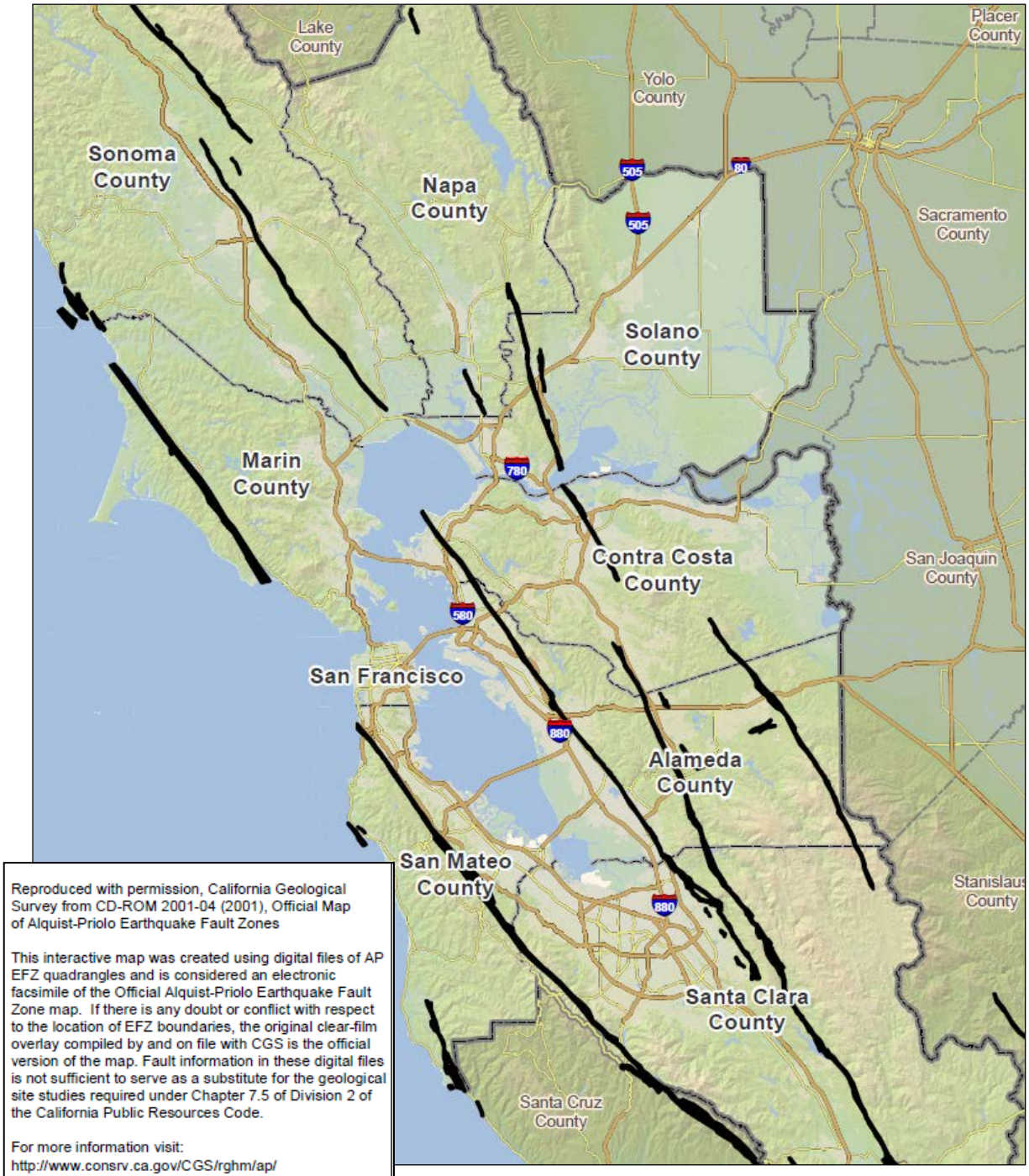
3.3.1 Historical Earthquakes

Destructive earthquakes struck the Bay Area in 1838, 1868, 1898, 1906, 1911 and 1989. Impacts of the earlier earthquakes in Berkeley are not well documented, but the damage of the 1989 Loma Prieta earthquake is fresh in the memory of many Berkeley residents. Sixty-two people died in the Bay Area as a direct result of this earthquake. Most of the fatalities, 42, were caused by the collapse of a two-level elevated highway in Oakland only a few miles from the Berkeley city limits. Damage in the City of Berkeley was minor in comparison to many of its neighbors. Many residential structures experienced collapse of unreinforced masonry chimneys, and new cracks were found in the Martin Luther King, Jr. Civic Center Building. The earthquake epicenter was far from Berkeley, but region-wide impacts and disruption increased the Berkeley community's awareness of the high risk Berkeley faces from much closer earthquakes.

3.3.2 Earthquake Hazard

Map 3.1 shows the city of Berkeley and its proximity to the region's key faults, which are identified using red lines. The Hayward fault, of particular concern, stretches from the middle of San Pablo Bay, runs directly beneath Berkeley, and terminates in Hayward. A large earthquake could occur on any of these faults, or on smaller or as-yet unidentified faults, such as those that caused the 1989 magnitude 6.9 Loma Prieta and the 2001 magnitude 5.1 Napa earthquakes. Most of these events would affect the City of Berkeley.

Map 3.1 Regional faults and their location with respect to Berkeley



As of 2008, there is a sixty-three percent chance that an earthquake of magnitude 6.7 or greater will strike the Bay Area at least once over the next thirty years, and a thirty-one percent chance that an event of this magnitude would occur on the Hayward/Rodgers Creek fault system during that time.[4] This means that current Berkeley residents are likely to experience a severe earthquake during their lifetime. To provide a historical context, the 1994 Northridge earthquake, which caused an economic loss of $40 billion dollars,[5] was a magnitude 6.7 earthquake. This strength of earthquake in the Bay Area would produce strong shaking and ground failure throughout the region, causing significant damage in nearly every Bay Area city and county.

3.3.2.1 Ground Shaking

The most significant physical characteristic of a major earthquake is ground shaking. During an earthquake, the ground can shake for a few seconds or up to a minute or more. The strength and duration of ground shaking is affected by many factors, including the types of soils underlying a city, and the distance, size, depth, and direction of the fault rupture that caused the quake.

The strongest shaking is typically close to the fault where the earthquake occurs. Horizontal shaking in particular causes most earthquake damage, because structures often have inadequate resistance to this type of motion.

Weak soils, such as bay mud and fill at the city's waterfront, also experience strong shaking in earthquakes, even from distant quakes. According to the USGS, as seismic waves pass from rock to soil, they slow down but get bigger. Hence a soft, loose soil may shake more intensely than hard rock at the same distance from the same earthquake. An extreme example for this type of amplification was in the Marina district of San Francisco during the 1989 Loma Prieta earthquake. That earthquake was 100 kilometers (60 miles) from San Francisco, and most of the Bay Area escaped serious damage. However, some sites on landfill or soft soils, like San Francisco's Marina district, experienced significant shaking.

Magnitude and Intensity[6]

Two commonly-used scales represent different earthquake characteristics: magnitude and intensity.

Magnitude
An earthquake has a single magnitude, which indicates the overall size and energy released by the earthquake. Magnitude is measured using moment magnitude (M).

Intensity
In the same earthquake, different locations will experience different amounts of shaking. The shaking experienced at different locations varies based on:

- The earthquake's overall magnitude
- The distance from the fault that ruptured in the earthquake

- The ground type: thick valley deposits shake longer and harder than rock.

Intensity measures the strength of earthquake shaking at a particular location. Intensity is measured using the Modified Mercalli Intensity (MMI) scale. Intensity is based on observed effects. The MMI value assigned to a specific site after an earthquake provides a more meaningful measure of the earthquake's severity at that location than the magnitude, which applies one value to the entire earthquake.

The MMI scale is composed of twelve increasing levels of intensity that range from imperceptible shaking to catastrophic destruction. Lower numbers on the intensity scale generally deal with the manner in which the earthquake is felt by people. Higher numbers on the scale are based on observed structural damage.

Map 3.2 shows the different levels of intensity anticipated across the Bay Area for a magnitude 7.3 Hayward fault earthquake. The map shows that the most intense shaking will be felt along the East Bay, stretching from Pinole to Milpitas, as well as in the North Bay from Novato to Vallejo.

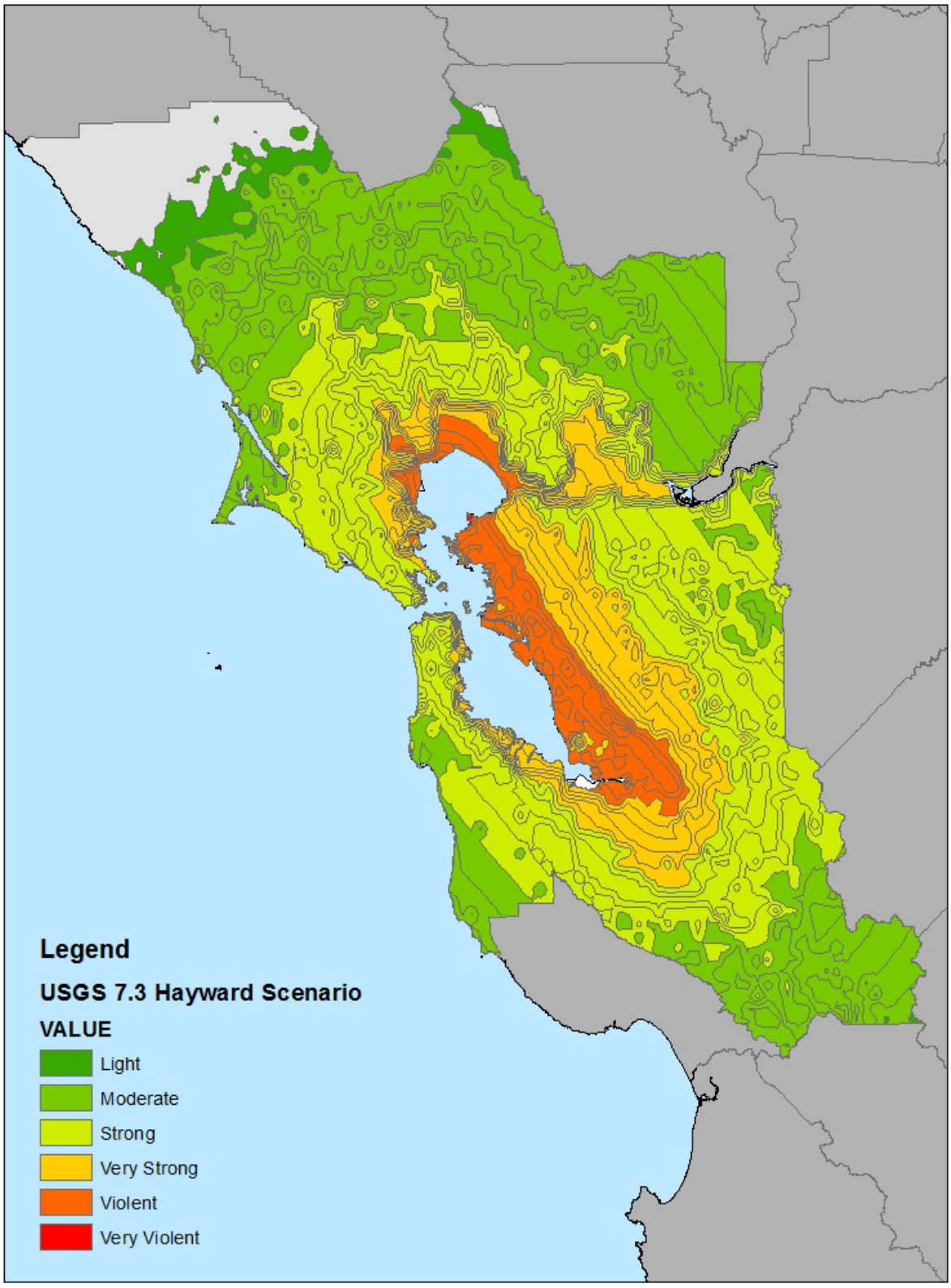
Map 3.2 depicts Berkeley in orange, indicating that in this scenario, Berkeley will experience violent shaking, associated with MMI Level IX:

- Considerable damage in specially-designed structures
- Well-designed frame structures thrown out of plumb
- Great damage in substantial buildings, with partial collapse
- Buildings shifted off foundations.

Comparatively, Map 3.2 depicts western San Francisco in light green, indicating that in this scenario, shaking will be strong in western San Francisco. Strong shaking is associated with MMI Level VII:

- Negligible damage in buildings of good design and construction
- Slight to moderate damage in well-built ordinary structures
- Considerable damage in poorly-built or badly-designed structures
- Some chimneys broken.

Map 3.2 Modified Mercalli Intensity for Magnitude 7.3 Scenario Earthquake on the Hayward fault



3.3.2.2 Ground Failure

Earthquakes can cause the ground to fail in several ways: through surface fault rupture, liquefaction and seismically-triggered landslides.

The State of California is required by two Acts of the State Legislature[7] to establish and map three Seismic Hazard Planning Zones, depicting areas within the state with the potential to experience these types of ground failure[8]. Map 3.3 shows areas of Berkeley deemed by the State to be part of the Earthquake Fault Planning Zone, the Earthquake-Induced Landslide Planning Zone and the Liquefaction Planning Zone.

Seismic Hazard Planning Zones, also known as Zones of Required Investigation, are regulatory maps that depict areas identified as having a high potential for earthquake-triggered ground failure caused by fault rupture, landsliding or soil liquefaction. These maps are used to guide land use planning and construction permitting for projects that fall within the area. Applicants for permits who are in one of the zones are required to have site-specific geotechnical investigations and use engineering measures to mitigate the hazard.

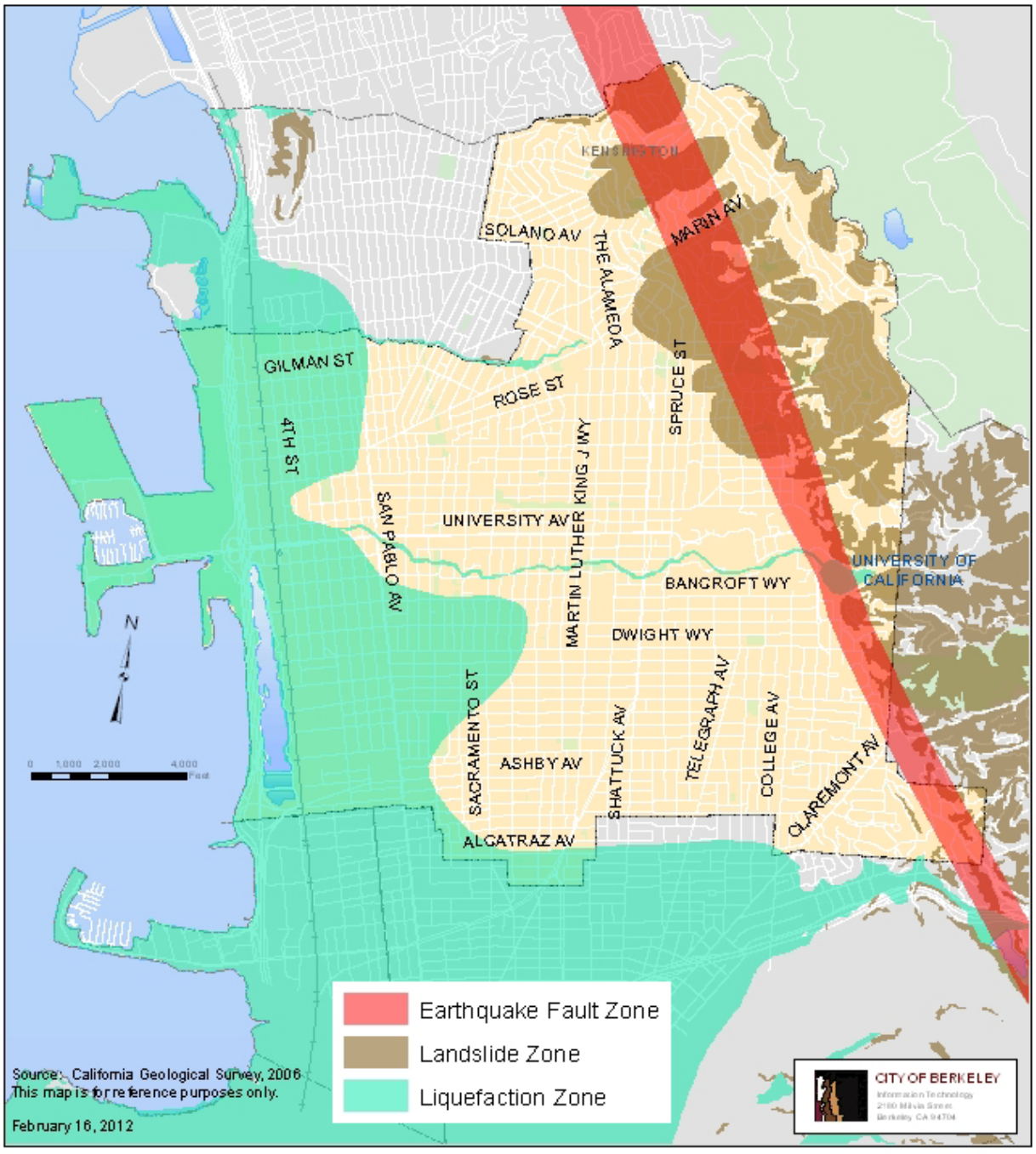
Unlike Map 3.2, these Seismic Hazard Planning Zones do <u>not</u> show effects of a particular earthquake scenario, but rather, consideration of all future earthquakes affecting the area. They are used:

- To support land use decisions by identifying areas where future earthquake-induced ground failure is more likely to occur, and

- To determine whether approval of more in-depth site-specific hazard investigation and mitigation may be required for certain projects during the construction permitting process.[9]

Each type of ground failure is discussed in detail below. Particular impacts of each type of ground failure in Berkeley are discussed in relevant sections throughout Section 3.3.3: *Exposure and Vulnerability*.

Map 3.3 Berkeley Seismic Hazard Planning Zones



3.3.2.2.1 Surface Fault Rupture

Surface fault rupture occurs when movement on a fault deep within the earth breaks through to the surface. After an earthquake, one side of a fault can shift by several feet vertically and horizontally from its previous location, causing splits in any structures or pipelines crossing the area.

The Earthquake Fault Planning Zone in Berkeley is indicated in red on Map 3.3. The Zone includes an area approximately ¼-mile wide along the Hayward fault, which runs in the northwest-southeast direction along the base of the hills in the eastern portion of the city.

Fault rupture may not occur in every earthquake, but when it does, it is likely to be concentrated in a narrow zone, with small parallel surface ruptures occurring over a wider area. If fault rupture occurs, potential impacts include damage to:

- Underground and aboveground utilities (electricity, water, sewer) and communications conduits that cross the fault
- Gas lines that cross the fault, causing fire ignitions
- Important east-west streets, making travel between the hills and flatland areas difficult where displacements are large
- The Solano Tunnel, which is an important transportation connection in the north-south direction
- Buildings, due to ground displacement.

3.3.2.2.2 Seismically-Triggered Landslides

Rainfall-triggered landslides are described in detail in Section 3.5.

Seismically-triggered landslides can result in significant property damage, injury and loss of life. Berkeley expects to experience landslides during the next earthquake, particularly if the earthquake occurs during the rainy winter months. While rainy weather or earthquakes could cause small landslide events that would impact a few homes, strong earthquake shaking coincident with wet, saturated hills presents a worst-case scenario. Movement could range from a few inches to tens of feet, but ground surface displacements as small as a few inches are enough to break typical foundations. Even small aftershocks could continue to cause slides for weeks and months after a quake, blocking roads and damaging homes. Even small landslide displacements caused by earthquake shaking can open surface cracks, which allow subsequent rainfall to infiltrate the slide mass and cause instability long after the earthquake.

In Berkeley, the potential for landslide from seismic activity is high in the hill areas and along creek banks. Areas of Berkeley that are exposed to seismically-triggered landslides are displayed in increasing levels of detail on the three maps described below.

The California Geological Survey has identified the areas of Berkeley with potential to experience earthquake-induced landslide. These areas are shown in brown on Map 3.3. These areas are identified by combining information on rock or soil strength, slope gradient (steepness), and anticipated future shaking levels. All areas underlain by known active or dormant landslides are included in the zone. Map 3.3 indicates that significant portions of the Berkeley hills have the potential to experience earthquake-induced landslide.

The US Geological Survey has also mapped Berkeley's earthquake-induced landslide hazard potential[10], shown in Map 3.4. Unlike Map 3.3, which considers areas of potential landslides from all potential earthquakes, Map 3.4 is a scenario map: it considers effects of a singular 7.1 magnitude earthquake on the Hayward fault.

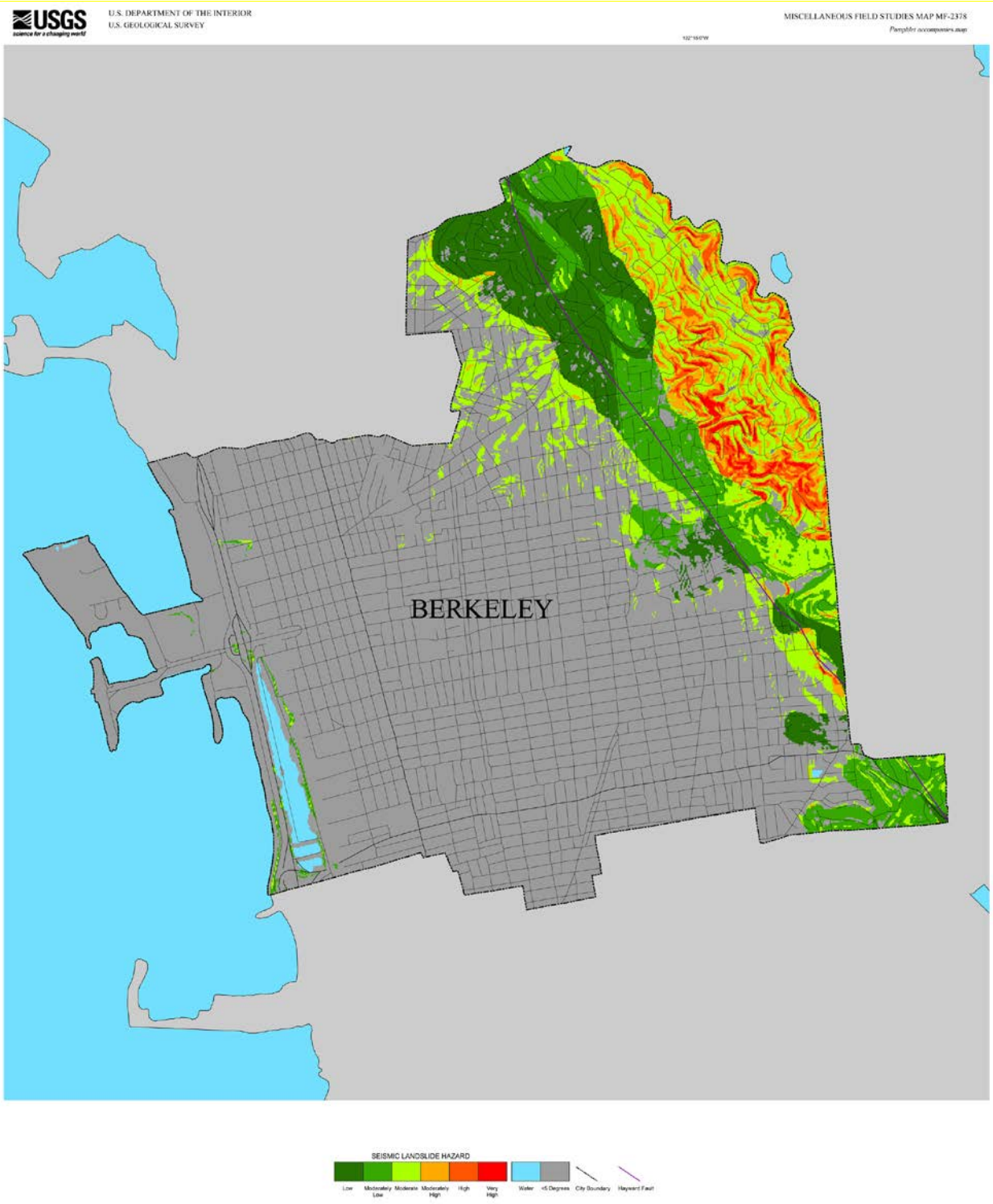
Map 3.4 is based on estimates of rock strength and slope gradient, and uses a methodology developed by Jibson et al. (1998) following the 1994 Northridge earthquake in southern California. [11]

Like Map 3.3, Map 3.4 shows that significant portions of the Berkeley hills have potential to experience earthquake-induced landslide. Map 3.4 not only identifies all the areas of potential landslide after a 7.1 Hayward fault earthquake, it also uses colors to identify the differing landslide potentials of each area:

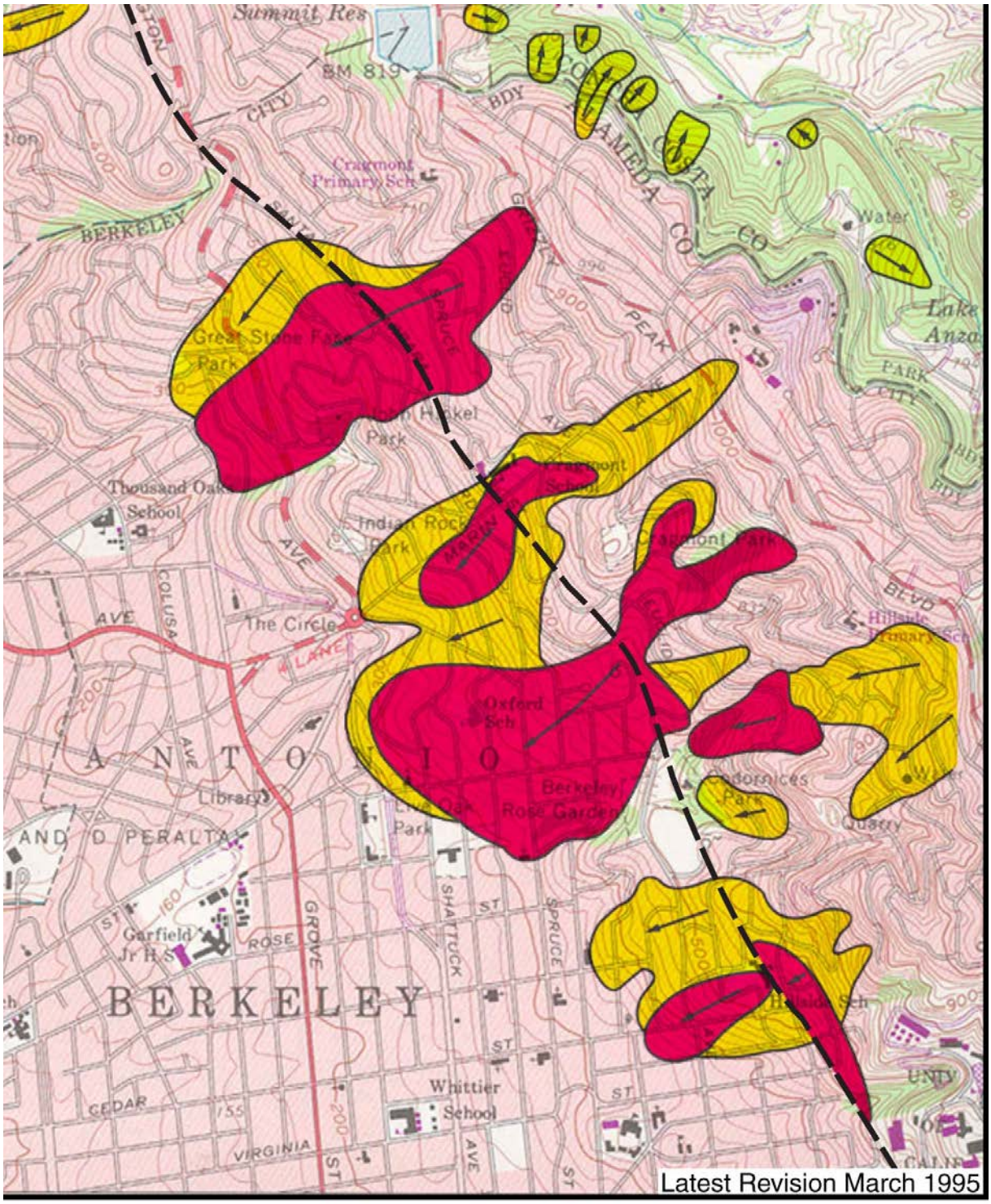
- Very high (red)
- High (dark orange)
- Moderately high (light orange)
- Moderate (yellow-green)
- Moderately low (light green)
- Low (dark green)

Map 3.5, created by Alan Kropp and Associates, focuses on a specific area in the northern part of the Berkeley hills. This map illustrates this area in particular because the area has active landslides, indicated in red on the map. Potentially-active slides are indicated in yellow. In a Hayward fault earthquake, significant movement is likely in active landslide areas. Earthquake shaking and active slides together could activate other potentially-active slides.

Map 3.4 Landslide hazard for 7.1 Hayward fault earthquake scenario[12]



Map 3.5 Active and potentially-active landslides in Berkeley hills (developed by Alan Kropp Associates and used with permission)



There are few generally-accepted methods to estimate damage from landslides caused by earthquakes.

Earthquake-induced slides may occur at the time of a major earthquake, or in subsequent aftershocks or rainstorms. Residents may have some warning that slides are imminent, helping to reduce damage and casualties. Landslide consequences would be seen primarily in the hills areas of Berkeley, and would likely include:

- Damage to structures, primarily residences. Damage homes could vary considerably, depending on their location and the quality of their foundations, and if there are any retaining walls. Some houses could be entirely destroyed or moved down the hill, while others could see minimal, repairable damage.
- Gas line rupture, igniting multiple fires
- Water line rupture, reducing water supply to fight fires
- Rupture of other underground and aboveground utility and communication systems
- Distortion of major and minor roads. This would make access difficult or impossible for firefighters and other emergency responders. It would also make egress difficult for residents of impacted areas.

In an earthquake-induced landslide in Berkeley, a worst-case scenario could cause approximately five to ten percent of all susceptible areas to slide. This would impact about 300 structures, primarily residences. The total value of these structures could be about $200 million.[13] A single landslide-triggering event impacting all 300 structures is unlikely, but possible. Smaller slides affecting a handful of structures are more probable.

3.3.2.2.3 Liquefaction

Liquefaction is a phenomenon that occurs in wet, sandy or silty soils. When shaken, the soil grains consolidate, pushing water towards the surface and causing a loss of strength in the soil. The ground surface may sink or spread laterally. Structures located on liquefiable soils can sink, tip unevenly, or even collapse. Pipelines and paving can tear apart.

Map 3.3 depicts in green the areas in Berkeley where soil types and groundwater conditions are susceptible to liquefaction. The State deems these areas to be a Zone of Required Investigation, meaning that special investigation and reporting requirements exist for construction or transfer of property in this Zone, per both the Seismic Hazards Mapping Act and Natural Hazards Disclosure Act. [5]

The Liquefaction Hazard Planning Zone exists primarily to the west of San Pablo Avenue in low-lying areas adjacent to the San Francisco Bay, and also extends one half mile east

around Dwight Way to about Jefferson Avenue and along Alcatraz Avenue. There is also a potential for liquefaction along major creeks such as Strawberry and Codornices creeks.

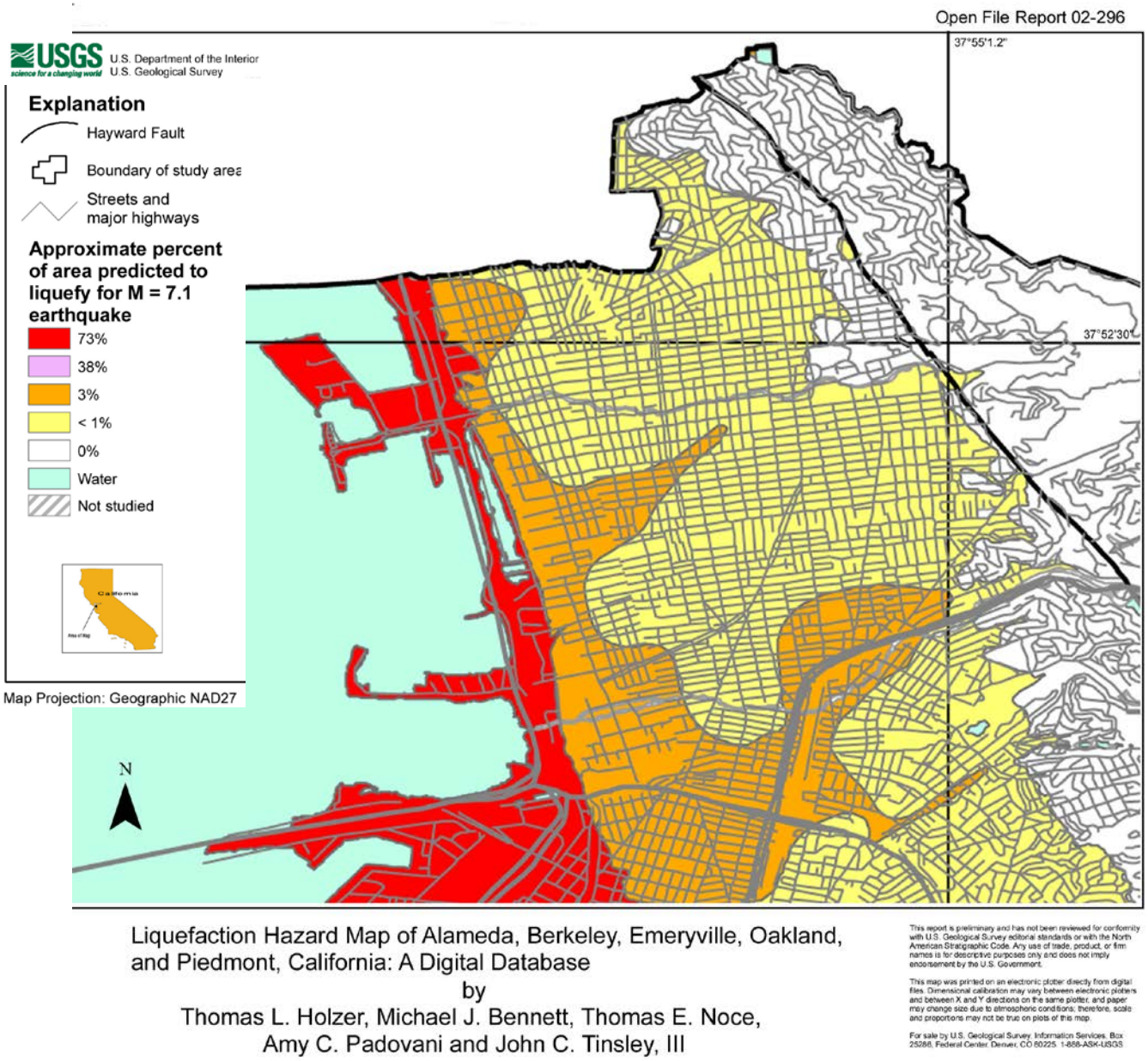
In an earthquake, liquefiable soils need to be shaken hard and long enough in order to trigger liquefaction. An earthquake on the Hayward fault is the most likely to cause significant liquefaction within the city.

Map 3.6 considers the liquefaction predicted to occur in Berkeley in a magnitude 7.1 earthquake on the Hayward fault. The map divides Berkeley into three areas with different liquefaction potentials, and describes the approximate percentage of each area that is predicated to liquefy in this earthquake scenario. This map can also be interpreted as the likelihood that any particular location within that area will experience liquefaction.

In this scenario, depicted on Map 3.6, the liquefaction hazard is most pronounced along the western edge of the City: seventy-three percent of the area west of the Union Pacific railroad tracks and Interstate 80 is expected to experience varying degrees of liquefaction. This liquefaction potential drops radically just east of the railroad tracks, where only three percent of the area colored in orange is expected to liquefy. The potential drops even further for the majority of central and eastern Berkeley (colored in yellow), where less than one percent of the land is predicted to liquefy. Maps 3.3 and 3.6 show slightly different extents of liquefaction across the city because the approach and data used to develop each map were different and the purpose of the maps is different: Map 3.3 is regulatory while Map 3.6 depicts one possible scenario of liquefaction resulting from a likely earthquake scenario.

Sea level rise resulting from climate change may raise the water table in Berkeley and increase the areas of Berkeley that are susceptible to liquefaction.[14]

Map 3.6 Liquefaction Scenario Map



3.3.2.3 Fire Following Earthquake

Significant portions of the following section were originally developed for the City of San Francisco through the Community Action Plan for San Francisco (CAPSS)[15]. While the report was developed for San Francisco, many of the findings are relevant to Berkeley. Both cities have potential for high earthquake shaking, which increases the risk of post-earthquake fire ignitions. Both cities also have dense multi-family housing, which facilitates fire spread.

Fires break out following all major earthquakes. Fire following earthquake presents a significant problem in dense urban environments, where many simultaneous ignitions lead to a firestorm. In these cases, fire damage is even more severe than damage from earthquake shaking. There are many examples from around the world of fire following earthquake:

Earthquake	**Impacts of Earthquake-Caused Fire**
1995 Kobe Earthquake	More than 100 fires broke out following the 1995 Kobe earthquake, during which broken water mains left the fire department helpless, and fires destroyed more than 7,000 buildings. Fire was also a major contributor to the death toll.
1994 Northridge Earthquake	More than 100 fires broke out following the 1994 Northridge earthquake, severely impacting area fire departments, even though it largely affected only the edge of greater Los Angeles.
1989 Loma Prieta Earthquake	Thirty-six fires broke out in San Francisco. Natural gas line rupture was responsible for some of the fire ignitions. Failure of the city's electrical systems may have actually reduced the number of fire ignitions. Fires in the Marina District claimed four structures in the area, but lack of wind that night assisted in preventing the fires from spreading. Overall, the shaking experienced in the Loma Prieta earthquake was moderate, as the epicenter was 70 miles away.
1906 Great Earthquake	The earthquake was followed by a firestorm that lasted for three days, and in that time swept over an area of over 3.5 square miles.[16] It is estimated that 80 percent of San Francisco's property value was lost in the fire.

Earthquake shaking can start fires in numerous ways, such as:

- Tipping over appliances with pilot lights
- Damaging electrical equipment leading to sparks
- Exposing materials to open flames from stoves, candles, fireplaces and grills

In the 1994 Northridge earthquake in Los Angeles, over half of the ignitions were due to electrical systems, and about a quarter were fueled by gas.

Ground failure due to liquefaction, surface fault rupture and landslide can rupture gas lines (both underground and at the private gas meter). These ruptures can start and fuel fires.

Earthquakes can also damage the systems we have in place to stop fires. Earthquake shaking can damage a building's active fire protection systems (e.g., fire alarms and sprinkler systems), as well as its passive fire protection systems (construction features designed to slow/stop fire, e.g. fire walls, fire-rated floor-ceiling assemblies, fire doors).

Post-earthquake fires can also spread quickly due to spilled flammable chemicals.

Fires also spread more quickly after major earthquakes because earthquakes damage the infrastructure needed to fight fires. Earthquake shaking and ground failure due to liquefaction, surface fault rupture and landslide can simultaneously:

- Break water mains, causing a drop in water pressure
- Damage electrical systems necessary to provide energy to pump water
- Damage communication infrastructure
- Impede transportation routes with debris or landslides
- Jam firehouse doors, preventing apparatus from responding.

Soft-story and unreinforced masonry buildings are more prone to earthquake damage (see Section 3.3), and thus are also likely to be a key source of earthquake-caused fires when gas or electricity lines break or rupture. Additionally, Berkeley has many older multi-unit apartment buildings without fire sprinkler systems. These buildings could both cause and feed fires following an earthquake. Even buildings that survive earthquake shaking can succumb to fire, including those buildings that have been seismically retrofitted.

Densely-populated neighborhoods with wooden homes, such as most of the residential areas in Berkeley, are at high risk of fire spread following a major earthquake. Earthquakes in places with this type of construction have caused the two largest peacetime urban fires in history: in 1923 in Tokyo; and in 1906 in San Francisco, where 80% of the 28,000 destroyed buildings were lost due to fire.

Risk and Loss Estimates

The Berkeley Fire Department today is a well-prepared, professional organization that trains for earthquake-caused fires. However, after the next large earthquake, there are likely to be more fires than Berkeley's firefighters can respond to at one time. Compounding this challenge, fire personnel will not only be fighting fires, but will also be responding to needs for search and rescue and emergency medical services. Firefighters in nearby cities will be struggling to address response needs in their own jurisdictions, and State and federal resources may not be able to help the City for many hours. The 1991 East Bay Hills Fire destroyed 3,354 structures in only a few hours and overwhelmed the capacity of local fire departments, even though neighboring departments were available to assist.

Fires in Berkeley could burn out of control, and may threaten entire neighborhoods. Fire damage will add to the city's overall earthquake damage, making recovery more difficult and lengthy by increasing the number and severity of damaged buildings, lengthening the time required to repair and replace damaged buildings, displacing residents, and weakening neighborhoods.

3.3.3 Exposure and Vulnerability

This section describes Berkeley's built environment and its earthquake vulnerabilities. It contains three parts:

- Buildings
- Infrastructure (systems for utilities, transportation and communications)
- Critical response facilities

This section describes earthquake vulnerabilities for each component of the built environment. In some instances, a system's earthquake vulnerability could potentially create a secondary hazard (e.g., if earthquake shaking were to result in a hazardous materials spill.)

Much of Berkeley's built environment is owned and operated by other public and private entities and is not under the City's direct authority. The City works with other public agencies and companies on disaster planning, and this section includes information about some of the activities that the City's key community partners are undertaking to mitigate the hazards that may impact or originate on their own property.

Buildings

According to the State of California's Multi-Hazard Mitigation Plan, damage due to ground shaking produces over 98 percent of all building losses in typical earthquakes. Buildings are also vulnerable to ground displacements associated with primary fault rupture, liquefaction and landslides.

This section first addresses the earthquake exposure and vulnerability for City-controlled buildings. Secondly, it describes earthquake exposure and vulnerability for buildings *not* controlled by the City, including private residences and commercial buildings.

Retrofitting vs. New Construction

Building codes are continually improved, incorporating new knowledge about building methods that effectively resist seismic forces.

Buildings built using older techniques can be especially vulnerable to earthquake damage. Buildings are usually retrofitted with the goal of reducing loss of life, but damage can still be expected in many retrofitted buildings. Building retrofit is often preferable to building replacement, as retrofitting an existing building can be more cost-effective and environmentally-friendly, while preserving historic architecture.

New building construction is expected to perform better than retrofitted buildings in an earthquake. However, the goal of the building code is to reduce loss of life in an earthquake, not to ensure the continued use of the building. This means that a large

earthquake will damage even new buildings, which may remain unusable for long periods of time.

City-Owned Buildings

The City of Berkeley owns or leases approximately 156 buildings. These buildings have multiple uses, including running City government, providing emergency services, low-income housing, and recreation. In recent years, the City has been seriously examining the risk to its buildings from disasters, particularly earthquakes. Many important City buildings have been assessed for seismic safety and, when possible, strengthened or replaced. Three of these buildings are known to be seismically vulnerable. There is no identified funding source to retrofit the buildings below:

- *Old City Hall, 2134 Martin Luther King, Jr. Way*

  This building, used for offices and assemblies, including City Council meetings, is a potential collapse hazard that needs to be retrofitted. It is also a recognized historic building. The Berkeley Unified School District has moved its administrative offices to a new building.

- *Veterans' Memorial Building, 1931 Center Street*

  This historically landmarked building, used for public assembly, as a homeless shelter, and for daytime homeless services, is a potential collapse hazard that needs to be retrofitted. The homeless shelter operating in the building currently houses about 50 people per night. During the day, the Dorothy Day House, Berkeley Food and Housing Project, Options Recovery, and Building Opportunities for Self Sufficiency (BOSS) use the building for their homeless service programs.

- *Center Street Garage, 2025 and 2033 Center Street*

  This building is vulnerable to significant damage or collapse in an earthquake. It is used for City and public parking. A retrofit would be prohibitively expensive, so the City is looking at replacement alternatives.

With the exception of Fire Station No. 7, no significant City buildings are located in the fault rupture or earthquake-induced landslide planning zones. Constructed in 2006, the Fire Station No. 7 is in Fire Zone 2 and incorporates state-of-the-art hazard-resistant construction.

However, a number of City buildings need to be assessed to determine their level of vulnerability to seismic events. Some may pose some risks to life and emergency operations. A listing of the City's buildings and known information about their disaster risk appears in Appendix B: *List of City Owned and Leased Buildings*.

Notable Mitigation Activities

The City strengthened important buildings for emergency response and recovery, including the Martin Luther King, Jr. Civic Center Building (City Hall), the Main Library, and all seven of the City's fire stations. Since then, the City has continued its program to strengthen or replace key at-risk structures:

Ratcliff Building, 1326 Allston Way

In 2012, seismic retrofit work was completed for the Ratcliff Building, also known as the Facility Maintenance Building. This work was made possible by a pre-disaster mitigation program grant for $2.89 million, provided in 2006 by the State Office of Emergency Services and the Federal Emergency Management Agency. This building houses the City's Public Works Department Operations Center, the location at which the department's field response activities will be coordinated during a disaster. This retrofit will enable the department to better respond during and after seismic events.

Dona Spring Animal Shelter, 1 Bolivar Drive

The City's new animal shelter opened in November 2012, replacing the old shelter at 2013 Second Street. The new building is a steel-frame structure on a concrete mat slab, and was designed to governing seismic standards. The two-story building is approximately 11,700 square feet, and was funded through bonds and other sources.

The building has many features, including a medical suite for onsite spaying and neutering of shelter animals, facilities for protecting healthy animals and caring for sick ones, and indoor-outdoor kennels. This new facility supports the City's Animal Care Services Division in providing services to community members and their pets during and after disaster events.

Branch Libraries

In November 2008, City of Berkeley voters approved Bond Measure FF, a $26 million measure limited to the renovation, construction, and seismic and disabled access improvements at the City's four neighborhood branch libraries. Libraries function as community gathering spaces before, during and after disasters. Seismic retrofit work will help the City to make these spaces available to the community, especially at times when community members need each other most.

A description of the renovations completed or underway for each library is detailed below:

- *North Branch Library, 1170 The Alameda*

The North Branch Library, constructed in 1936, reopened in April 2012, following significant renovations. Through this effort, the building was seismically retrofitted to governing standards; a fire sprinkler system was added, and the library's mechanical, electrical, and telecommunication systems were upgraded. The building was upgraded to full ADA compliance, and historic features were preserved. A dedicated community meeting room was added; these changes nearly doubled the library's square footage to 9390 square feet.

- *Claremont Branch Library, 2940 Benvenue Ave*

The Claremont Branch Library, originally constructed in 1924, was renovated and reopened in May 2012. Through this effort, the building was seismically retrofitted to governing standards; a fire sprinkler system was added, and the library's mechanical, electrical, and telecommunication systems were upgraded. The building was upgraded to full ADA compliance. 340 square feet were added for a new square footage of 7,640 square feet. The project achieved LEED Silver certification.

- *West Branch Library, 1125 University Avenue*

The West Branch Library was constructed in 1923, and has been replaced by an all new building measuring 9,400 square feet. The building complies with today's seismic standards and will be fully ADA accessible. It uses a net-zero energy design with roof-mounted photovoltaic panels and use of natural light and ventilation.

- *South Branch/Tool Lending Library, 1901 Russell Street*

The South Branch/Tool Lending Library was constructed in 1961, and was replaced in 2013 by a new single-story building measuring 8,656 square feet. It meets governing seismic codes and is fully ADA accessible. Photovoltaic panels will offset energy grid draws. The new building was designed as a LEED Gold Certificate project.

Privately-Owned and Other Structures

Berkeley has about 43,636 housing units[17], serving the city's population of 112,580[18]. Most were built before 1980, meaning that few of Berkeley's homes were constructed to modern building code standards, which require earthquake-resistant structural measures, fire-resistant materials, and landslide-resistant siting and landscaping.

Older houses constructed with a crawl space or aboveground basement below the first floor can have several weaknesses, because older building codes were inadequate to resist seismic forces, or because codes were not followed properly. The bottom of the wood frame exterior walls may not be adequately bolted to the foundation, meaning the house can slide off the foundation during strong shaking. The foundation itself may be constructed of weak or deteriorated materials, like brick or very old concrete. Also, the wall that encloses the crawl space, known as a cripple wall, may be weak and vulnerable to collapse due to inadequate bracing and deterioration of wood members from termite attack and dry rot. Hillside houses can suffer from any of these weaknesses, but have increased risks of failure to cripple walls and poorly braced extra-tall walls along the sloping sides.

A number of City incentive programs and educational efforts promote seismic strengthening activities. The Transfer Tax Rebate Program reduces the real estate transfer tax by one-third for homeowners who perform qualifying seismic safety work on their homes. Since July 2002, the City has distributed over $9 million to homeowners through the program, as outlined in Table 3.1 below.

Table 3.1 Transfer Tax Rebate Program

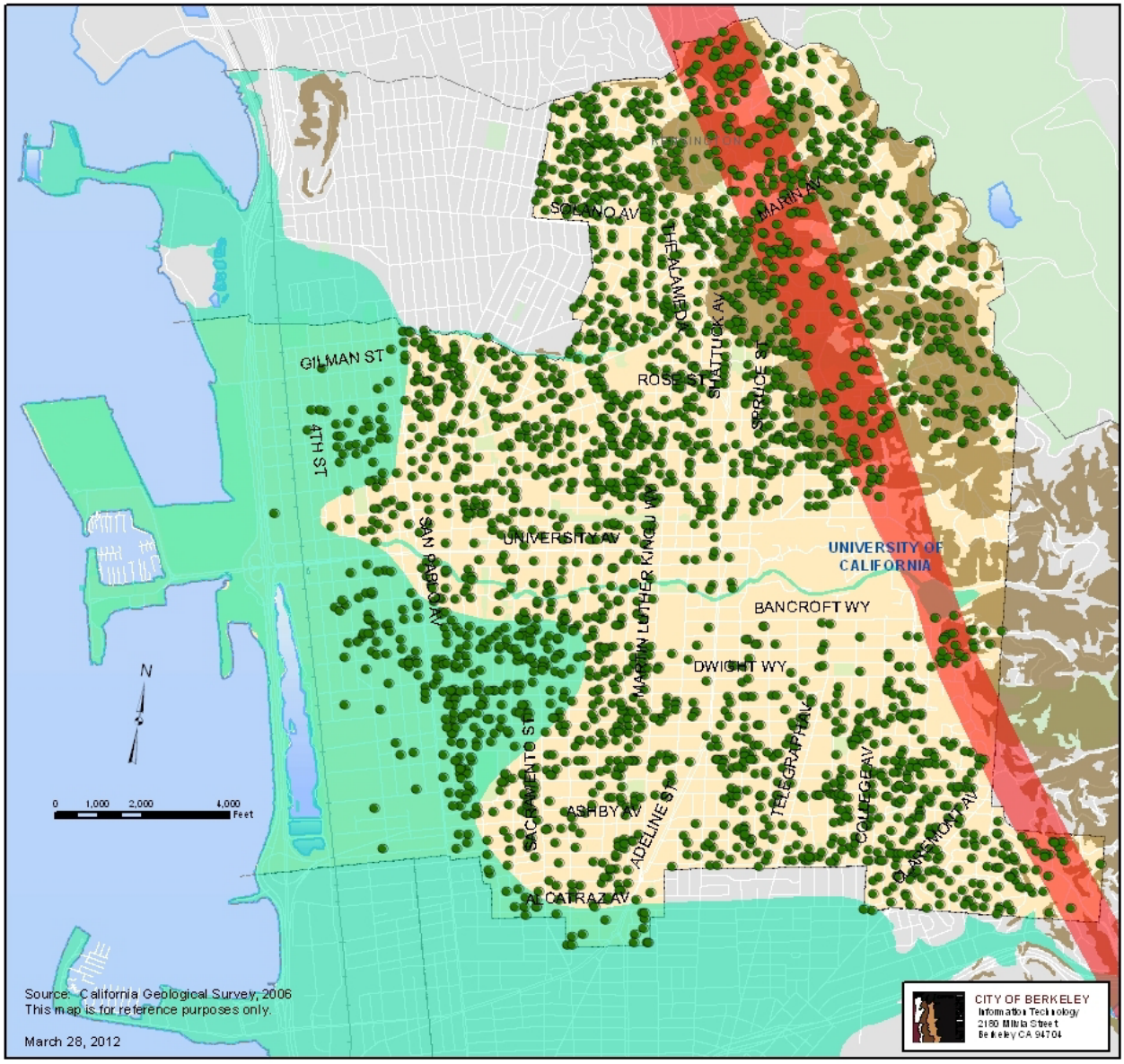
Fiscal Year	Property Transfer Rebates	Total Funds Issued
2003	382	$1,133,047
2004	467	$ 1,539,738
2005	385	$ 1,459,510
2006	262	$ 1,168,654
2007	144	$ 611,433
2008	152	$ 681,002
2009	138	$ 533,061
2010	150	$ 592,539
2011	157	$ 593,974
Total (FY 2003-2011[A])	**2,237**	**$ 8,312,958**

The City's adoption of Standard Plan Set A[19] educates homeowners and contractors about measures to improve seismic resistance of their homes. Contractors' adherence to this Standard simplifies the City's plan review and inspection process.

Through these and other efforts, more than 2,500[20] (12 percent) of single-family homes have been strengthened to various degrees since this plan was first adopted in 2004. These upgrades include both structural and nonstructural mitigation measures. Map 3.7 shows the locations of these upgraded homes, as of 2011, which are distributed across all residential neighborhoods.

[A] Program totals for Fiscal Years 2012 and 2013 are not included in Table 3.1. Property owners have up to two years to take advantage of the program, and numbers are not yet finalized.

Map 3.7 Single-Family Homes with structural and nonstructural mitigation work from 2004 -2011



- Single-Family Homes with structural and nonstructural mitigation work, 2004 -2011

Earthquake Fault Zone
Landslide Zone
Liquefaction Zone

Soft-Story Housing

A soft-story building is a multi-story building in which one level is significantly more flexible than the floors above it and the floors, or foundation, below it. In Berkeley, this weakness tends to occur in multi-family structures with openings for parking or commercial spaces and few interior partitions at the ground floor. These openings result in a significantly more flexible ground floor than in the stories above. When subjected to earthquake forces, this weak first story can be severely damaged and shift out of plumb or even collapse.

Many of the city's more affordable units are located in this type of structure. An Association of Bay Area Governments study in 2003 estimated that nearly two-thirds (sixty-six percent) of uninhabitable housing in the Bay Area would be from wood-frame multifamily residences after a large earthquake on the Hayward fault, whereas less than nine percent of uninhabitable housing would be in single-family homes[21]. This is of concern because in many instances, multifamily units, which disproportionately house the poor, minorities, elderly and university students, take longer to repair and reoccupy than single-family units[22].

Notable Mitigation Activities

On December 3, 2013 City Council adopted Ordinance No. 7,318-N.S. amending Berkeley Municipal Code Chapter 19.39 to require property owners of soft, weak or open front buildings with five or more dwelling units to retrofit their buildings within the next five years. Owners have three years to apply for a building permit and two years to complete the work after submitting their permit application. The law applies to buildings constructed prior to 1978 and takes effect January 4, 2014. This is the second phase of the Soft Story Program.

Under the first phase of the soft story program, a City ordinance passed in 2005 required owners of soft-story buildings with five or more units to hire professional engineers to evaluate their buildings' seismic vulnerability and to submit evaluation reports to the City. The initial soft-story inventory included 321 buildings. The 2005 ordinance has a 94% compliance rate. As shown in Table 3.2, of the 321 buildings on the inventory, 51 were removed from the list due to reconsideration; 112 were retrofitted; owners of 140 buildings complied with the Phase I ordinance building assessment requirement and submitted an engineering evaluation report; and owners of 18 buildings did not submit an evaluation report.

Buildings removed from the list either proved they did not have a soft story condition, had fewer than five residential units, or were a hotel or commercial building, unaffected by the ordinance.

Table 3.2 describes the status of the 321 buildings identified as soft-story in 2005.

Table 3.2 Berkeley Soft-Story Building Status

Number of buildings	Percent*	Status
112	35	Retrofitted; removed from the soft-story inventory
51	16	Reconsidered; removed from soft-story inventory
140	44	Confirmed to be soft-story via engineering evaluation report; remain on soft-story inventory
18	6	Noncompliant; remain on soft-story inventory
321	*100%*	*Total buildings identified as soft-story in 2005*

*Due to rounding, percentages do not add up to 100 percent.

Despite their owners' compliance with the ordinance, the 140 soft-story buildings in Berkeley that have not been retrofitted are still considered hazardous in an earthquake, as well as the 18 buildings that are out of compliance with the ordinance. These buildings contain 1,611 residential units.

Map 3.8 shows the locations of retrofitted and unretrofitted soft-story structures relative to the seismic hazard planning zones. Green dots indicate locations of soft-story buildings that have been retrofitted or are in the process of being retrofitted. Red dots indicate locations of potentially-hazardous soft story buildings. These buildings include buildings with reviewed seismic engineering and evaluation reports under review by the Building and Safety Division, and buildings which have not yet submitted the evaluations reports.

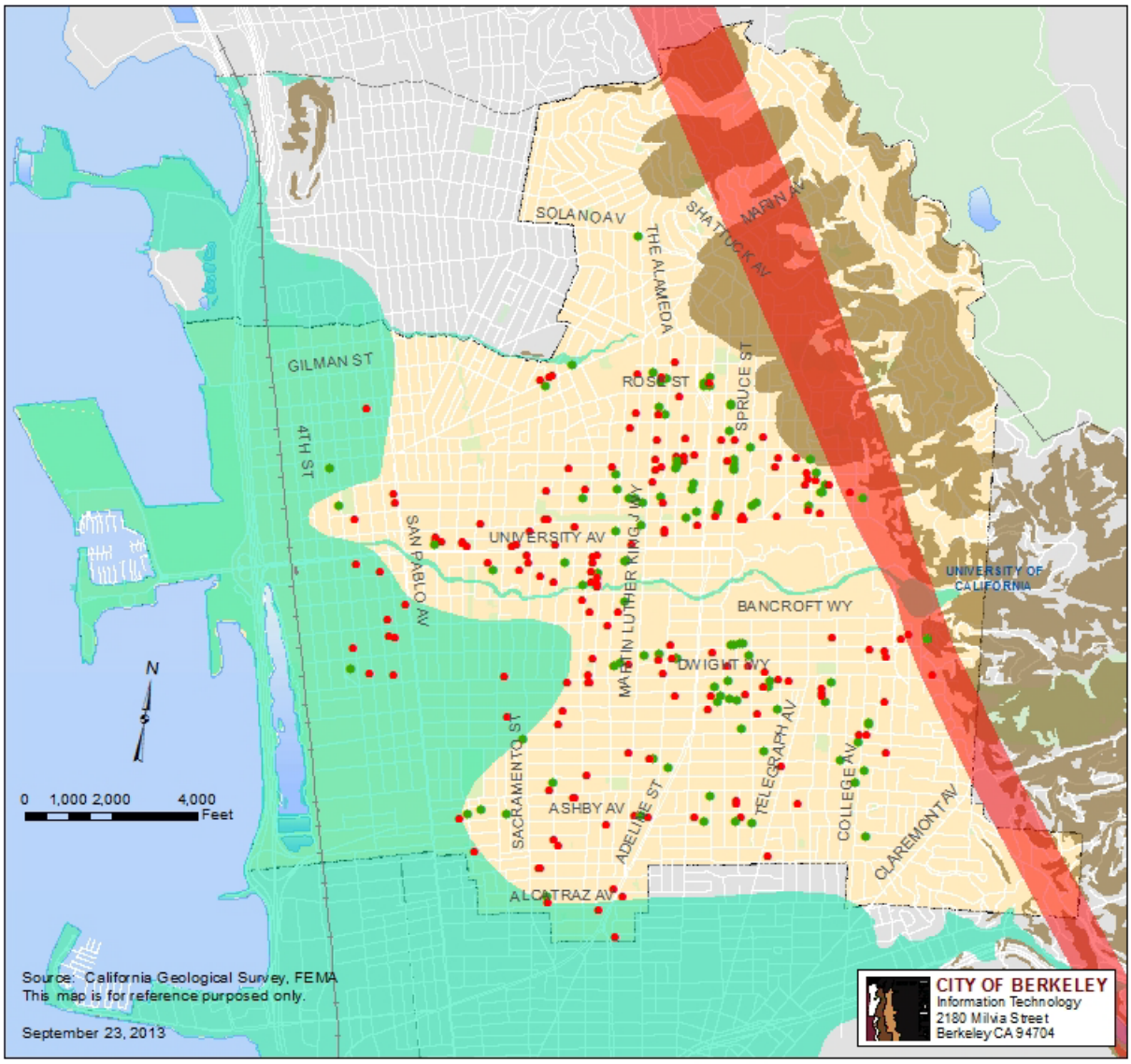
According to Map 3.8, there are 19 potentially-hazardous soft-story buildings within the liquefaction hazard planning zone. These buildings may be especially susceptible to sinking, tipping unevenly or collapsing in an earthquake.

Map 3.8 also shows that the two soft-story buildings in the earthquake-induced landslide hazard planning zone have been retrofitted.

Map 3.8 shows that two potentially-hazardous buildings are within the fault rupture planning zone, meaning that these buildings may be especially vulnerable to damage if fault rupture occurs during a major earthquake.

The remaining buildings do not lie in an earthquake hazard planning zone. However, according to Map 3.2, all of these buildings will still be subject to violent shaking in a magnitude 7.3 Hayward fault earthquake. Soft-story retrofitting will improve these buildings' safety but cannot completely address their earthquake vulnerability.

Map 3.8 Retrofitted and Unretrofitted Soft-Story Buildings



*Includes retrofitted soft-story buildings and soft-story buildings in process of retrofit.
**Includes buildings with reviewed seismic engineering evaluation reports confirming the soft story status, buildings with seismic engineering evaluation reports under review by the Building and Safety Division, and buildings which have not yet submitted the evaluation reports.

Commercial and Industrial Structures

Unreinforced Masonry Structures

Unreinforced masonry (URM) buildings are constructed of brick, block, tile, stone, or other types of masonry and have no or inadequate reinforcement to keep them from structural collapse in earthquakes. Most URM buildings have features that can threaten lives during earthquakes. These include unreinforced masonry parapets, unreinforced masonry exterior and interior walls, chimneys, and high brick veneers. The walls, floors and roofs are often not tied together or are weakly connected. When earthquakes occur, inadequate connections in these buildings can allow masonry to fall. Floors and roofs can collapse, placing occupants and pedestrians in harm's way.

The URM building type was discontinued many decades ago due to the buildings' high vulnerability to earthquake damage. Existing URM buildings can be retrofitted to reduce the life safety hazard they pose to occupants and pedestrians. Following strong earthquakes, retrofitted URM buildings are likely to remain stable, but they may still sustain moderate or greater damage, including possible collapse. Earthquake-damaged URM buildings would be expected to be replaced, as the cost of extensive repairs may exceed economically justifiable limits for these older buildings.

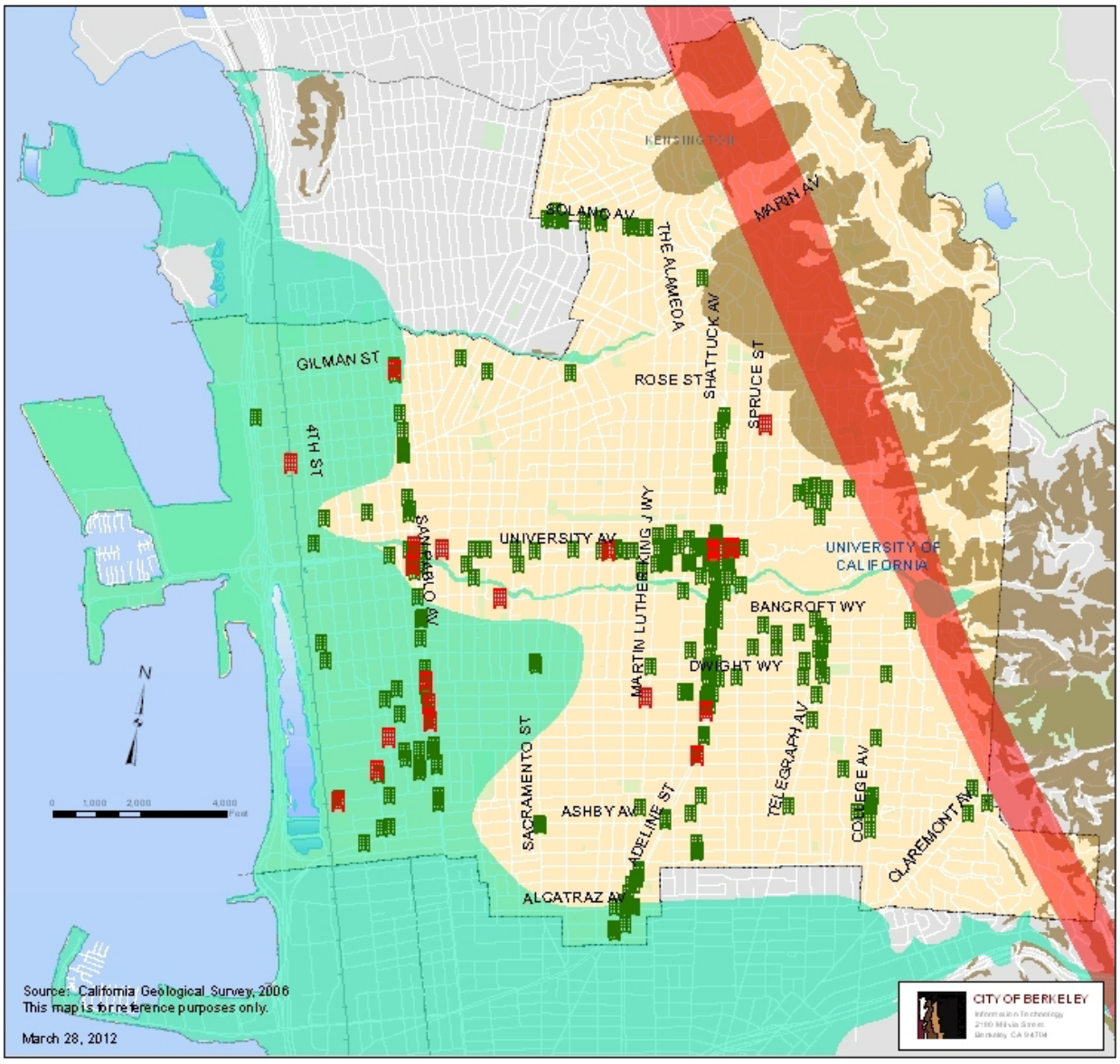
Notable Mitigation Activities

In 1989, in response to State law, the City of Berkeley compiled an inventory of URM buildings. Berkeley identified about 700 URM structures constructed before 1956, used for both commercial and residential purposes. In 1991, the City adopted Unreinforced Masonry Ordinance 6088-N.S. The ordinance mandated that all URM buildings on the inventory be seismically retrofitted to the established minimum performance standards on a schedule determined by the designated risk category of each building.

The program has brought considerable increases in safety. As of 2012, over 90% of the URMs on the City's Hazardous Buildings Inventory have been seismically retrofitted, demolished, or demonstrated to have adequate reinforcement. Nineteen remaining URM buildings have not yet had significant action taken to reduce their risk.

Map 3.9 shows locations of both retrofitted and yet-to-be retrofitted URM structures. Green building icons indicate URM structures that have been retrofitted or are in the process of being retrofitted. Red building icons indicate URM buildings that have not yet been retrofitted or are otherwise out of compliance with the URM retrofit program. These buildings are most frequently located in Berkeley's commercial corridors, along Shattuck, San Pablo, University and Solano Avenues. None of these buildings sits in the earthquake-induced landslide or fault rupture hazard planning zones (indicated on Map 3.9 in brown and red, respectively). However, many of these structures are within the liquefaction hazard planning zone, indicated in green. This means that in addition to damage from earthquake shaking, many of these buildings may sink, tip unevenly or collapse due to potential liquefaction.

Map 3.9 Retrofitted and Unretrofitted Unreinforced Masonry Buildings



* Includes all buildings that are out of compliance with the Unreinforced Masonry Safety Program.
** Includes URM buildings that have been retrofitted or are in the process of being retrofitted.

Tilt-Up Concrete Construction

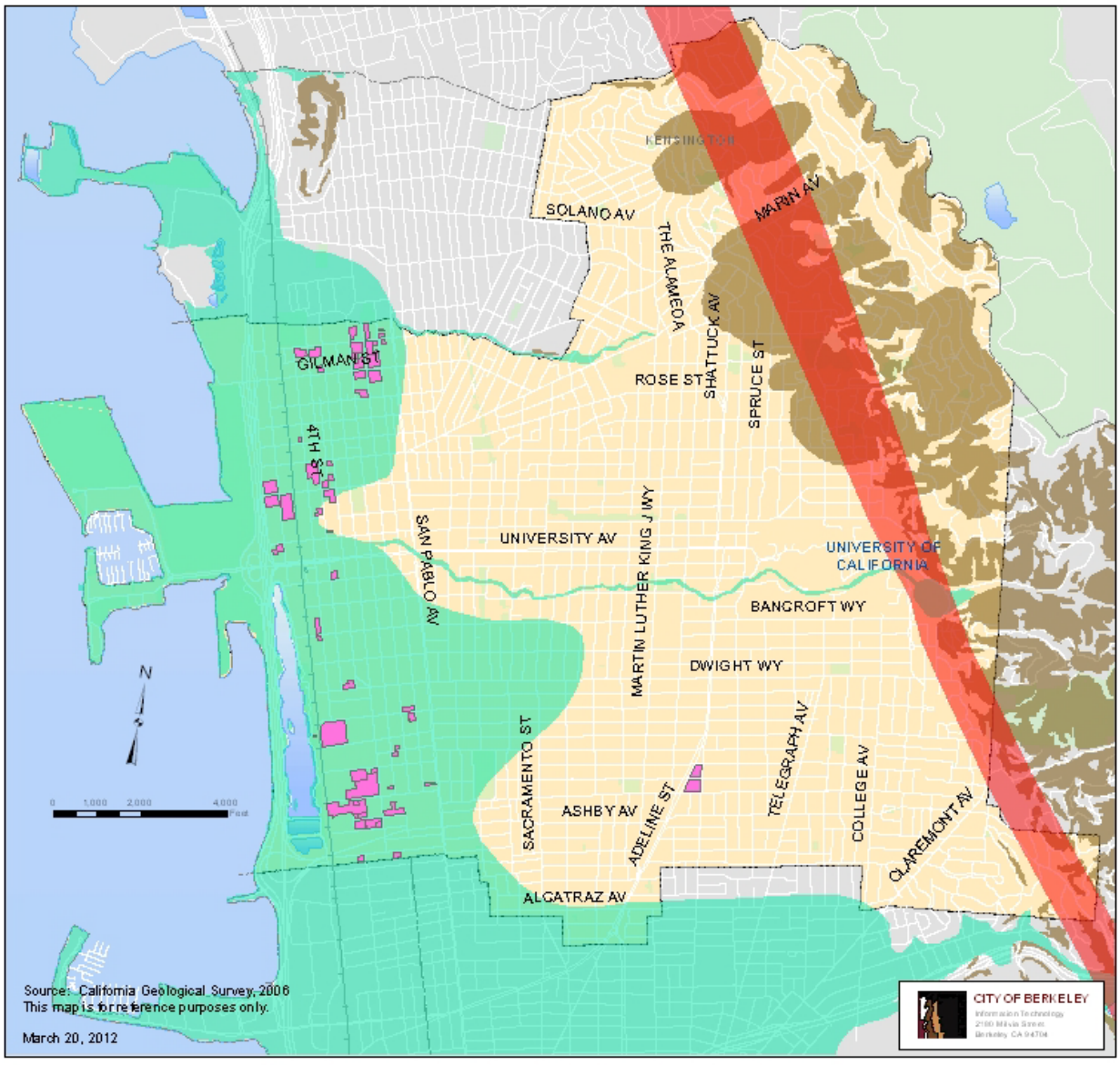
Tilt-up buildings are typically one- or two-story commercial buildings constructed of concrete walls that are poured horizontally, tilted into vertical positions, and connected to each other and to roofs. If the connections between the walls and roofs are weak, the walls can pull away from roofs and collapse during ground shaking.

Tilt-up buildings built before the mid 1970's are of particular concern. A 1996 survey of buildings in the city identified 59 structures of this type.

Map 3.10 shows the locations of tilt-up concrete buildings relative to seismic hazard planning zones. Nearly all of the buildings are in the liquefaction planning zone, meaning that they could sink, tip unevenly or collapse if liquefaction occurs. However, none of these buildings sits in the fault rupture or earthquake-induced landslide hazard planning zones, and thus will not be exposed to these hazards in an earthquake.

There is currently no ordinance to require retrofit of these buildings.

Map 3.10 Potentially Hazardous Tilt-Up Concrete Buildings



Infrastructure

This section examines the earthquake exposure and vulnerability of Berkeley's infrastructure. It is organized into three components: utilities, transportation and communications.

Infrastructure described in this section provides the foundation for day-to-day life in Berkeley. These systems are also vital to many of the City's disaster response activities, and restoration of these systems will be critically important to Berkeley's recovery from a major earthquake.

Many of these systems are also significant because their failure in an earthquake could create secondary hazards, compounding the challenge to Berkeley's disaster response and recovery activities.

Much of the City-owned infrastructure was built before World War II when the city was growing and modernizing. After over 90 years in service, much of the infrastructure requires extensive maintenance, repair or enhancements.

Electrical, natural gas, petroleum, telecommunications, and potable water supply infrastructures are not under the City's control, but rather are owned and managed by other quasi-governmental, private or special district entities.

The following three sections (Utilities, Transportation and Communications) describe these key infrastructure systems and their vulnerabilities, demonstrated by the earthquake hazard exposure depicted on Maps 3.11 and 3.12. These sections also outline how these vulnerabilities may create secondary hazards following an earthquake. Included in each section are the City's key partners and their mitigation activities.

The Department of Public Works has an up-to-date database describing elements, characteristics and conditions of all roads, storm drains, and sewer pipelines. The database includes specific information on these systems and their conditions for maintenance and management purposes. This type of information will also facilitate Public Assistance applications after a disaster, as federal repair guidelines attempt to apportion damage due to the hazard event and damage from normal wear and tear. Disputes over existing element conditions can lead to additional expense and delays in making needed repairs.

Utility Systems: Earthquake Exposure and Vulnerability

The table below shows owners of key utility system infrastructure in Berkeley.

Table 3.3 Key Berkeley Utility Systems

Owner/Manager	**Infrastructure**
City of Berkeley	• Storm drains • Retaining walls in right-of-way • Sanitary sewer collection system that links to the EBMUD system • Creeks, open channels and creek culverts in right-of-way and on City property • Street Lights and traffic lights on poles or utility poles and above- and below-ground conduits supplied from the PG&E system • Transfer Center, city waste disposal and recycling, located at Second and Gilman streets
EBMUD	• Potable and fire suppression water supply system consisting of pipelines, pumping plants, flow/pressure control facilities, and storage tanks and reservoirs owned by the East Bay Municipal Utility District • Sanitary sewer transmission pipeline (EBMUD wastewater interceptor) and pumping station
PG&E	• Electric distribution system, including substations, mains, laterals and meters, owned by the Pacific Gas and Electric Company • Natural gas distribution system, including main pipelines, lateral pipelines and meters
AT&T, Comcast and others	• Telecommunications aerial and underground conduits
Kinder Morgan Corporation	• Aviation fuel and multi-product pipelines buried under the right-of-way of the Union Pacific railroad tracks
Various	• 376 sites in the city storing more than 55 gallons, 200 cu ft or 500 lbs accumulated hazardous materials and hazardous waste

Liquefaction is a significant contributor to utility failure after an earthquake. When soil liquefies, the effective stress of a soil is reduced to essentially zero, which corresponds to a complete loss of shear strength or shear resistance. Sloping ground and ground next to creeks and the Bay may slide on a liquefied soil layer, opening large cracks or fissures in the ground. This can cause significant damage to infrastructure lines such as water,

natural gas, sewage, storm, electrical and telecommunications systems installed in the affected ground. Buried tanks, pipelines, conduits, and manholes may float in the liquefied soil due to their buoyancy.

Landslides, liquefaction, or subsidence caused by earthquakes may subject pipelines to significant displacement, causing the pipelines to develop leaks or breaks.

The following systems are described in further detail:

- Water System
- Sanitary Sewer System
- Storm Drain System
- Natural Gas and Electricity Systems
- Aviation Fuel Pipeline
- Hazardous Materials Management

Water System: Earthquake Exposure and Vulnerability

Key Partner: East Bay Municipal Utility District (EBMUD)[23]

The East Bay Municipal Utility District (EBMUD) provides drinking water to approximately 1.3 million people and sewer services to 640,000 in the East Bay. After an earthquake, EBMUD is responsible for maintaining and providing water and sewer services to its customers, including water for post-earthquake fire suppression. Much of the water for the East Bay comes through the Claremont Tunnel. This water is stored in a network of reservoirs throughout the Berkeley Hills and is distributed to customers through underground pipelines. EBMUD was created in 1923, and the age and extent of its system makes it particularly vulnerable to damage in earthquakes. EBMUD has studied the impacts of earthquake shaking, liquefaction, landslides and fault rupture on most of its infrastructure.

Following a major seismic event:

- Earthquake-induced landslides in the Berkeley hills could impact water lines, reducing water available for firefighting
- If fault rupture occurs, water lines within the fault rupture planning zone could be broken

The 1994 Northridge earthquake led to significant disruption of the water supply system of Los Angeles. Several communities were without water for as long as two weeks and boil water orders were in effect for a few communities for two weeks as a precautionary measure.

- Liquefaction in the western part of the city could impact water service

It could take seven days or more to restore basic services to nearly 80% of customers, depending on the severity of the earthquake. EBMUD crews will likely begin working to repair the system immediately after an event. Full service, however, may not be restored for six months.

Depending on the severity of earth movement, water and sewer lines may break, and the safety of the drinking water supply may be compromised. In addition, without power, sewer lift pumps will fail, leading to major sewage overflows. For this reason, the City's Environmental Health and Public Health Divisions may issue precautionary drinking water advisories, either in collaboration with water utilities or independently. These advisories may be in place until the drinking water system is confirmed safe.[24]

Key Partner's Notable Mitigation Activities

EBMUD has taken aggressive steps to strengthen its systems. In 1994, EBMUD allocated $189 million for seismic upgrades that were completed by 2006. Steps to provide system redundancy included building a new connector pipeline at the southern end of the EBMUD service area, purchasing flexible joints and hoses to temporarily reroute water flows, anchoring local water storage reservoirs, and upgrading pumping plants.[25] EBMUD has worked with PG&E to identify portions of the electricity grid critical to the water supply. The Berkeley Fire Department has worked with EBMUD to better understand the water distribution system and EBMUD emergency response capabilities in order to develop alternate water sources for firefighting should EBMUD's supply become unavailable.

The Claremont Tunnel crosses the Hayward fault 130 feet below Tunnel Road in Berkeley. It could experience severe displacements of 7.5 feet in a magnitude 7.0 earthquake on the Hayward fault.[26] EBMUD completed a seismic retrofit of the Claremont Tunnel in February 2007, which included constructing a bypass tunnel where the Claremont Tunnel intersects the Hayward fault. The bypass tunnel is capable of absorbing an 8-1/2 foot offset at the Hayward fault while maintaining flow capacit.

There are two reservoirs with dams in or near the city that have been evaluated for their seismic safety as part of EBMUD's dam safety program. Both reservoirs are safe for continued operation and do not pose a life safety risk. Claremont Reservoir holds about 8 million gallons and is located on Claremont Avenue in southeast Berkeley. In 2006, Claremont Reservoir dam was evaluated for seismic risk. The study concluded the dam will perform satisfactorily based on a magnitude earthquake of 7.25 on the Hayward fault. Summit Reservoir, at Berkeley's northeast border, has been evaluated for seismic risk and meets the stringent state safety requirements of the Division of State Dams; however, it is in need of replacement. It will be replaced with one 3.5 million gallon water tank within the footprint of the existing reservoir basin. Summit Reservoir construction is estimated to start in 2014 and is estimated to take two years to complete.

Sanitary Sewer System: Earthquake Exposure and Vulnerability

The City's sanitary sewer system is made up of pipelines with large diameter (six inches to 120 inches). Some of the large diameter pipes provide temporary storage when the EBMUD wastewater interceptor[27] system cannot accept flows. The amount of storage time provided by these large diameter pipes depends on the inflow rate and the ability of downstream segments to accommodate flow. Failure of the EBMUD interceptor system or the City's sanitary sewer system could cause sewage to back up beyond the Berkeley sanitary sewer system's storage capacity. When the volume of effluent is larger than the sanitary sewer system's storage capacity, it will overflow through manhole covers onto city streets and into the storm drain system and creeks that flow to the Bay.

The table below outlines the total length of Berkeley's sanitary sewer system, as well as the length and percentage of the system that lies within each hazard planning zone depicted on Map 3.3.

Table 3.4 Sanitary Sewer System

Infrastructure Element	**Total Length**	**Length in Hazard Areas**		
		Earthquake-Induced Landslide Planning Zone	Fault Rupture Planning Zone	Liquefaction Planning Zone
Sanitary sewer	259 miles	50 miles (19%)	29 miles (11%)	53 miles (20%)

The Berkeley hills have a high landslide risk, which could particularly impact the sanitary sewer system.

If fault rupture occurs, it could critically damage portions of the sanitary sewer system that are within the Fault Rupture Planning Zone.

The liquefaction hazard is more acute on the west side of the city. Liquefaction-caused earth movements will affect underground infrastructure, including a high proportion of the sanitary sewer system. Liquefied areas may move laterally, breaking Berkeley's underground sanitary sewer pipelines. Liquefied areas could also compromise EBMUD's wastewater interceptor line, adjacent to Interstate 80. Damage to either system would interrupt the systems' ability to convey sewage.

Storm Drain System: Earthquake Exposure and Vulnerability

Areas of the city's storm drainage system are known to be extremely weak and at risk of collapse. An earthquake would cause significant damage to this system. If the next earthquake occurs during or shortly before a rainstorm, the city could experience significant flooding in areas that have not seen floodwaters previously. The weaknesses of this system are described in more detail in Section 3.6, which addresses floods.

The table below outlines the total length of Berkeley's storm drain system, as well as the length and percentage of the system that lies within each hazard planning zone depicted on Map 3.3.

Table 3.5 Storm Drain System

Infrastructure Element	Total Length	Length in Hazard Areas		
		Earthquake-Induced Landslide Planning Zone	Fault Rupture Planning Zone	Liquefaction Planning Zone
Storm Drains	101 miles	15 miles (15%)	9 miles (9%)	29 miles (29%)

Earthquake-caused ground failure could change the horizontal alignment of pipes so that storm drains would not function.

The Berkeley hills have a high landslide risk, which could block or damage storm drains.

If it occurs, fault rupture could damage portions of the storm drainage system within the Fault Rupture Planning Zone.

The liquefaction hazard is more acute on the west side of the city. Liquefied areas may move laterally, breaking underground storm pipelines and affecting other underground infrastructure and creeks.

Electricity and Natural Gas Systems: Earthquake Exposure and Vulnerability

Electricity

Berkeley's electricity system is almost entirely aboveground. Earthquakes can topple or break utility poles, and falling trees or collapsing structures can damage utility lines. Electrical switches and transformers in the distribution system can be damaged, as can equipment at substations and transmission lines, possibly leading to system wide loss of these utilities. Photovoltaic (solar) panels, which can collect energy and deliver it back to the grid, are reliant on the electric grid being functional.

Because electrical system infrastructure exists throughout Berkeley, earthquake shaking, liquefaction, fault rupture and earthquake-induced landslides can all damage this infrastructure both above and below the ground. This means that a major earthquake will cause significant power loss to Berkeley.

Natural Gas

Underground systems are particularly prone to damage from ground failure in earthquakes and landslides. Natural gas line rupture is one of the chief causes of post-earthquake fires, as discussed in Section 3.3.2.3: *Fire Following Earthquake.* Additionally, rupture compromises this lifeline unless redundant connections unaffected

by the earthquake are available. Underground damage is harder to detect and repair, and the length of service losses may be greater than for aboveground systems.

This plan is focused on natural hazards and their impacts. This plan addresses gas pipeline rupture as a secondary hazard to earthquake liquefaction, earthquake-induced landslides and surface fault rupture.

The term “gas pipeline” includes:

- Transmission pipelines, which carry natural gas across long distances, usually to and from compressors or to a distribution center or storage facility. Transmission lines are large steel pipes (10" to 42" in diameter) that are federally-regulated. They carry unodorized gas at a pressure of approximately 60-900 psi.

- Distribution pipelines (“gas mains”), which are the middle step between high-pressure transmission lines and low-pressure service lines. Distribution pipelines are small- to medium-sized pipes (.25" to 24" in diameter) that are federally-regulated and carry odorized gas at intermediate pressure levels, from 2 to 60 psi.

- Service pipelines, which connect to meters to deliver natural gas to individual customers. These narrow pipes are usually less than 2” in diameter, and carry odorized gas at low pressures, such as 6 psi.

Like electricity infrastructure, service and distribution pipelines exist throughout Berkeley. In a 7.3 magnitude earthquake along the Hayward fault, service and distribution pipelines will be exposed to violent shaking, as well as to liquefaction in the western part of Berkeley, earthquake-induced landslides in the Berkeley hills, and potential fault rupture along the fault line. All three of these hazards can rupture service and distribution lines, igniting and fueling and multiple fires.

In addition to service and distribution lines, transmission pipelines are also vulnerable to ground failure in a major earthquake. Map 3.11 uses blue lines to identify PG&E’s natural gas transmission lines. Per Map 3.11, significant portions of PG&E natural gas transmission lines lie in Berkeley’s Liquefaction Hazard Planning Zone. This zone identifies where future liquefaction is more likely to occur, but does not show effects of a particular earthquake scenario. In an earthquake, these soils need to be shaken hard and long enough in order to trigger liquefaction. If liquefaction does occur, pipelines located in liquefiable soils can tear apart. Residents or business owners in the direct proximity of such a pipeline could be heavily affected by a rupture.

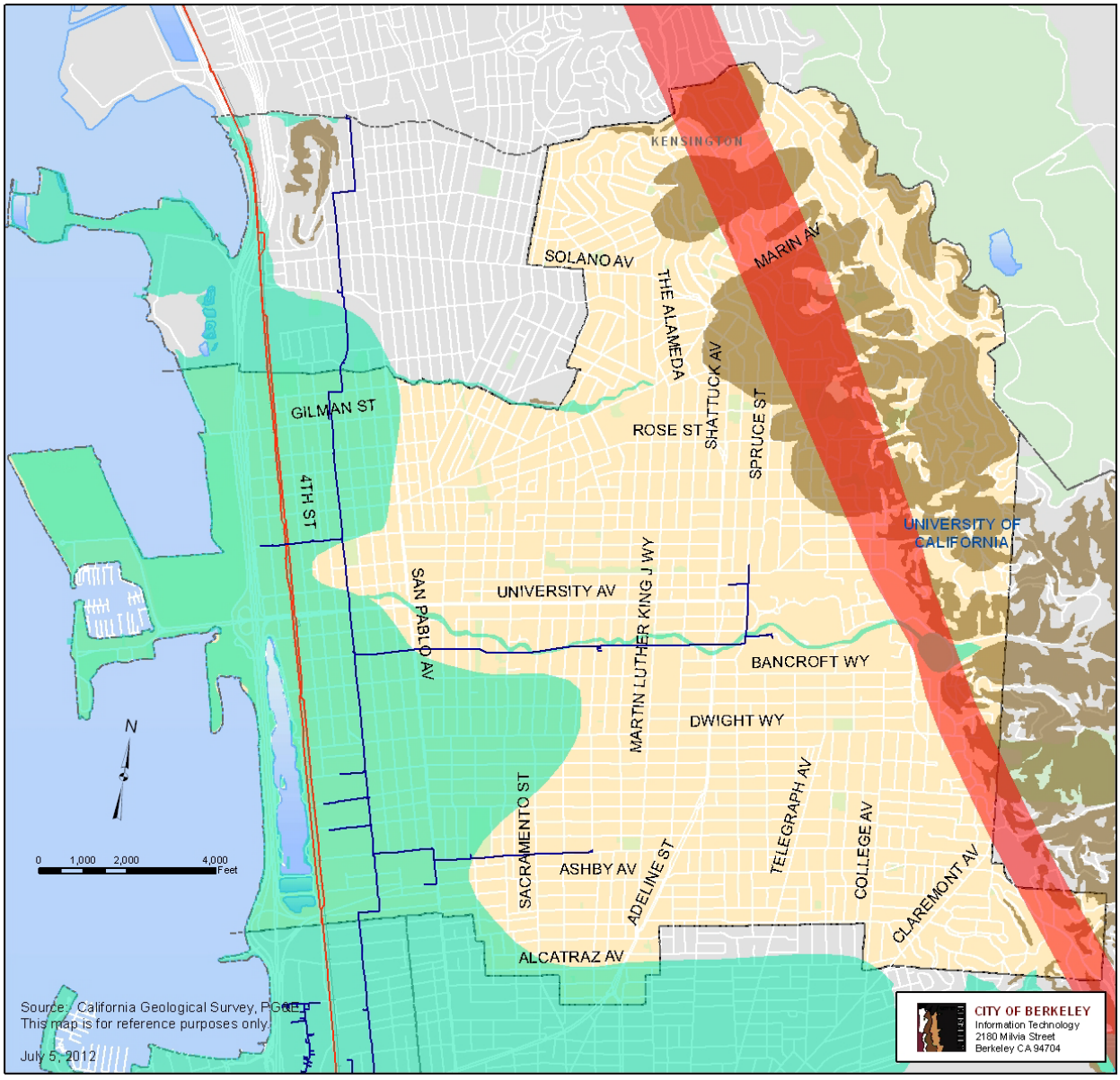
The natural gas transmission line runs the length of Berkeley (north-south direction) under Seventh Street. Nearly all of this stretch of transmission line lies within the Liquefaction Hazard Planning Zone.

- The Seventh Street transmission line branches out to the West in four locations, all of which lie in the Liquefaction Hazard Planning Zone: Grayson, Carleton,

Parker and Virginia Streets. The Virginia street branch runs almost all the way to the Eastshore Freeway.

- The Seventh Street transmission line branches out to the east in two locations, portions of which lie in the Liquefaction Hazard Planning Zone. The first is at Heinz Avenue, continuing onto Russell Street after passing San Pablo Avenue. The Liquefaction Hazard Zone extends east until Mabel Street. The transmission line ends where Russell Street crosses McGee Avenue. The second is at Allston Way. The Liquefaction Hazard Planning Zone extends to the Allston's intersection with San Pablo Way. The transmission line extends the entire length of Allston Way, to the edge of UC Berkeley campus at Oxford Street, where it splits. One short transmission line continues into the campus and the other follows Oxford Street north just past Hearst Avenue, where it ends.

Map 3.11 Seismic Hazard Planning Zones, Gas Transmission Pipelines and Jet Fuel Line



Earthquake Fault Zone
Landslide Zone
Liquefaction Zone
Gas Transmission Lines
Jet Fuel Line

Key Partner: Pacific Gas and Electric Company (PG&E)[28]

Pacific Gas and Electric (PG&E) provides electricity and natural gas to 15 million people in northern and central California. They have a staff of 20,000 prepared to respond to restore electrical service after disasters and storms. They also have a well-established priority system for restoring power to emergency services before other community needs. PG&E recognizes that large earthquakes may damage key facilities and that electric power might be lost for limited periods of time. The potential for a loss of power means that emergency and critical uses should have dedicated emergency power sources.

Natural gas is subject to damage and disruption in areas with soil failure, for example landslide and liquefaction. Broken lines can create fires if ignited until the fuel supply is exhausted. The repair of damaged underground lines will take time. Following the Loma Prieta earthquake it took about 30 days to repair damaged lines in the San Francisco Marina.

Key Partner's Notable Mitigation Activities

PG&E has assessed the seismic vulnerability of many elements of its system and has taken steps to improve its functionality after an earthquake, such as replacing bushings on high voltage lines, anchoring substation equipment and replacing old gas lines with more flexible alternatives.

As a consequence of the San Bruno rupture, the National Transportation Safety Board (NTSB) has issued a number of recommendations to State and federal administrations and institutions to improve the safety of pipeline networks as well as to upgrade the integrity management program and emergency response system[29].

As a result, PG&E has proposed $2.2 billion in pipeline upgrades through 2014 and outlined a Pipeline Safety Enhancement Plan to modernize its gas transmissions operations over the next several years. As part of this plan and in direct response to the recommendations issued by the NTSB, PG&E has begun improving its network by automating shutoff valves, with more automatic shutoff valves planned for Berkeley; updating its emergency response plan to reflect industry best practices; and implementing data management systems intended to ensure its pipeline records are traceable, verifiable and complete.

Additionally, PG&E has created a First Responders Safety website, which provides secure access to maps and information about natural gas transmission lines, natural gas storage facilities, and shut-off valves. The City's Information Technology department has incorporated this information into its GIS maps. Berkeley first responders have attended PG&E's First Responder Workshops to learn more about components of natural gas and electric utility infrastructure, as well as how to respond to natural gas hazards and avoid dangers presented by migrating natural gas and secondary ignition sources.

Aviation Fuel Pipeline

Map 3.11 shows in red lines the location of pipelines carrying aviation fuel. These pipelines run along the Union Pacific railroad right-of-way in the western part of the city. Per Map 3.11, soils in this area are potentially susceptible to liquefaction. Like with the PG&E natural gas transmission lines, rupture of these aviation fuel lines during an earthquake could spark and feed a dangerous fire.

Key Partner: Kinder Morgan Corporation[30]

Two aviation and multi-purpose pipelines run along the railroad tracks from Richmond to the Oakland Airport, through western Berkeley. The pipes are made of high-pressure welded steel, installed primarily in the 1960s, although a few segments were installed in the 1950s. The company has not conducted a study of the impacts of an earthquake on the Hayward fault. This type of pipeline, however, is known to have performed well, due to its ductile nature, in earthquakes elsewhere in the world. Kinder Morgan has focused on developing procedures to respond immediately after a disaster to shut down the pipeline. Each pipeline has automatic, remote control and other manual valves along its length and the flow can be shut down within minutes. Kinder-Morgan reported that after the 1989 Loma Prieta earthquake, these pipelines were shut down and monitored for leaks, breaks and changes in pressure. No damage was found.

Hazardous Materials Management

The shaking and ground failure that can accompany earthquakes could cause hazardous materials release. The City carefully tracks and regulates hazardous materials in both public and private structures through its Toxics Management Division. There are 376 sites in the city that store more than 55 gallons, 200 cu ft or 500 lbs accumulated hazardous materials and hazardous waste.[31] The majority of these sites are automobile-related facilities (e.g., facilities with motor oil), and medical facilities. To minimize the risk of release during an earthquake, the City requires engineering studies for facilities having extremely hazardous substances. These studies are discussed in more detail in Section 3.9: *Hazardous Materials Release*.

Transportation System Earthquake Vulnerabilities

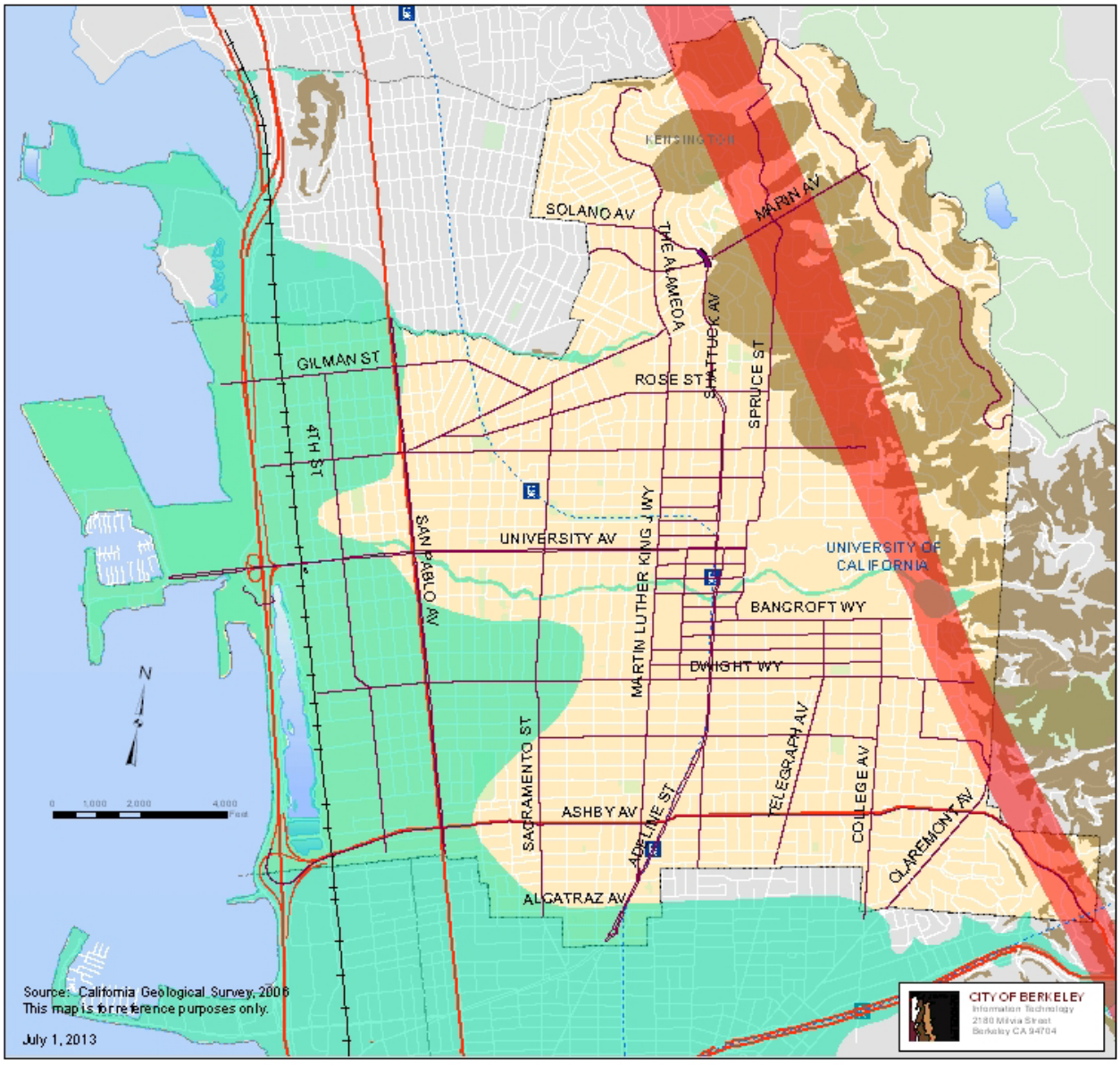
The table below shows key transportation system infrastructure in Berkeley, along with the agencies responsible for the systems.

Table 3.6 Key Berkeley Transportation Systems

Owner/Manager	Infrastructure
City of Berkeley	• Roads, curbs, paths and sidewalks • Traffic lights on poles, and above and below ground conduits supplied from the PG&E system • Traffic circles and islands • Sutter Street Solano Avenue tunnel • I-80 Pedestrian Bridge • University Avenue interchange approach structure and railroad crossing
Caltrans	• US Interstates 80 and 580 and freeway access structures at Ashby, University and Gilman streets in Berkeley, and at Powell and Buchanan streets in Emeryville and Albany owned by the State Department of Transportation • Tunnel Road/Ashby (State Route 13), and San Pablo Avenue (State Route 123)
Bay Area Rapid Transit District	• BART system, consisting of four miles of underground rails and three stations, at Adeline/Ashby, Center Street, and North Berkeley
Union Pacific	• Train tracks
Amtrak	• University Avenue passenger stop

Map 3.12 shows the location of major transportation infrastructure relative to seismic hazard planning zones. Designated evacuation routes[32] are indicated with purple lines. The Union Pacific railroad is indicated with a black hatched line along Berkeley's western shoreline. Interstate 80 and California State Highways 13 and 123 are indicated in red, running along Berkeley's western shoreline and traversing the southern end of Berkeley, respectively. The Bay Area Rapid Transit (BART) tracks are indicated in blue dashed lines, with station icons for the system's three Berkeley stations and the El Cerrito Plaza station in the City of El Cerrito provided for context. The Solano Tunnel, which provides a key north-south connection to vehicles in the eastern portion of the City, is indicated with a thick purple line.

Map 3.12 Seismic Hazard Planning Zones and Transportation Infrastructure



Railroad
State Highways
Emergency Access and Evacuation Routes
BART Stations
Solano Tunnel
Earthquake Fault Zone
Landslide Zone
Liquefaction Zone

Map 3.12 shows the potential exposure of all Berkeley's key transportation infrastructure to potential liquefaction, fault rupture and seismically-triggered landslides. The table below calculates the exposure of City-owned transportation infrastructure to each of these hazards.

Table 3.7 Curbs, Streets and the Solano Tunnel

Infrastructure Element	Total Length	Length in Hazard Areas		
		Earthquake-Induced Landslide Planning Zone	Fault Rupture Planning Zone	Liquefaction Planning Zone
Curbs	354 miles	44 miles (12%)	31 miles (9%)	93 miles (26%)
Streets	257 miles	42 miles (16%)	26 miles (10%)	68 miles (27%)
Solano Tunnel	0.09 miles	0 miles (0%)	0 miles (0%)	0 miles (0%)

Map 3.12 and Table 3.7 together indentify key areas of exposure within Berkeley's transportation infrastructure.

Over one quarter of all City streets are in the liquefaction hazard planning zone, meaning that vehicle movement in the western part of the city is likely to be impacted by liquefaction-caused earth movements in a major earthquake. This movement will also affect aboveground infrastructure (streets, curbs and sidewalks.) Transportation infrastructure west of Interstate 80 is especially vulnerable to liquefaction. Per Map 3.6, in a 7.1 Hayward Fault earthquake, 73 percent of this area is expected to liquefy. Transportation infrastructure in the area could be severely damaged. Additionally, emergency services vehicles may not be able to access the area, at least until the University Avenue overpass is inspected for damage.

One-quarter of City curbs are located in the Liquefaction Hazard Planning Zone. Curbs serve as water barriers to property when it rains, curbs function as part of the drainage system. If curbs are impacted by ground failure from an earthquake, they lose their ability to function in this way.

To the city's east, 16% of City streets are situated in the earthquake-induced landslide planning zone. Landslides in this area could distort major and minor roads. This would make access difficult or impossible for firefighters and other emergency responders. It would also complicate evacuation for hills residents.

Fault rupture, if it occurs, could damage important east-west streets along the fault, making travel between the hills and flatland areas difficult where displacements are large.

The Solano Tunnel is an important connection in the north-south direction. It is not located in a hazard planning zone. However, it is situated in the direct proximity of the Fault Rupture Planning Zone, as well as the Earthquake-Induced Landslide Planning Zone. Should one of these hazards occur, access to Solano Tunnel could be limited or even impossible.

Key Transportation Partners

Partner-run transportation systems have varying levels of exposure to seismic hazards.

Map 3.12 shows that Interstate 80 sits entirely in the liquefaction hazard planning zone. Additionally, the liquefaction scenario map (Map 3.6) shows that in a 7.1 magnitude earthquake on the Hayward fault, 73% of the ground underneath Berkeley portions of Interstate 80 is predicted to liquefy. This is a major thoroughfare for Berkeley and the Bay Area overall.

Caltrans[33]

Caltrans is responsible for constructing and maintaining the statewide highway system. The 1989 Loma Prieta earthquake caused significant damage to Caltrans structures, such as bridges, overpasses and on-ramps. As a result, Caltrans launched a comprehensive review of earthquake safety on highways throughout the state. A program to retrofit all vulnerable structures was started and the two overpass structures in Berkeley, at Ashby and University Avenues, have already been strengthened. These retrofits were designed to prevent collapse in a major earthquake, but will not guarantee that these structures can be used after an earthquake. Depending on damage levels, demolition may be required. Caltrans also strengthened the City-owned approach ramps to the overpass on University Avenue to the same standards. Caltrans emergency response teams are trained to inspect their facilities and manage some elements of traffic flow after a major earthquake.

The City owns a portion of a structure at University Avenue that provides access to the state-owned interchange structure connecting to Interstate 80. The City portion of this structure extends over the railroad tracks and west to ground level. Caltrans owns the eastern portion. Caltrans retrofitted both the state-owned and City-owned structures in recent years to high standards of safety.

Bay Area Rapid Transit District (BART)[34]

The Bay Area Rapid Transit District (BART) provides an important public transportation link between Berkeley, San Francisco, and other Bay Area locations to 360,000 riders daily. In the 1960s, Berkeley taxpayers issued a separate tax to have the BART facilities in Berkeley (three stations and over four miles of tunnel) put underground, and these tunnels are generally considered low risk by BART engineers.

According to Map 3.12, within Berkeley, the BART system is not exposed to ground failure from earthquakes. However, Map 3.2 shows that BART infrastructure in Berkeley will be subject to violent shaking in a 7.3 magnitude Hayward fault earthquake.

Key Partner's Notable Mitigation Activities

In 2002 BART completed a study of the earthquake vulnerability of the entire system, analyzing multiple earthquakes, predicting damage, and assessing cost-effectiveness of retrofits. Upgrades to the system are being funded by $980 million in General Obligation Bonds, authorized by voters in Alameda, Contra Costa, and San Francisco counties, supplemented with an additional $240 million from other sources. Since 2008, retrofit has been completed on many elevated tracks, stations, parking structures, and rail yards. Work to upgrade the Transbay Tube seismic joints was completed in 2010. BART is continuing to secure the Transbay Tube to a higher level of strength against future large earthquakes. The current effort is expected to be completed in 2014. Evaluations of several other areas of the Tube are ongoing and further retrofits may be constructed in the future. At this time, those retrofits are expected to be completed in approximately 2018.

As part of the vulnerability study, BART determined that the Berkeley Hills Tunnel which crosses the Hayward fault may be damaged in an earthquake on that fault, cutting a key commuting link. Initial evaluations determined that retrofit or replacement of this tunnel were not viable options. BART continues to study the feasibility of adequately strengthening the tunnel but as yet there is not a retrofit solution that can appropriately achieve this goal. Therefore there are no current plans to perform retrofit construction on the tunnel. BART will however be prepared with materials and crews to respond quickly to any damage that may occur in an earthquake.

BART's investment in earthquake retrofit is strengthened by its earthquake early warning system, which can help prevent train derailments in the system by slowing or stopping trains upon notification of an earthquake. Currently, BART has a system in place, which is activated when an earthquake larger than magnitude 4 or 5 is experienced within the BART system. BART is working with UC Berkeley and others to implement a statewide earthquake early warning system. This system would issue notification to operators such as BART upon detection of P-waves.[35] Upon notification, BART would automatically slow or stop trains within the system. The length of advance warning depends on how far away the earthquake originates.

Communications System Earthquake Vulnerabilities

The table below shows key communications system infrastructure in Berkeley, along with the companies responsible for the systems.

Table 3.8 Key Berkeley Communications Systems

Owner/Manager	Infrastructure
AT&T	• Land line telephone distribution system that shares poles with PG&E in some locations and is located underground in other locations
Comcast and other companies	• Cable systems that share poles with PG&E in some locations and are located underground in other locations
Verizon, Sprint PCS, Nextel and other companies	• Cellular telephone antennae distributed throughout the city

Communications infrastructure is spread throughout Berkeley, and thus is exposed to all earthquake ground failure hazards.

Telephone and cable communications systems are almost entirely aboveground in Berkeley. Earthquake shaking can topple or break utility poles, and falling trees or collapsing structures can damage utility lines.

Additionally, Berkeley's underground utilities include communications conduits. Underground systems are particularly vulnerable to damage from ground failure in earthquakes. Displacement on the Hayward fault could rupture these systems, compromising these lifelines unless redundant connections unaffected by the earthquake are available. Ground movement due to liquefaction in the west and landslides in the east will also severely impact these systems. Liquefied areas may move laterally, breaking underground cables and damaging communication lines. Landslides can damage underground and aboveground communications infrastructure during earthquakes, or in separate slides that can occur for weeks or months following an event.

Underground damage is harder to detect and repair and the length of service losses may be greater than for aboveground systems.

Key Communications Partners

AT&T[36]

AT&T provides and maintains telephone service to Berkeley residents, along with internet access, Uverse Television Service, mobile telephone service, and other business services. The telephone wires, conduits, coaxial cables and fiber optic lines have been tested and designed to be highly resistant to earthquake shaking, and easy to reroute

should problems occur. For example, slack is provided in underground cables to permit earth movement without damage. All AT&T facilities have batteries that can run for four hours without electrical service, and many diesel generators are available to supplement the batteries if needed. Minimal water is required to keep the electrical equipment from overheating. AT&T expects some telephone outages, including mobile phone service, after a major earthquake, and service restoration would take hours to days, depending on location and the situation. A major earthquake could impact service in a 50 square mile radius. The central office in Berkeley, with major equipment, has been seismically strengthened, but it is possible that neighboring buildings that have structural deficiencies could collapse into this building and cause damage. If the central office building was completely destroyed, portable equipment and trailers could quickly reestablish service. AT&T is prepared to set up additional phone lines open to the public at a central location if major service losses occur.

The AT&T Network Disaster Recovery (NDR) team has managers, engineers, and technicians who receive special training in physical recovery of AT&T's network. Members participate in several recovery exercises each year to test, refine, and strengthen AT&T's business continuity and disaster response services in order to minimize network downtime.

AT&T's Network Disaster Recovery organization is responsible for the rapid recovery of service at AT&T sites following a catastrophic event.

In the case of an event or disaster the NDR has three primary goals:

1. Route noninvolved telecommunications traffic around an affected area
2. Give the affected area communications access to the rest of the world
3. Recover communications service to a normal condition as quickly as possible through restoration and repair

AT&T won Frost & Sullivan's 2010 Product Leader Leadership of the Year Award for Business Continuity and Disaster Recovery Services in North America.

Verizon Wireless[37]

Verizon Wireless serves its individual, government and business customers with voice and/or data services via Verizon's wireless cellular network.

Verizon has designed and built its network with day-to-day reliability and disaster resilience in mind. Since inception, all Verizon Wireless facilities in California have been built to the most stringent California building codes. Verizon also follows an internal Network Equipment Building System standard. Since 2004, Verizon has hardened its network by moving two of its Bay Area switching facilities to newly-constructed facilities. These facilities meet or surpass all then-current earthquake standards; they also provide additional redundancy with respect to capacity for battery back-up, generators,

fuel and HVAC. The facilities also have increased security through design and alarming capabilities. All major transport facilities (i.e., the links between switching facilities, network hubs, the internet, etc.) are fully redundant either through SONET Ring architecture or diverse path routing.

Verizon Wireless has worked with the City to place all 13 of its Berkeley cell site facilities. In the Verizon Wireless Northern California network, about two-thirds of all sites have permanent generators. This represents an approximately 250 percent since increase since 2004. In Berkeley in particular, cell site facilities have relatively few generators, with only 2 of the 13 sites so equipped.

In a disaster, Verizon's basic service mission does not change. However, it is understood that the network may be damaged from the impacts of a disaster, such as an earthquake, and that the demand on the network will simultaneously rise. In this case, the mission of Verizon Wireless will be to:

1. Restore and/or enhance the network as quickly as possible, to the greatest extent possible.

2. Assist with local communities' wireless communications needs to the greatest extent possible to enhance public safety and relief or rescue efforts.

Verizon's local network group trains and drills for disaster events, and local personnel have aided recovery efforts for other disasters outside the area, such as Hurricanes Katrina and Sandy. In the event of a disaster, Verizon makes the resources of the entire company available locally.

Comcast[38]

Comcast provides the following services to the Berkeley community:

- Voice (wireline telephone service)

- Video (television)

- Data (high-speed Internet, Wi-Fi hotspots, cellular backhaul services)

- Home security/home automation

Comcast's distribution telephony network depends on other communications providers. If supporting providers' networks are operational, Comcast will maintain connectivity to all its customers. If an individual network fails, Comcast will lose its connection to the customers using that particular network.

To protect its infrastructure in earthquakes and other disasters, Comcast has hardened all its sites. Additionally, all sites are connected via redundant fiber networks to maintain service to greater service areas. Major metro fiber routes are backed up by redundant routes and failover technologies.

After a catastrophic earthquake, due to facility redundancy of backbone/regional networks, Comcast expects that transport of major traffic should continue. However, local serving areas are more likely to experience gaps in service due to lessened redundancy between headend facilities[39] and customer homes.

In the event of a power outage, Comcast will use battery backup to maintain service for up to eight hours. Comcast monitors its power supplies, and in the event of the backup batteries being depleted, generators are in place to maintain service.

Comcast's ability to recover from facility damage after an earthquake will be determined by its ability to access headend locations, as well as to refuel generators if commercial power is lost. Customers may experience a total loss of video service, and total loss or severe network congestion of voice and data services. Comcast also provides cellular backhaul services[40] for Verizon Wireless. Impacts to Comcast's infrastructure could potentially impact Verizon's service to its customers.

Critical Response Facilities

In addition to the infrastructure mentioned above, a key network of facilities supports disaster response activities. This network includes facilities owned by the City, as well as others owned by the City's key partners. Map 3.13 shows the locations of these facilities relative to seismic hazard planning zones. Because these facilities serve the whole Berkeley community on a day-to-day basis, they are positioned throughout the City.

Recognizing that these facilities will need to be as usable as possible following a catastrophic earthquake, the City has put major effort into ensuring seismic stability of these buildings:

- The Public Safety Building was built in 2000 to essential services standards. This facility houses the Police Department Headquarters and 9-1-1 Communication Center, the Fire Department Headquarters, and the City's primary Emergency Operations Center.

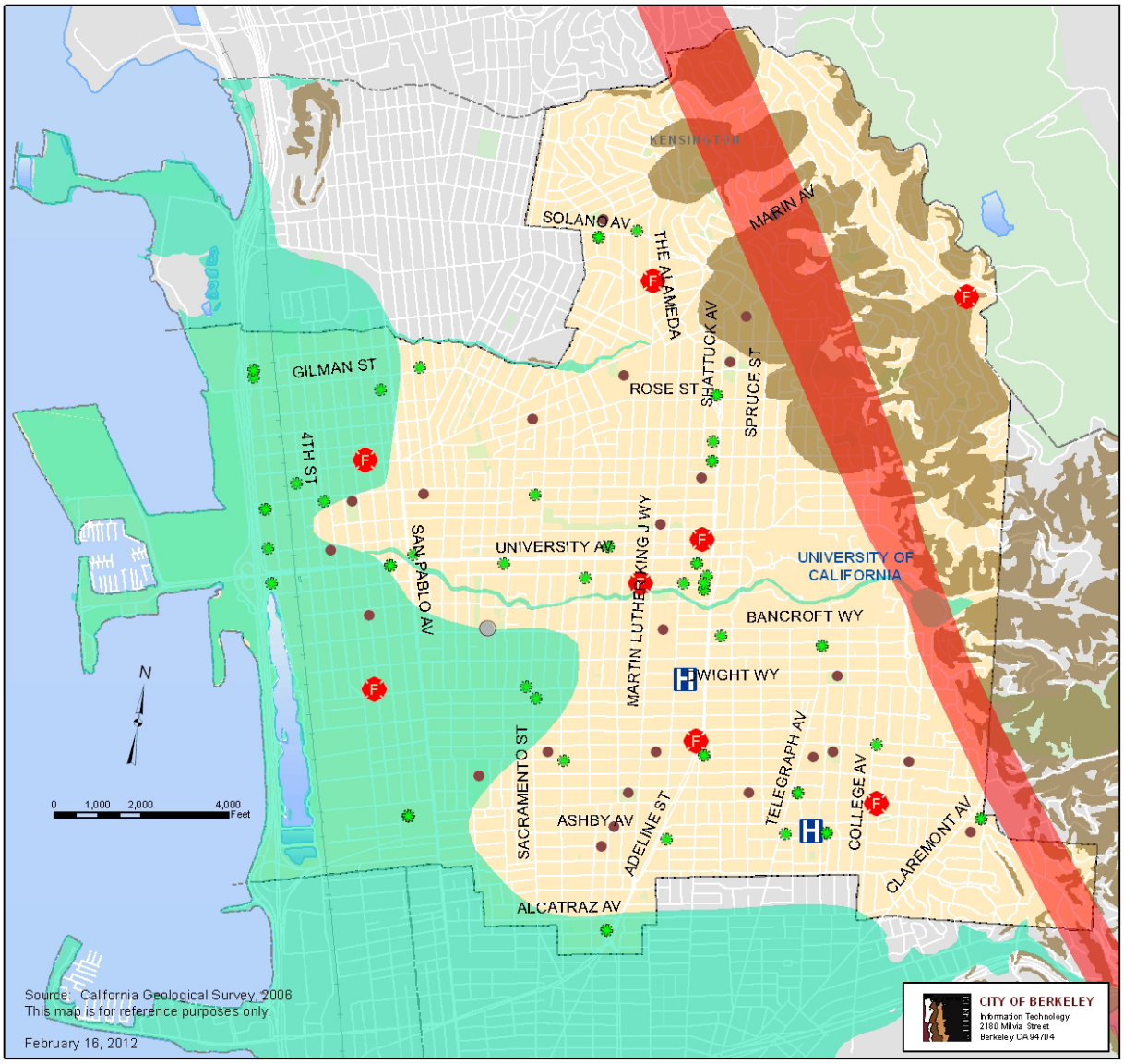
- The City's seven fire stations have all been retrofitted or built to essential services standards.

- City libraries serve as community gathering points both prior to and following disasters. The City's Main Library, which underwent a complete retrofit in 2002, is planned for use as a disaster volunteer reception center. In 2009, the Branch Library Improvement program began work to renovate the City's four branch libraries for seismic safety.

- The Civic Center Building's isolation system and retrofit elements were designed to provide life safety and limited repairable damage in a Design Basis Earthquake (DBE), and life safety and repairable damage in the Maximum Considered Earthquake (MCE). Although the building's base isolation system would meet the essential services standard of the 2010 California Administrative Code, the building was not built to essential services standards. The nonstructural systems and equipment in the Civic Center Building would need to be evaluated to ensure that their support and bracing systems also meet essential services requirements. Nonstructural elements along the access path to the essential services area should also be evaluated to ensure unobstructed access to these areas in the aftermath of an earthquake.

- City recreation centers and senior centers are considered potential disaster shelter sites. All of these sites need to be evaluated for their seismic resistance and vulnerabilities. Appendix B: *List of City Owned and Leased Buildings* details construction history and condition of City facilities.

Map 3.13 Seismic Hazard Planning Zones and Critical Facilities



Fire Stations
Hospitals
Schools, Rec. & Senior Centers
Corporation Yard
Telecom Antenna
Earthquake Fault Zone
Landslide Zone
Liquefaction Zone

Key Critical Response Facility Partner: Hospitals

Hospitals are not operated or owned by City government, but they are critical to disaster response: Following an earthquake, hospitals must be able to care for not only their existing patients, but also a surge of new patients who are injured in the earthquake.

In 1973 as a direct result of the devastation caused by the 1971 San Fernando earthquake (65 deaths and a hospital collapse), the State Legislature passed the Alfred E. Alquist Seismic Safety Act. The Act requires every hospital in California with acute care patient facilities to be built to higher standards than other buildings so they can be reoccupied after major earthquakes. Eleven years later, following the 1994 Northridge earthquake, Senate Bill 1953 expanded the scope of the 1973 Act, requiring:

- By 2002, all critical non-structural components in surgery and emergency medical rooms be retrofitted;
- By 2013, all hospital buildings built before 1973 be replaced or retrofitted so they can reliably survive earthquakes without collapsing or posing threats of significant loss of life; and
- By 2030, all existing hospitals (including those built after 1973) be seismically evaluated and retrofitted, if needed, so they are reasonably capable of providing services to the public after disasters.

The Office of Statewide Health Planning and Development develops and regulates seismic performance standards for hospitals.

Alta Bates Summit Medical Center[41]
There is one acute care hospital in Berkeley, Alta Bates Summit Medical Center, owned and operated by the Sutter East Bay Hospitals. The hospital has two campuses in Berkeley, Alta Bates and Herrick.

The Alta Bates campus is a full service acute care hospital, while the Herrick campus provides acute care limited to rehabilitation services. Alta Bates is comprised of eight buildings used to provide acute patient care, five of which were built to pre-1973 seismic standards. These buildings are not considered a threat to life safety, but may not be functional or repairable after an earthquake.[42] The Hospital Seismic Safety Act requires these buildings to be retrofitted or replaced by 2030 to meet standards to be repairable or functional following an earthquake. Three additional buildings at Alta Bates and three at Herrick have already met this standard.[43] Four buildings at the Herrick Campus contain acute care facilities and are considered to be a significant risk to life safety. [44] The acute care functions housed in these buildings are all being relocated into seismically compliant portion of the Herrick campus prior to the end of 2013.

UC Berkeley Tang Center
The Tang Center is a fully-accredited ambulatory health facility serving the students, faculty and staff of the University of California, Berkeley. The Center provides medical

care, including primary and specialty services, supported by a pharmacy, high complexity CLIA-certified lab, physical therapy, immunization/travel services, a medical records department, radiology services and advice nurse access. The Center also offers counseling, social services and psychiatric care to support students' academic success.

The Tang Center's disaster response role depends on the needs at the time of the event. In a localized emergency, the Center may provide for members of the campus by addressing mental health needs, distributing vaccinations, assisting with relocation, or by providing other support services. In a catastrophic earthquake, the Tang Center will use available resources to triage and care for campus persons, but the Center will require additional resources to care for large numbers of people who may present. By providing care on campus, the Center will help to reduce demand on local emergency rooms from people who do not need tertiary care.

The Center coordinates its disaster readiness activities with both the City of Berkeley's Public Health Division and the Alameda County Public Health Department. Relationships between these entities have been built over many years, establishing the understandings and relationships that will support effective disaster response.

In 1993, the Tang Center was constructed to an essential facilities standard, due to both its health-related mission and its then-designation as a backup Emergency Operations Center for the campus.[45] Since then, the Center has taken nonstructural mitigation steps to reduce the risk of injury to patients and staff during an earthquake, and to speed the Center's ability to return to function following an earthquake.

To secure access to electronic health records, the Center moved its clinical management system to a hardened data server on campus, and is arranging a "hot" standby server out of the area.

The Center has located shipping containers adjacent to the building to store to medical supplies to support basic triage immediately following a major earthquake.

This fall, the Center and the City's Public Health Division successfully tested their two-way communications capability via the California Health Alert Network. They also participate in planning and drills for various emergency scenarios, including loss of water and power.

Currently, the groups are developing a Memorandum of Understanding to store a cache of State disaster medical supplies on campus.

Lifelong[46]

LifeLong delivers comprehensive medical, dental, mental health and social services to help low-income people of all ages in Contra Costa, Marin and Alameda Counties. LifeLong currently operates 11 primary care health centers, two dental clinics, two school-based health centers and six supportive housing sites. In 2012, LifeLong served over 43,000 patients in 224,193 encounters.

LifeLong's programs and services are designed to give everyone a chance to live a healthy life, including individuals and families who are struggling to get by. As a safety-net provider of health services, LifeLong aims to address gaps and promote wellness throughout the communities it serves. Services are designed for people who have difficulty accessing care through traditional paths, due to factors such as lack of insurance, homelessness, or cultural and linguistic barriers.

Lifelong's Berkeley facilities and their services to the community are described in the table below:

Table 3.9 LifeLong Berkeley Healthcare Facilities

Name	Service Type	Community Members Served
Berkeley Primary Care	Primary Care Health Center	2,500+ patients/month
LifeLong West Berkeley	Primary Care Health Center	3,000+ patients/month
Over 60 Health Center	Primary Care Health Center	1,800+ patients/month
LifeLong Dental Care	Dental Clinic	700+ patients/month

Following a disaster, LifeLong plans to coordinate with local hospitals to provide care to an anticipated surge of patients. LifeLong expects that an influx of new patients from surrounding neighborhoods will seek care at its sites, and that in the event of a disaster it will need to perform more basic first aid and trauma management at its facilities. To this end, LifeLong plans to care for the "walking wounded and worried well," while sending its urgent care patients to hospitals.

Notable Mitigation Activities

Many facilities were seismically retrofitted prior to 2004, to help make facilities ready to provide care following an earthquake. Currently, the LifeLong West Berkeley Health Center is undergoing major renovation to expand and enhance service to patients. This construction includes both structural and nonstructural mitigation efforts.

LifeLong actively coordinates with local government on disaster readiness activities. LifeLong participates in Alameda County's regular disaster preparedness meetings, and is working with the County on an MOU that would identify LifeLong a County partner in disaster response. LifeLong also exercises communication capabilities with the City during Statewide disaster drills.

Additionally, LifeLong works to increase disaster readiness through community groups. Through the Heart 2 Heart (H2H) program, LifeLong worked with the City and other partners to help the McGee Avenue Baptist Church to become eligible for a disaster equipment cache, which was awarded by the City. H2H is currently collaborating with other community groups in the Oregon Park neighborhood on disaster readiness

activities. Most recently, LifeLong awarded an H2H mini-grant to the Collaborating Agencies Responding to Disasters (CARD) organization.

Key Critical Response Facility Partner: Public Schools

Public schools are not operated or owned by City government, but they are critical to disaster response: they may be used for temporary sheltering of people displaced from their homes following an earthquake. Schools also support disaster recovery, providing a welcome return to normal routines for children, and childcare so that parents can rejoin the workforce.

Unlike laws and regulations for privately-owned buildings, there is a statewide approach to retrofitting and upgrade of existing schools, which must meet special earthquake design standards. The Division of the State Architect is the review agency for the design and construction of public K-12 school facilities in California. The Field Act, originally passed in 1933, regulates the design, construction and renovation of public school buildings, and the inspection of existing school buildings. Many subsequently adopted State laws, amendments to the Field Act, and supplementary laws, call for additional safety measures for all public K-12 schools in the state. California has the most stringent safety codes for school buildings in the U.S.

Up until June 30, 2006, community colleges had to comply with the Field Act. In 2006, Assembly Bill 127 was passed, giving community colleges the option of choosing to design and construct under local building codes or under the Field Act.[47]

Only some charter school buildings are subject to Field Act provisions. Many school and building officials are unclear about the rules that apply when the Field Act does not.[48]

Berkeley Unified School District[49]

The Berkeley Unified School District, a special local government district, manages primary and secondary education and educational facilities, including all public schools in the city. City government provides police and fire services to the District, but has limited authority over these structures.

In 1989, shortly after the Loma Prieta earthquake, the District hired engineers to evaluate the structural safety of the buildings. Engineers found significant problems at many schools. The District's Board took swift action. Within a year, the District closed a number of schools, took precautionary measures at ones that remained open, and developed a plan of action to correct safety problems within the District as a whole.

Local voters have approved several bond measures to renovate and modernize city schools. In June 1992, local voters approved a bond measure to raise taxes to provide $158 million to renovate and modernize the city's schools. In November 2000, voters approved another supplemental bond measure for the safety program totaling an additional $116.5 million. In the years since voters approved the original tax measure, all of the schools identified by the engineers have been seismically strengthened or demolished and replaced.

Notable Mitigation Activities

As of 2013, all District pre-K, K-12, adult, transportation, and administration buildings requiring retrofit under the Field Act and subsequently adopted State safety laws have been retrofitted.

In November 2010, Berkeley voters approved Measure I, funding improvements to school safety and facilities. Seismic work funded by the measure includes:

- Demolition of the Old Gymnasium at Berkeley High School.
- Replacement of the unreinforced masonry building at the BUSD corporation yard that functions as its maintenance facility (due to begin work in 2016).

In 2012, the District moved its administrative offices out of the seismically-unsafe Old City Hall and into a newly-renovated building on Bonar and University.

In addition, as the building code becomes more stringent, Berkeley continues to improve the seismic safety of its schools. For example, Berkeley plans to do a voluntary upgrade of the Jefferson Elementary School over the next two years.

Berkeley City College[50]

Berkeley City College is a community college serving about 4,500 students in downtown Berkeley. It recently constructed a new building on Center Street to serve as its permanent home. This building, funded by two local bond measures, is a state-of-the-art facility meeting the latest seismic and fire safety codes. The building's primary Emergency Operations Center (EOC) is located in the Auditorium, Room 021 and Atrium. Its secondary EOC is located in the Learning Resources Center. The EOC will be connected to the Alameda County Sheriff and the Peralta Community College district headquarters through short-wave radio.

UC Berkeley Campus

UC Berkeley is a major institution separate from the City but located at its core. 36,000 students, 2,100 faculty and over 11,000 staff work or study on campus.[51] The Hayward fault runs through the eastern half of the UC Berkeley campus, and beginning in the early 1970's, the University began earthquake vulnerability studies and retrofit projects, championed by senior University officials. In the early part of 1997, the campus reassessed the condition of its buildings and began an effort to comprehensively address its seismic risk. The SAFER Program (Seismic Action Plan for Facilities Enhancement and Renewal) was launched through Chancellor Robert Berdahl and Vice Provost Nicholas Jewell. A 1997 structural survey of existing campus buildings revealed that about 27 percent of the building space could perform poorly in a major local or regional earthquake.[52] These findings led to SAFER effectively becoming a physical renewal plan for UC Berkeley's built environment. Since 1997, $500 million worth of seismic improvements have been made to campus buildings and, as of early 2006, work has been completed or started on 72 percent of the square footage identified as needing seismic improvement.[53] The seismic improvement work completed at UC Berkeley has reduced

by half the life safety risks for students, faculty, and staff and has cut the risks of potential earthquake-caused economic losses by 25 percent.[54] Planners and executive staff also devoted attention to a wide range of disaster preparedness efforts, ranging from emergency preparedness to facilities and lifeline planning, along with a robust financing strategy.[55]

The City and the University have independent disaster planning programs. However, their risks are inextricably intertwined. A significant portion of UC Berkeley students, faculty and staff live in the city and rely on Berkeley's private industries, housing, and infrastructure. The city's condition after a disaster directly impacts the ability of the University students, faculty and staff to continue their work. Likewise, the city depends on the jobs, commerce, and income created by the University. This means that the viability of University labs, research and other facilities after a disaster has a large influence on the current way of life. The University depends on the City's fire, search and rescue, and hazardous materials emergency services for the campus. Therefore, the risk of fire and catastrophic building collapses on campus directly impacts the capacity of the City's emergency responders. It is in the mutual interest of both the City and the University to coordinate disaster readiness efforts.

Berkeley Lab[56]

Berkeley Lab serves as a host for and employer of 4,200 scientists, engineers, support staff and students, and some 2,000 participating guests annually.

Berkeley Lab is located northeast of the UC Berkeley campus, on hill slopes adjacent to parkland. Parts of the Lab are located in the planning zones for fault rupture and earthquake-induced landslide. However, geologic investigations have indicated that the campus is not vulnerable to fault rupture, and buildings are not vulnerable to landslides.[57]

Berkeley Lab has an in-house, ongoing program to regularly review and update information on the seismic condition of its buildings. Several buildings have been strengthened in the last two decades due to the findings of these assessments. Non-structural mitigation safety measures are part of Berkeley Lab policies and procedures, and are inspected regularly.

The Lab's emergency management function is administered through the Berkeley Lab Emergency Services Program. The mission of the Lab's Emergency Services Program is to prepare for, respond to, recover from, and mitigate all natural or manmade hazards to Berkeley Lab.

Berkeley Businesses

Businesses are vital to the economy of the city and provide jobs to city residents. Ensuring that businesses and employers can return to normal function quickly will in turn ensure that the city recovers quickly from a disaster.

Table 3.10 Ten Largest Berkeley Employers

Employer	Number of Employees
University of California, Berkeley (Oct. 2012)	21,809
Berkeley Lab (website)	4,200
Alta Bates Medical Center (2012)	2,621
City of Berkeley[58]	1,301
Berkeley Unified School District	1,194
Bayer Corporation	1,350
Kaiser Permanente Medical Group	819
Berkeley Bowl[59] (2011)	768
Berkeley YMCA	358
Berkeley City College	281

3.3.4 Earthquake Risk and Loss Estimates

No one knows what the characteristics of the next damaging quake to strike Berkeley will be. A quake could occur on any of the regional faults, be deep or shallow under the ground, and shake for a few seconds or up to nearly a minute. The degree of shaking and resulting damages will vary greatly depending on these characteristics.

However, FEMA developed the Hazards US (HAZUS) software to help estimate the consequences of different earthquake scenarios. HAZUS runs a computer model of a hypothetical earthquake, defining the earthquake's magnitude, epicenter location, rupture mechanism and time of day. Using this information, HAZUS estimates losses for that particular earthquake. **These theoretical losses will not exactly predict the actual damage of the scenario earthquake.** Instead, they provide reasonable data to help guide earthquake readiness activities.

Scenario Predictions
For the 2004 version of this plan, a magnitude 6.9 scenario earthquake on the Hayward fault underneath Berkeley was simulated using HAZUS.[60] These 2004 loss estimates have been combined with impact descriptions from newer HAZUS scenarios for a larger earthquake.[61] Together, these scenario descriptions create a broad picture of the impact to Berkeley from a catastrophic earthquake. HAZUS predicts:

- One hundred people in Berkeley could be killed by this earthquake. Fifty more will be in critical condition requiring urgent medical care. Three hundred additional people will need hospitalization and 1,000 people will require first aid.

- In the first day following the earthquake[62], fires could ignite in six to twelve[63] different locations around the city. The City's Fire Department is equipped to respond to one two-alarm fire or two single-alarm fires simultaneously. Outside fire departments may not be able to provide mutual aid. Emergency personnel will be stretched thin fighting these fires and may need to use a temporary, aboveground water supply system to pump water from the Bay. Fire could burn for hours or days in a worst-case scenario. Post-earthquake fires could add $30 to $60 million[64] of damage to structures in Berkeley.

- Following the earthquake, the city will need to remove and dispose of up to 570 tons of debris, consisting of building materials, personal property, and sediment will be generated by the earthquake. "Traditional" household waste volumes will also increase due to large amounts of spoiled food resulting from power outages and other debris from residential cleaning. Equipment beyond the current capacity of the region's private waste management companies will be needed to clear debris. Transportation routes will need to be cleared and restored to move debris out of damaged areas. Before heading to landfill or recycling areas, debris must be sorted at separate facilities. A key challenge will be the disposal of large amounts of contaminated, electronic, and hazardous materials waste. Landfill space is scattered throughout the region.

Buildings

Over $1.8 billion[65] of building damage could occur in Berkeley. Commercial corridors will see damage to URM buildings. Damage to tilt-up buildings will impact businesses in the western area of the city. Soft-story buildings, which are situated throughout Berkeley, will be damaged. 620 buildings will be completely destroyed. 21,000 more will have slight to moderate damage, primarily residential structures.

From 3,000 to 12,000 households will be displaced from their homes after the quake. About 200 more families will be forced to leave their homes due to fire damage. This represents up to a quarter of households in the city. One thousand to 4,000 of those households will seek temporary shelter provided by the City and the Red Cross. The remainder may stay with friends, relatives or in hotels.

Low-income and student populations disproportionately live in soft-story multi-unit apartment buildings, older buildings with weak foundations, and other vulnerable types of structures. Much of the damage to residential structures will occur in housing for these populations.

Infrastructure

Sanitary Sewer System

Interceptors (sewer pipes) will suffer major damage following an earthquake. Loss of electrical power will render pumping plants unusable, causing sewage backups and spills through the street access holes, posing potential public health concerns. Open trenches may be necessary to carry sewage for short distances. Sewer pipeline breaks may cause "sinkholes" that undermine roads and buildings.

Water System

Water service is likely to stop functioning in up to 70% of Berkeley homes within 12 hours of the earthquake, when local reservoirs and tanks drain and are not resupplied. Although most water service will be restored within 10 days[66], water outages will last up to 50 days, with residents needing to purchase bottled water or collect water from tanker trucks at central locations.

EBMUD serves Alameda County and has strengthened its water treatment plants and major aqueducts. Of particular concern, however, are underground pipes, which distribute water from larger aqueducts to customers. The buried pipes will be particularly vulnerable to breakage in areas of major liquefaction such as in Richmond and Oakland along the Bay. EBMUD's Claremont Tunnel has been seismically retrofitted and is not likely to be vulnerable to landslide. It may incur fault offset of up to 7.5 feet immediately but this effect has been incorporated into the mitigation design.[67]

Electricity

Immediately following the earthquake, 29,000 homes, more than 60% of Berkeley households, will be without electricity. Power will be down for days to a week. The majority of electrical power in the region is transmitted by Pacific Gas & Electric Company (PG&E). Most of PG&E's electrical substations in the Bay Area were built in

the 1900s and 1920s. Although mitigation efforts have been made, significant damage to these buildings is expected. Underground cables that cross liquefiable and weak soils are vulnerable. Immediately after the earthquake, PG&E is likely to initiate power shedding to balance the grid, followed by a progressive blackout of the Bay Area to prevent cascading power failure.

Damaged sections in the transmission and distribution system will need to be repaired or bypassed. Before electrical circuits are energized, inspections for gas leaks in impacted areas will be necessary. Under the normal circumstances, it takes 2 to 3 days to restore a transmission system. Impeded accessibility as well as workforce shortages will, at the minimum, double restoration times.

Natural Gas

PG&E is the provider of natural gas in the Bay Area. Across the Bay Area, ground failure is expected to damage the network of pipes beneath city streets. Hundreds of breaks in mains, valves, and service connections will occur. Broken gas mains could fuel street fires. Structural fires will occur as a result of broken service connections.

Restoration of service across the Bay Area could take as long as two months for customers because individual connections will need to be inspected and appliances re-lighted. Most gas shutoffs are expected to be initiated by cautious customers.

Hazardous Materials Management

Building structural failures, dislodging of asbestos or encapsulated asbestos, laboratory spills, transportation accidents, pipeline breaks, storage tank failures, and industrial equipment problems will be the major sources of hazardous materials accidents following an earthquake.

Transportation

Highways

In Oakland, Highways 580, 880, 980, and 24, where they form the MacArthur Maze, a complex of elevated interchange structures, are built on liquefiable soils. Closure of sections of the Maze due to inspection or damage will restrict access into and throughout areas of need in the East Bay.

The Caldecott Tunnel provides the central link between Contra Costa and Alameda, carries Highway 24, as well as main electrical and gas, transmission lines beneath the roadway. Adjacent, separate tunnels are used for BART and water pipelines. The Claremont Tunnel (EBMUD) has been retrofitted. The BART tunnel is vulnerable to closure due to landslide. If the utilities or mass transit below the roads are damaged, Highway 24 will be closed for months for reconstruction.

BART

BART could be damaged in neighboring cities on all sides, shutting off a major mode of public transit to San Francisco, Oakland and other destinations. Additional ferries and bus lines could be established within a week to provide substitutes for BART.

The BART Berkeley Hills Tunnel which crosses the Hayward fault would be damaged in a major earthquake on that fault, cutting a key commuting link. As yet, retrofit or replacement of this tunnel is not a viable option and BART has instead developed plans to quickly return this section to service. Depending on the amount of damage sustained, the line could return to partial service within weeks of an earthquake with full replacement potentially taking several years to complete. This will cause inconvenience to many Berkeley residents and may change employment patterns. Temporary transport options, such as buses and increased use of individual cars, are likely to be more polluting than BART. In general, the traffic on all Berkeley roads and highways will probably increase for at least two years following the earthquake. Since 2008, retrofits have been completed on many elevated tracks, stations, parking structures and rail yards. At this time, all retrofits are expected to be completed by approximately 2018.

Communications

AT&T
Telephone services, including mobile phone and internet, will be down for days to a week.

An overload of post-earthquake calls in the region will make phoning difficult. Carriers will block the calls coming into the region to relieve circuit overloading. Outbound calls, as well as text messaging, are likely to be available. The region's telecommunications companies will prioritize calls to allow emergency responders to communicate by phone.

Customers located in areas subject to severe ground shaking and high probability of ground failure may lose land-based connections to the telephone system. Access for repairs in those areas will be a major problem.

The cellular phone system relies on the integrity of antennas that are mostly located on building tops. Cell phone calls typically connect to the same landline systems that will be hampered by the expected overload of calls.

UC Berkeley
Enrollment at UC Berkeley may slow for a few years, depending on the level of damage experienced on campus. In the unlikely but possible event of a catastrophic incident, such as significant loss of life in a dormitory or classroom building, declines in enrollment will be significant. Remaining students, currently about 30 percent of the city's population, may struggle to find affordable housing. Businesses may rebuild or may move to new, cheaper locations. Many local, independent businesses will need to make the tough decision to rebuild or close shop. Retail businesses will be affected by demographic changes after an earthquake. Businesses located in neighborhoods with significant damage will suffer as customer demand changes, even if the businesses themselves are undamaged by the earthquake.

Businesses
Additional losses to income will likely occur due to Berkeley business closures, estimated at $265 million.[68]

Rebuilding

Based on experiences in New Orleans and other large urban areas being rebuilt following disaster, planners expect that rebuilding activities will begin quickly, but will prove expensive as construction professionals around the Bay Area are overloaded with work. Owners of damaged multi-unit rental housing may not be able to rebuild affordable housing, and may choose to build condominiums or other higher-profit housing to replace the damaged structures. Many residents will discover they are underinsured for earthquake and fire damage, making it difficult or impossible for them to rebuild. Rebuilt homes, meeting modern codes and style considerations, will change the look of the city.

Although much harder to predict, demographic shifts may also follow an up-ended housing market. Older homeowners may be unable or unwilling to rebuild, for example, and young families may need to relocate, at least temporarily, to ensure the continuity of their children's education. The likely loss of older, more affordable housing stock will also change Berkeley's economic profile.

An event similar to this scenario is likely to occur in the next few decades. Earthquakes causing significantly more or less damage are also possible.

3.4 *Wildland-Urban Interface Fire*

There are two primary types of wildfires: "wildland" fire and "wildland-urban interface" (WUI) fire. WUI fires occur where the natural landscape and urban-built environment meet or intermix. There may be a distinct boundary between the built and natural areas, or development or infrastructure may be intermixed in the natural area. WUI fires primarily cause damage to the natural and built environment, as well as injury and death of people and animals.

3.4.1 Historical Wildland-Urban Interface Fires

Berkeley has significant WUI fire history, most recently in the October 20, 1991 Tunnel Fire. This fire in the Oakland/Berkeley hills was declared the most destructive wildland-urban interface fire in United States history. It started the day before as a vegetation fire in the drought-dried hills east of Oakland. It was reignited and whipped into firestorm proportions by 20-30 mph winds, gusting to 60 mph, and spread within minutes to residential structures. While the fire burned a greater area in Oakland, it raged across city boundaries between Oakland and Berkeley, destroying entire neighborhoods in both cities and remaining out of control for more than 48 hours. Sixty-two single-family homes[69] were destroyed in Berkeley. Ten thousand people were evacuated from the hills areas. Most of the 25 people killed in the blaze were trying to evacuate when they were killed. FEMA estimated the damage at $1.5 billion in 1991 (approximately $2.5 billion in 2013 dollars[70]).

The 1991 firestorm also caused $3 million of damage to Berkeley's public infrastructure[71]. The 2,000-degree fire affected utility systems, including power, gas, telephone and water. Ten key water tanks were drained at the peak of the fire as a result of unprecedented demand from firefighting units, fire prevention measures by homeowners (e.g. wetting roofs with garden hoses), and broken water service connections in burned homes. Early in the fire, burning power lines and melting underground services resulted in a loss of power, which affected water system pumping plants. A total of eight pumping plants, which refilled the water tanks being used by fire fighters, lost power by the first afternoon. Although these were restored by evening, the capacity of the water system pumps was far less than the amount of water used by firefighters and spilled by broken connections.

Total damages in the city of Berkeley, including loss of private structures, loss and damage of public infrastructure, and the cost of City services, are estimated at $61 million.[72]

The day of the 1991 fire, the Bay Area experienced high temperatures of 80-90 degrees, and unusually hot, dry winds blowing from the east, rather than the normal, moisture-laden western winds from the ocean. This type of wind, referred to as Foehn or Diablo winds, occurs only eight to ten days per year, generally in fall. These winds, combined with the high temperature, low humidity, and built-up dry fuel load created the "critical fire weather" that resulted in the Tunnel Fire. The firefighters were helped when on the second day, the winds shifted to the west and cooler temperatures and fog rolled in.

Historically, major fires have occurred in the wildland-urban interface under virtually the same critical fire conditions. The table below identifies significant WUI fires in Berkeley history.

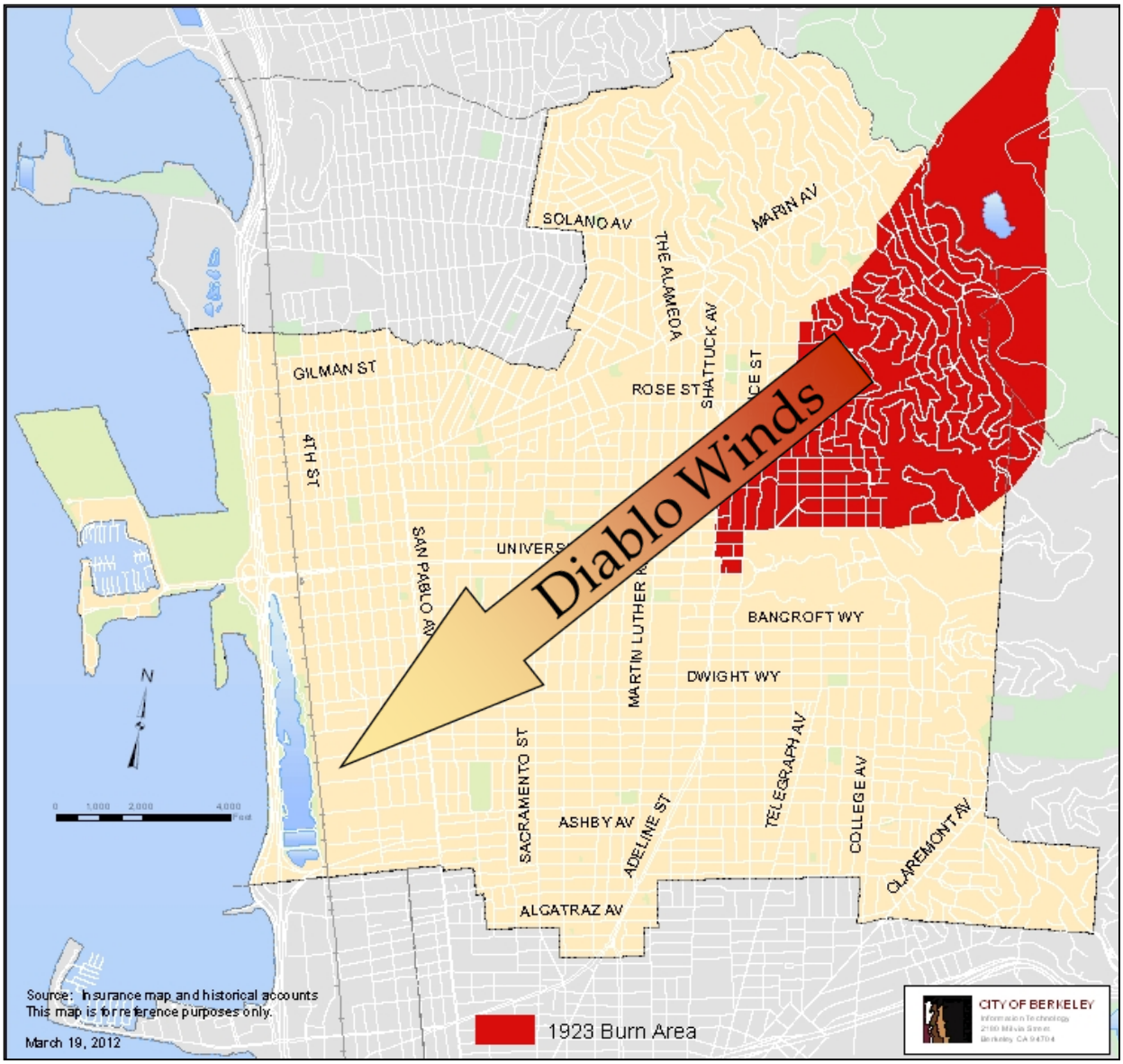
Table 3.11 History of Major Wildland-Urban Interface Fires in the Oakland/Berkeley Area[73]

September 17, 1923	Berkeley Fire	568 structures
September 22, 1970	Fish Canyon Fire (Oakland)	39 structures
December 14, 1980	Wildcat Canyon Fire (Berkeley)	5 structures
October 20, 1991	Tunnel Fire (Oakland/ Berkeley)	3,354 dwellings; 25 lives lost

The Berkeley Fire of 1923 began in the open lands of Wildcat Canyon to the northeast and, swept by a hot September Diablo wind, penetrated residential north Berkeley and destroyed nearly 600 structures, including homes, apartments, fraternities and sororities, a church, a fire station and a library. Wood shake roofs are cited as a large contributing factor in the spread of this fire. The fire burned downhill all the way to Shattuck Avenue in central Berkeley. A total of 130 built-up acres were burned, and about 4,000 people were made homeless. Historical analysis of newspaper reports after the fire indicates that significant acreage was burned in both Strawberry and Claremont Canyons. Because there were few, if any structures in these areas, the full scope of the fire has been underreported in subsequent years. After this devastating fire, officials stated that the only reason that the fire stopped spreading was because the northeast wind stopped and the damp western wind took over. Fire officials at the time were certain that if the northeast wind had not stopped, the buildings would have burned all the way to the bay in Berkeley, and the fire would have devastated Emeryville and moved south and west into Oakland[74].

Map 3.14 depicts in red the area burned by the 1923 fire. It also overlays the Diablo wind pattern to demonstrate how the fire could have spread into the Berkeley flatlands, had it not been for the change in wind direction.

Map 3.14 Area burned by 1923 Berkeley Fire



3.4.2 Wildland-Urban Interface Fire Hazard

The City of Berkeley faces an ongoing threat from a very likely wildland fire along its hillsides, where wildland and residential areas intermix. Wildland-urban interface (WUI) fires can be sparked by both human activity and natural causes. Once ignited, these fires can be difficult to contain when they occur during extreme fire weather conditions. A WUI fire can move with breathtaking speed, expanding to one square mile in under an hour, and consuming hundreds of structures in an hour.

Hot, dry, windy weather often coincides with WUI fires. WUI fire spread is affected by wind speed and direction, fuel and topography. Dry, dense vegetation feeds fires, including some residential landscaping. Wooden homes also serve as fuel for fire. Tall trees, present throughout Berkeley, can harbor canopy fires at the treetops that contribute to fire spread and are particularly difficult to fight. Fire spreads uphill quickly.

Fires burn buildings and threaten infrastructure. The intense heat associated with a firestorm can deteriorate concrete and asphalt pavement, curbs, sidewalks, and drainage structures. Other infrastructure that burns includes aboveground wiring for electricity, telephone and cable, and poles for lights and street signals.

In addition to impacts on the natural and built environment, fire has impacts to public health. Fires can result injuries and death from burns and smoke inhalation. Air pollution from fires can cause eye and respiratory illnesses, and can exacerbate asthma, allergies, chronic obstructive pulmonary disease, and other cardiovascular diseases.

Secondary Hazards: Landslide and Flooding

WUI fires can increase an area's risk of landslide and flooding. Fire season in the Bay Area is late summer to fall. When all supporting vegetation is burned away, hillsides become destabilized and prone to erosion. The charred surface of the earth is hard and absorbs less water. When winter rains come, this leads to increased runoff, erosion and landslides in hilly areas.

Erosion and land slippage subsequent to fires can lead to temporary or permanent displacement and property damage or loss,[75] [76] making it a secondary hazard that must be mitigated immediately after a fire.

3.4.3 Exposure and Vulnerability

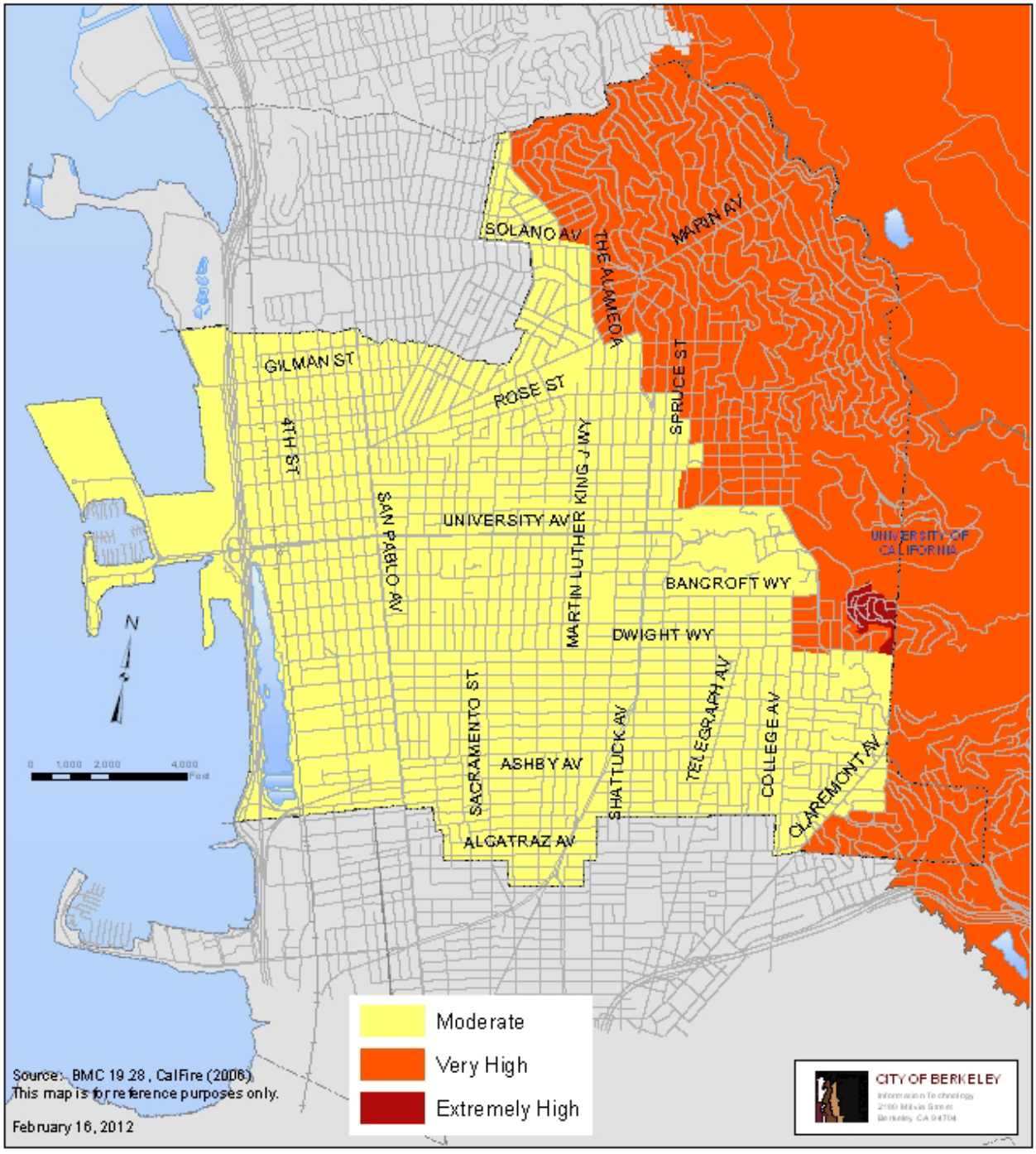
Berkeley is most vulnerable to a wind-driven fire incident originating in an area adjacent to the City's eastern border, in land owned by UC Berkeley, Berkeley Lab, the East Bay Regional Park District, the City of Oakland or Contra Costa County. The WUI fire risk facing Berkeley's wildland-urban interface area is compounded by the area's mountainous topography, its limited water supply, its minimal access and egress routes, and its location, overlaid upon the Hayward Fault. These factors have all contributed to the area's significant WUI fire history. Given the right wind conditions, a fire in one of these areas could quickly enter and encroach itself in Berkeley.

Since before the 1920s, the City of Berkeley has established and adjusted fire zones in Berkeley. While the zones were initially established to address urban fire issues, they

have evolved to designate the City's WUI fire hazard. Currently, the Berkeley Fire Department currently has divided the city into Fire Zones 1, 2, and 3, designated in order of ascending fire risk. These zones are shown in Map 3.13: *City-designated and Calfire hazardous fire zones.*

Fire Zone 3 is the Panoramic Hill area specifically; Fire Zone 2 covers the remainder of the city's eastern hills; Fire Zone 1 covers the rest of the City west of the hills. Fire Zones 2 and 3 currently include about 8,300 properties. These zones have the strictest fire prevention standards in the City for issues such as building materials for new structures. The City also enforces vegetation management measures in these areas.

Map 3.15 City-designated and Calfire hazardous fire zones



While much of the concern for fire is placed on the hills, Berkeley's flatlands are at risk as well. The flatlands are densely covered with old wooden buildings that have narrow side yards and dense vegetation. Most of these houses are old and not built with modern, fire-resistant materials. They have a high risk of damage in an earthquake, which could spark multiple ignitions, for example, by damaging gas/electric lines.

Panoramic Hill Area

The Panoramic Hill area (labeled as the "Extremely High" Fire Zone on Map 3.13) has the greatest WUI fire vulnerability.

It is a wildland-urban interface area located on a hill above Memorial Stadium, between Strawberry Canyon to the north and Claremont Canyon Nature Preserve to the south. The ample vegetation in both canyons adds to the neighborhood's WUI fire risk. Many of the homes in this area have wood shake and shingle roofs and are surrounded by brush-type vegetation. Panoramic Hill also includes one of Berkeley's most architecturally-significant residential districts, which is listed in the National Register of Historic Places because of its association with the Arts and Crafts movement.

The neighborhood lies in both Berkeley and Oakland. There are about 280 dwelling units on Panoramic Hill, including 215 dwelling units in the Berkeley part of the neighborhood. There are approximately 520 residents in the area, including close to 100 in Oakland. The area is surrounded by the Berkeley Lab, the University of California, Berkeley (Clark Kerr campus) and the East Bay Regional Park District.

The Hill's limited water supply, access/egress routes, and its exposure to fault rupture further exacerbate the area's WUI fire risk above that of Fire Zone 2.

Water Supply Limitations

Water supply to the Panoramic area is limited to one undersized water main. If the main is damaged by an earthquake or landslide, any area beyond the point of the break will be without water service. This is different from other areas in the hills and flatlands, where the "gridded" structure of the water system allows for more redundancy in the event of a water main break. In Panoramic Hill, an earthquake could spark a fire, which could be fueled by damaged gas lines. Damage to the area's one water main from an earthquake or resulting landslide could limit residents' and professionals' ability to suppress the fire. This sequence of events could devastate the neighborhood and grow into a firestorm, threatening other parts of the city and neighboring jurisdictions.

Access and Egress

Panoramic Way is the only paved road into and out of this neighborhood. It forms a single loop, 12-18' wide, that begins and ends just south of Memorial Stadium. The street's narrow width and hairpin turns make it barely accessible to fire apparatus, which are required to perform three-point-turns to ascend the Hill.

Panoramic Way's narrow width also means that at many points the road is not wide enough to allow vehicles to pass one another. Under normal conditions, vehicles

responding to medical emergencies have been impeded by commercial vehicles, trash collection trucks, and illegally-parked personal vehicles.

History demonstrates that endangered residents in the path of a major fire will attempt to leave the area via private vehicles crammed with personal belongings. When there is another major hill area fire or an earthquake, emergency access and egress on the substandard road will be highly constrained. People trying to leave a dangerous condition will conflict with emergency personnel trying to address it or trying to reach others who need help to leave. Further, an earthquake-induced landslide impacting Panoramic Way could also block any vehicles from entering or leaving the area.

Exposure to Fault Rupture

Further intensifying the neighborhood's vulnerability, the Hayward Fault runs under Panoramic Way, just before it crosses the parking lot and bisects the Memorial Stadium. In a Hayward Fault earthquake, the Panoramic Hill area will likely be isolated from the City's emergency services, all of which lie on the other side of the fault to the West (with the exception of Fire Station 7, which lies north of the UC Berkeley campus).

Notable Mitigation Activities

The City, working together with key partners, is using a comprehensive strategy to aggressively mitigate Berkeley's WUI fire hazard. These approaches include prevention through development regulations; natural resource protection through vegetation management; improvement of access and egress routes; and infrastructure maintenance and improvements to support first responders' efforts to reduce fire spread.

Prevention

The City enforces several programs to reduce Berkeley's fire hazard, especially the WUI fire hazard in the hills. These include strict building and fire code provisions, as well as more restrictive local amendments[77] for new and renovated construction, and vegetation control inspections in high-risk properties.

Panoramic Hill Area Development Regulations

Following the 1970 Fish Canyon Fire, the Planning Department established the Berkeley portion of the area as an ES-R (Environmental Safety-Residential) zone. This action limited the use of land and the size and occupancy of residential structures in the area. The ES-R regulations are the most stringent residential standards in the Berkeley Zoning code.

The City has continued to adopt strict standards that curtail development on Panoramic Hill, so that as few additional people as possible are placed at risk until the area's underlying infrastructure issues are addressed. In 2008, City Council adopted a moratorium on development on the hill. In May 2010, the Council repealed the moratorium, passing an ordinance that blocks establishment of any residential units on the Hill. The restriction remains in effect until Council adopts a Specific Plan for the area's land use. The Specific Plan must include:

- Proposals for water, wastewater and storm water systems
- Proposals for a circulation system adequate to accommodate projected traffic, and to provide for emergency access to the area
- An action plan and finance measures necessary to carry out the Specific Plan.

Because the neighborhood resides in both Berkeley and Oakland, in 2006, the Alameda County Local Agency Formation Commission (LAFCo) expanded Berkeley's Sphere of Influence to include the Oakland part of Panoramic Hill. LAFCo acted to do so despite opposition letters from the City Manager of the City of Berkeley and City Administrator from City of Oakland. LAFCo's action means that the City of Berkeley is now officially charged with planning for all of Panoramic Hill, including those areas currently in Oakland. While Berkeley must consider the entire Hill in its planning documents, it only gains zoning authority if those portions of the Hill in Oakland are annexed to the City of Berkeley – a long and complicated process requiring agreement of both Cities.

Since it is highly unlikely that there will be City funds available to undertake the planning and then the design and construction necessary to address the area's infrastructure deficiencies in the foreseeable future, existing land and homeowners in Berkeley and Oakland will likely need to collaborate to provide the necessary funding for a Specific Plan. Grant funding may also be available to undertake some of the necessary planning, design and construction.

Natural Resource Protection

The Hazardous Fire Area Inspection Program is in place for a subset of properties within Fire Zones 2 and 3. Each year, Fire Department personnel inspect over 1,200 parcels in Fire Zones 2 and 3. Additionally, personnel conduct complaint-driven inspections in all three of the City's Fire Zones.

The City also runs a number of vegetation management programs to reduce fuel loads, including:

- The Fire Fuel Chipper Program, a popular yard waste collection service. The Program serves properties in the hills from June through September each year. From 2005 to 2011, over 200 tons of vegetation was collected and recycled, on average, each year.[78]
- The Fire Fuel Debris Bin Program is coordinated by the Department of Public Works' Solid Waste Division, which delivers and removes 30 yard roll-off boxes from requesting neighborhoods. This effort yields an average of 20 tons of plant debris per year.[79]
- Additionally, 14,000 tons of residential plant debris is collected each year through weekly curbside collection. In 2007, the City switched curbside plant debris collection from every other week to weekly. This program enhancement doubled residents' capacity to help reduce the buildup of vegetation year-round.[80]

- A fire fuel abatement program on public land. From mid-June to mid-August each year, an average of 125 tons of debris is removed from 95 public sites, including parks, pathways and medians. This effort is a joint effort of the City and the East Bay Conservation Corps.[81]

Access and Egress
Key Partner: Berkeley Path Wanderers Association

Berkeley Path Wanderers Association (BPWA) is an all-volunteer nonprofit organization concerned with Berkeley paths. In the city's many steep neighborhoods with winding roads, these paths take the shortest, most direct routes, mimicking city block grids that do not exist. In addition to producing a community recreation asset, these pathways can assist evacuation and firefighting efforts in the hills.

Since 1998, BPWA has built and maintained rustic paths using wood ties secured to the ground with rebar, replaced wooden ties and rebar when necessary, cleared overgrown vegetation, and conducted annual weeding. The group also cleans and clears historic cement paths. The City's Department of Public Works performs more heavy maintenance, such as cement work and hand rail installation and replacement.

Since 2004, BPWA has improved 21 paths in the hills north of the UC Berkeley campus. Most of the paths offer more expeditious evacuation routes than the surrounding city streets. The table below shows some of the BPWA paths that significantly reduce pedestrian evacuation distances.

Table 3.12 Noteworthy BPWA Paths

Path Name	**Distance**	**Distance without Path**
Acacia Walk	0.1 miles	0.4 miles
Atlas Path	<0.07 miles	0.2 miles
Bret Harte path	< 0.1 miles	0.2 miles
Glendale Path	0.2 miles	0.6 miles
Northgate Path	< 0.1 miles	0.4 miles
Upper Covert Path	< 0.1 miles	0.5 miles
Wilson Walk	< 0.03 miles	0.4 miles
Yosemite Steps	0.1 miles	0.4 miles

The BPWA does not maintain paths on UC Berkeley land, but is exploring ways to work with UC Berkeley to improve pedestrian transitions between UC and adjacent neighborhoods.

In addition to maintaining paths, the group raises awareness of the paths for use as both escape routes for residents and as access routes for emergency personnel. BPWA performs outreach through a published map, their newsletter, free public meetings, and free guided walks. In 2008, the BPWA sponsored an earthquake walk attended by 75 people. The group toured part of the Hayward fault, observing houses, schools, playgrounds and walkways that have been built atop the fault, and discussing mitigation activities undertaken in the area.

Notable Mitigation Activity

Using a FEMA grant award, in 2005 the City, the BPWA and Boy Scout Troops 4 and 19 partnered to build Glendale Path, a vital three-block-long evacuation route between the intersections of Fairlawn Drive/Arcade Avenue and Campus Drive/Glendale Avenue. By City streets, the evacuation route descends 160 feet over .6 miles. The Glendale Path shortens the evacuation distance by almost half a mile, significantly shortening evacuation time for pedestrians in the area. The path includes:

- Wood-tie steps and a switchback stairway by BPWA;
- Wooden steps and stepping stones constructed as part of three Eagle Scout projects;
- Cement stairs and handrails by the City.

The path was dedicated in August 2007, when the third and lowest portion was completed.

Improving Firefighting Readiness

Early suppression efforts prevent many WUI fires from growing out of control. Since the 1991 fire, the City has continued to build firefighting infrastructure to enable firefighters to reduce fire spread.

In 2006, the City constructed a new fire station on Shasta Road, just north of the UC Berkeley campus in the hills. This station, in addition to being in the wildland-urban interface, is the only City fire station east of the Hayward fault.

In 2010, the City put into operation an aboveground, portable water system that can pump water from any source, including the San Francisco Bay, in the event of drained tanks or damaged pipelines. This system is designed to carry up to 20,000 gallons of water per minute for a distance of one mile and elevation gain of 100 feet; it will also carry smaller flows to higher elevations. This capacity was based on calculations of water volumes required to fight the fire front presented in the 1991 blaze, assuming that some capacity will be available from EBMUD sources, in light of system upgrades.

Since the 1991 fire, the Berkeley Fire Department has been also working to strengthen its wildland firefighting skills and to prevent conflagrations. Firefighters remain in a constant state of readiness to respond to a wind-driven WUI fire in the hills, which could transition into a fast-moving urban firestorm in the flatlands. Additionally, the City has built cooperative relationships with neighboring fire departments to put out vegetation

fires before they grow into multi-jurisdictional problems. Mutual response agreements among the City and its neighboring jurisdictions have increased the fire resources that respond to the reporting jurisdiction.

This cooperation has been assisted through formal efforts, such as the inter-jurisdictional Hills Emergency Forum (HEF), started after the 1991 fire. HEF exists to coordinate the collection, assessment and sharing of information on East Bay Hills fire hazards, and to provide a forum for building interagency consensus on the development of fire safety standards and codes, incident response and management protocols, public education programs, multi-jurisdictional training, and fuel reduction strategies.

Key Partner: East Bay Municipal Utilities District[82]

EBMUD has completed various maintenance based pipeline improvements throughout the City of Berkeley that have improved the available flows and water distribution system on a localized basis. EBMUD's Berryman Reservoir was replaced in 2012 with a new seismically designed 2.6 million gallon storage facility. EBMUD recently purchased three new portable generators (two 400 kilowatt and one 750 kilowatt generator) for use at water treatment and distribution facilities. These improvements improve the water supply reliability, but there remains a high likelihood of outages for pumping stations, reservoirs, and pipeline during a major seismic disaster.

Key Partner: UC Berkeley

UC Berkeley campus lands include approximately 800 acres of wildland in the East Bay hills that border on residential neighborhoods in Berkeley and Oakland. The combination of an accumulation of dense nonnative vegetation and increased urbanization has created a wildland-urban interface (WUI) condition posing an extreme threat to lives and property. From 1923 to 1991, 14 major fires have occurred in this area, including the 1991 Tunnel Fire that destroyed more than 3,354 dwellings and claimed 25 lives.

UC Berkeley depends on the City for fire services, but does not fall under City fire preparedness ordinances. The University has an established Campus Fire Mitigation Committee to develop and oversee a program to manage the WUI fire hazard. The goal is to manage vegetation to ensure that the vulnerable areas are WUI fire-defensible by improving accessibility for fire crews, creating and maintaining escape routes, and lessening the rate of fire spread and/or reducing the potential for embers to ignite adjacent neighborhood. The University has made repeated efforts since 1974-75 to eliminate the vast groves of eucalyptus trees on its property. Earlier efforts were unsuccessful, as the felled trees regrew from their cut stumps. UC efforts since 2001 have emphasized the use of herbicides to kill the eucalyptus trees after felling, along with an integrated management approach to prevent the millions of viable eucalyptus seeds from germinating. The University's goal is to convert its eucalyptus- and pine-forested areas to oak/bay woodland, scrubland, grassland or other floral communities historically found in the East Bay hills. In 2006, UC Berkeley opened the Center for Fire Research and Outreach to encourage and facilitate collaboration on fire-related research questions and provide a central point for wildfire information.[83]

Key Partner: Berkeley Lab[84]

The Berkeley Lab maintains generators and reserve water tanks to back up utility services in many of its buildings. Water is supplied from the East Bay Municipal Utility District's Shasta and Berkeley View Reservoirs. The Berkeley Lab water delivery system is designed to provide service to many portions of the site from either one of these two sources. In addition, Berkeley Lab operates and maintains three 200,000-gallon water storage tanks onsite for emergency water supply. The water conveyance system is looped such that a pipe rupture from one source of water will not result in loss of firefighting water. Only multiple breaks in the system will result in loss of firefighting water.[85]

Berkeley Lab has an ongoing contract with Alameda County Fire Department (ACFD), which staffs Fire Station 19 on the Lab site. ACFD participates in the California Master Mutual Aid Agreement, whereby supplementary fire support can be requested through the local mutual aid coordinator in the event of an emergency. Additionally, Berkeley Lab maintains an automatic aid agreement with the City of Berkeley. ACFD also has trained staff and resources to address life-safety concerns and spill containment for hazardous materials releases. The Lab has an active drill and exercise program, and conducts major exercises regularly.

3.4.4 Wildland-Urban Interface Fire Risk and Loss Estimates

The 1923 fire was the worst WUI fire to impact Berkeley in recent history. This plan calculates losses that would occur if that fire were to recur today. A repeat of this fire would cause significantly more damage in Berkeley than the recent 1991 Tunnel fire.

The 1923 Berkeley Fire started in Wildcat Canyon to the northeast of the city and burned south and west down to Shattuck Avenue, stopping at the edge of UC Berkeley. Map 3.12 shows the area burned by this fire. The California Railroad Commission documented the burned area in 1923, three months after the fire. By superimposing this historical map onto the current day structures of Berkeley using the City's Geographic Information System, we find that, today, over 3,000 structures are located in the footprint of the 1923 fire. These structures include single-family homes, multi-family residences (many of which house UC Berkeley students), and stores, restaurants, and offices central to downtown Berkeley.

If a fire occurred today that burned the same area, the loss to structures could exceed $3 billion.[86] Destruction of contents in all of the homes and businesses burned could add another $617 million[87] to fire losses. The losses of electricity poles and lines to PG&E, for example, could be enormous. Efforts to stabilize hillsides after the fire to prevent massive landslides would also add costs.

While the financial losses from this scenario are staggering, the social impacts of such a fire could be devastating. Thousands of families could be homeless following such an event, losing all of their possessions. Many more could need short-term shelter while the fire was burning. Residents and firefighters could be killed, especially in difficult-to-access areas. Local, independent businesses might disappear forever. A large portion of the city would need to be entirely rebuilt. In short, the entire face of northeast Berkeley could be completely changed.

SECTION B: HAZARDS OF CONCERN

Rain-induced landslides, flooding, tsunami and climate change are hazards of concern for Berkeley, because of their potential to severely impact specific areas of the city. Section 4 of this plan identifies mitigation actions to reduce the impact of each of these hazards. Climate change is addressed in further detail in Berkeley's Climate Action Plan.

3.5 *Rainfall-Triggered Landslides*

Seismically-triggered landslides are discussed in detail in Section 3.3.2.2.2.

3.5.1 Historical Rainfall-Triggered Landslides

Berkeley's most significant recent landslide occurred in North Berkeley during the winter of 1997-98, when soil became oversaturated from heavy rains brought by the El Nino weather system. One home was significantly damaged and had to be demolished. Two additional homes were yellow-tagged, meaning they were of questionable safety, but residents were able to reoccupy these homes after the hillside was stabilized. No one was hurt. Other recent landslide experiences are limited to minor slides blocking roads, such as the collapse of the Euclid Road retaining wall in 1996.

3.5.2 Rainfall-Triggered Landslide Hazard

Landslides are natural geologic phenomena that range from slow moving, deep-seated slumps to rapid, shallow debris flows. Landslide risk can be exacerbated by development. Grading for roads, home construction and landscaping can decrease hillside stability by adding weight to the top of a slope, destabilizing the bottom of a slope, and/or increasing water content of the underlying materials.

Landslides are most frequently triggered in periods of high rainfall, and are likely to continue occurring in Berkeley. The hazard is greater in steeply-sloped areas, although slides may occur on slopes of 15 percent or less if the conditions are right. Slope steepness and underlying soils are the most important factors affecting the landslide hazard. However, surface and subsurface drainage patterns also affect the landslide hazard, and vegetation removal can increase the likelihood of a landslide.

The most dangerous landslides in terms of life safety are fast-moving, generally shallow debris flows. These are triggered when intense rainfall follows storms that have already saturated hillsides. Debris flows initiate in concave slope areas where subsurface water is concentrated, elevating pore pressure above the natural strength of the soil. Once initiated, debris flows can travel great distances at relatively high velocities, flowing down drainages and onto alluvial fans and damaging any structures lying in their paths. Preexisting and recently-active, larger landslides (such as those shown in Map 3.5) are more often triggered by exceptionally long periods of seasonal rainfall, and sometimes do not start moving until long after the rain has stopped. These types of slides may not move as rapidly as debris flows, but can damage large areas and many structures, resulting in extensive landslide losses.

3.5.3 Exposure and Vulnerability

There are a number of deep-seated landslides that continuously move, with the rate of movement affected by rainfall and groundwater conditions. These active landslides are shown in red on Map 3.5. Landslide movement could range from a few inches to tens of feet in any given year, but ground surface displacements as small as a few inches are enough to break typical foundations. In addition, there are many more deep-seated landslides that are not currently moving, but have moved in historic time or in recent geologic time. The more significant of these are shown in yellow on Map 3.5. These "dormant" landslides could be reactivated by changing surface or subsurface conditions.

Areas of the community situated on historic or recent deep-seated landslides are most vulnerable to landslide hazards. Vulnerabilities in these areas include hundreds of homes, roads, sidewalks, underground utilities (water, sewer lines, storm drains, natural gas lines, conduits) and aboveground utilities (electricity, telecommunications, cable).

For debris flows, hazard areas are typically at the base of steep hillsides, near the mouths of steep hillside drainages, and in or around the mouths of canyons that drain steep terrain[88]. In Berkeley, several collector streets that are critical for emergency access and evacuation are located in areas susceptible to landslides.

Key Mitigation Activities

Regardless of triggering mechanism, landslide hazard mitigation techniques are the same. Landslide hazard can be reduced through grading, soil strengthening, geotechnical engineering components, drainage, control of runoff, and landscape methods. In new development, the City regulates the issuance of permits and inspects new development activities. However, most Berkeley hillside development predates current best practices and codes and therefore remains vulnerable to the threat of landslides. The City maintains major retaining structures in the right-of-way that help to control landslide risk in key areas.

3.5.4 Landslide Risk and Loss Estimates

There are few generally-accepted methods to estimate damage from landslides caused by rain. However, many of Berkeley's hillside homes are located in areas that could slide under the right circumstances. According to a USGS report[89], approximately 6,000 structures are located in areas at moderate to high risk of landslides.

3.6 *Floods*

3.6.1 Historical Floods

Berkeley's most recent flooding occurred in 2004 - 2005 in the Codornices, Strawberry, Potter, and Schoolhouse Watersheds. Flooding also occurred during the 1997 - 1998 El Niño season. The problems caused by the El Niño winters in the 1990s totaled millions of dollars in emergency response and recovery efforts.

In the early 1960s, the Strawberry and Codornices Creeks overflowed, causing nuisance flooding in streets and intersections. A few buildings were flooded, including some on the University of California, Berkeley campus.

3.6.2 Flood Hazard

Berkeley faces a moderate flood hazard, primarily from local creek flooding and storm drain overflow.

Creek Flooding

Like in many urban areas, Berkeley's creeks are difficult to follow. Long stretches of Berkeley's creeks are completely contained by culverts, and open stretches of creeks are often segmented by shorter culverts and bridges.

Codornices, Strawberry and several other creeks flow year-round. However, most Berkeley creeks only flow in narrow channels for a short time after rainfall. When storm runoff exceeds a channel's capacity, the excess water flows into city streets.

Storm Drain Overflow

The City's storm drain pipe infrastructure is designed to intercept, collect storm water runoff from the public right-of-way, and convey it, either directly to the Bay, or to nearby watercourses that ultimately discharge to the Bay. Nuisance flooding may accompany heavy rainfall without flooding from any nearby creeks, due to either an event that exceeds the capacity of storm drain infrastructure, and/or that damages that infrastructure.

Capacity

When storm water runoff exceeds the capacity of the storm drain infrastructure, the excess water flows into city streets. Most of Berkeley's storm drain infrastructure is engineered to accommodate a 10-year design storm, which produces two inches of rainfall over a 6-hour period. Using this 10-year design storm standard is considered the most cost-effective design practice,[90] and provides guidance for computing flows and for sizing infrastructure (such as pipes, curbs and gutters, and valley gutters).

Age

Much of Berkeley's storm drain infrastructure is over 90 years old and is past its useful life expectancy. Concrete pipes have eroded or separated over the years. In some

locations, soil is being sucked into the pipelines, causing washouts. Berkeley's Watershed Management Plan (see *Notable Mitigation Activities)* includes an inspection program to identify the pipe segments that may be in danger of collapse during earthquakes and/or storms with high rainfall, but the Plan has not been funded. Additionally, maintenance reduces the frequency of flooding during rainfall that is less than a 10-year storm.

Flooding Factors

Factors that induce flooding in Berkeley are:

- Winter storms with heavy rainfall: Heavy rainfall increases the load on Berkeley's creeks and storm drains. Water may also pond in basements from street drainage or from high ground water during extremely wet seasons.

- Constricted or blocked flow ways: Berkeley has little record of overflows, but has experienced flood damage from blocked culverts. Intensified storm drain system maintenance efforts have reduced flooding. Patrols are sent out before storm events to ensure that drains are clear of leaves or other substances.

- Bay tides: Outfalls in Berkeley go directly to the Bay. When the Bay level rises, flooding is more likely.

- Power outage: A significant number of building owners in Berkeley rely on electric sump pumps to keep their homes or businesses free from water during the rainy season. Any protracted power outage during the rainy season would lead to water damage in many structures' basements because of the failure of these pumps.

- Climate change and its effects: Climate change increases the likelihood of flooding in Berkeley through earlier melting of Sierra snowpack, an increase in extreme rainfall events and sea-level rise. (See Section 3.8: Climate Change.)

Public Health Impacts[91]

Flooding may result in contamination of potable water, wastewater, and irrigation systems, which may negatively affect the quality of water supply, resulting in an increase of water- and food-borne diseases.[92] [93] Intense rainstorms and flooding can contaminate food crops through overflows from sewage treatment plants into fresh water sources and through increases in water-borne parasites, such as Cryptosporidium and Giardia, found in drinking water. Heavy storm water runoff can contaminate the ocean, lakes, and other bodies of water with other bacteria.[94]

3.6.3 Exposure and Vulnerability

Berkeley's flooding exposure has been identified from two sources: creek flooding and storm drain overflow.

Creek Flooding Exposure

Flood flows in Berkeley are not of great depth. The maximum flood depth associated with a 100-year flood from creeks is expected to be two-feet-deep, mostly near creek channels. However, surface runoff can flow into streets and intersections. A flood of one to two feet in depth could inundate the first floors and basements of a number of houses in the city, and a significant area of the city's western industrial portion. This type of flooding is unlikely to damage structures, but could significantly damage first floor and basement finishes, contents and appliances in these buildings.

Map 3.16 is the current Digital Flood Insurance Rate Map (DFIRM). Blue-striped flood boundaries on the DFIRM represent the 100-year flood, which has a one percent probability of occurring in a given year. Gray-striped boundaries represent the 500-year flood, which has a 0.2 percent probability of occurring in any given year.[95]

If the 100-year flood occurred in Berkeley, it would impact approximately 675 structures to various degrees. The majority of these structures would be inundated by one foot or less of water. Approximately 200 structures, however, could flood with up to two feet of water. None of these structures are Repetitive Loss Properties as defined by the National Flood Insurance Program.[96]

National Flood Insurance Program

The National Flood Insurance Program (NFIP) makes federally-backed flood insurance available to homeowners, renters, and business owners in participating communities. Berkeley has participated in the NFIP since September 1, 1978 and is currently in good standing with the Program. NFIP compliance is monitored by FEMA regional staff and by the California Department of Water Resources under a contract with FEMA.

Participants in the NFIP must, at a minimum, regulate development in floodplain areas in accordance with NFIP criteria. Before issuing a permit to build in a floodplain, participating jurisdictions must ensure that three criteria are met:

- New buildings and those undergoing substantial improvements must, at a minimum, be elevated to protect against damage by the 100-year flood;
- New floodplain development must not aggravate existing flood problems or increase damage to other properties;
- New floodplain development must exercise a reasonable and prudent effort to reduce its adverse impacts on threatened salmonid species.

Areas of special flood hazard in Berkeley are identified by the FEMA "Flood Insurance Study, Alameda County, California and Incorporated Areas," dated August 3, 2009. The study presents water surface elevations for floods of various magnitudes, including the one-percent annual chance flood (100-year flood) and the 0.2-percent annual chance flood (the 500-year flood). The boundaries of the 100- and 500-year floodplains in Berkeley are shown on the Flood Boundary and Floodway Maps and the Flood Insurance Rate Maps (Map 3.16), dated August 3, 2009.

Berkeley's Flood Zone Development Ordinance regulates development in areas identified in the Flood Insurance Study and Flood Insurance Rate Maps. To file insurance claims with FEMA for flood damage, owners of parcels in this area must have FEMA flood insurance, and these parcels' lowest base floor elevation must be 2 feet above the 100-year flood level. Few Berkeley homeowners are known to carry flood insurance, presumably because of negligible flood damage in recent decades, so those losses would be borne almost entirely by building owners.

In 2012, the U.S. Congress passed the Flood Insurance Reform Act of 2012 which calls on FEMA and other agencies to make a number of changes to the way the NFIP is run. As the law is implemented, some of these changes have already occurred, and others will be implemented in the coming months. Key provisions of the legislation will require the NFIP to raise rates to reflect true flood risk, make the program more financially stable, and change how Flood Insurance Rate Map updates impact policyholders. The changes will mean premium rate increases for some, but not all, policyholders over time. Beginning in May 2013, preliminary data will be phased into an online search tool where the City and community members can view any proposed changes to the flood maps and voice their opinion before they are finalized.

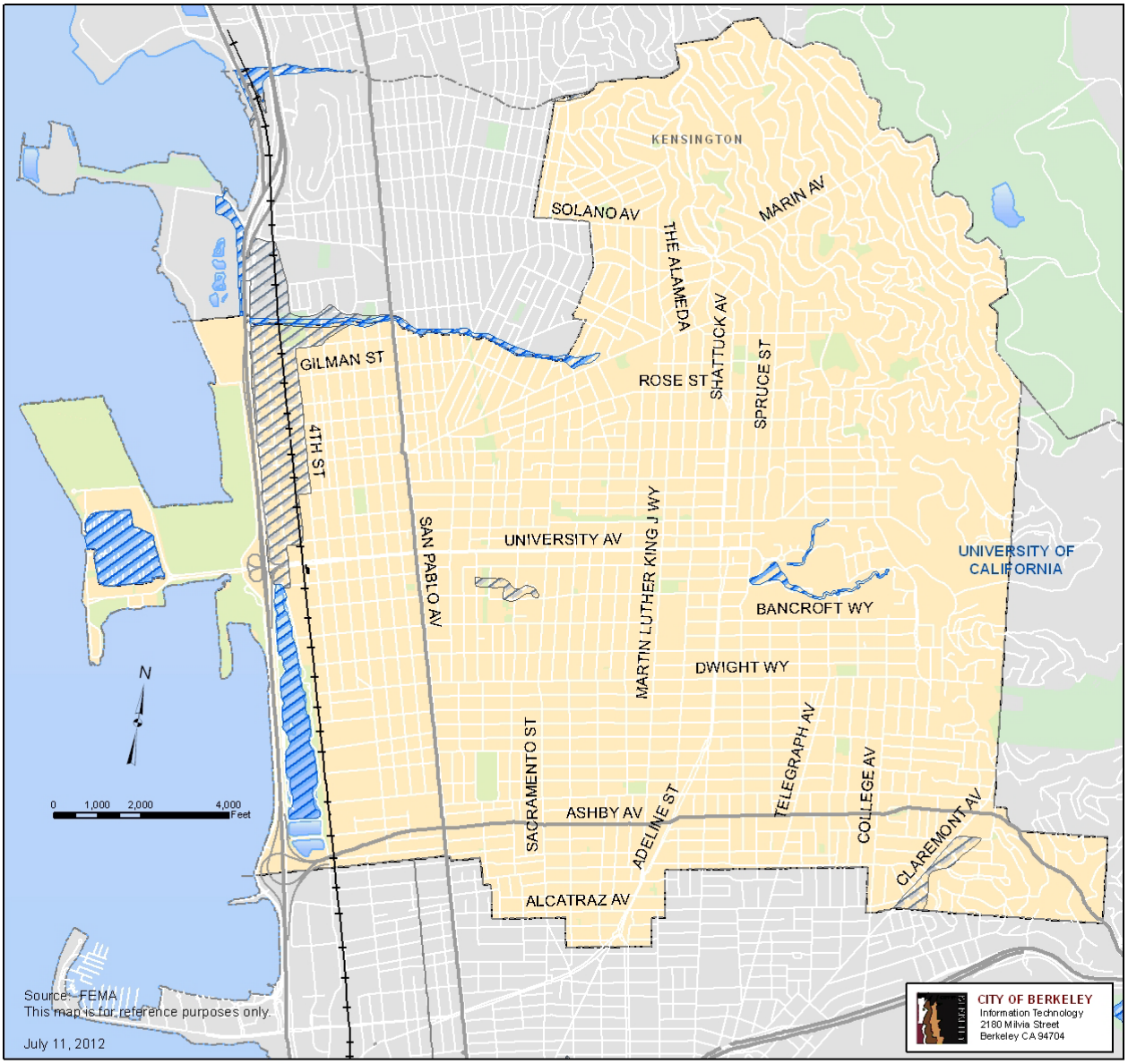
As part of its effort to comply with the requirements of the NFIP, Berkeley has adopted various floodplain management measures. For example, Berkeley requires one foot of freeboard on all development at risk from bay floodwater. Thanks to the foresight of the storm water system planners in the 1920s, and also thanks to the fact that the City has abided by and enforced federal flood insurance program requirements since the 1970s, flood insurance claims have been extremely low.

The City of Berkeley will maintain participation in the National Flood Insurance Program under the Public Works Department's Engineering Division. The Supervising Civil Engineer will work with FEMA and other partners to continue to continue to update and revise flood maps for the City, and to continue to incorporate FEMA guidelines and suggested activities into City plans and procedures for managing flood hazards.

Notable Mitigation Activities

In September 2009, the City updated Berkeley Municipal Code Chapter 17.12: *Flood Zone Development Ordinance* to ensure Berkeley's continued compliance with FEMA National Flood Insurance Program requirements. The Ordinance regulates all publicly- and privately-owned land within the areas of special flood hazard. It establishes the Director of the Public Works Department as the Floodplain Administrator for the City; addresses standards for construction, utilities, subdivisions, manufactured homes and recreational vehicles.

Map 3.16 Digital Flood Insurance Rate Map



FEMA Flood Hazard Areas

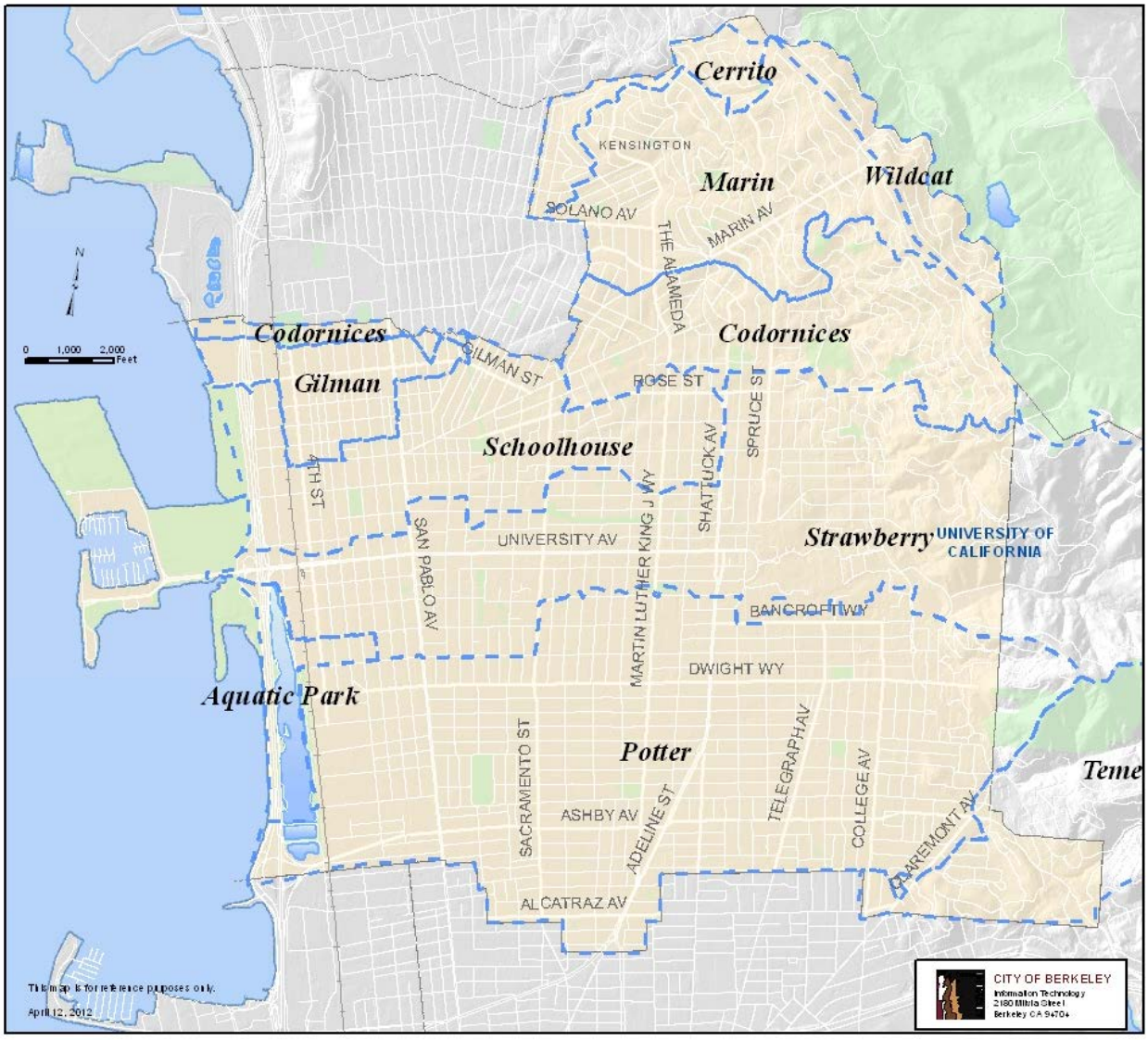
100-Year Flood Area

500-Year Flood Area

Storm Drain Overflow Exposure

In 2011, the Engineering Division of the City's Public Works Department developed hydraulic models for two of the City's ten watersheds, represented in Map 3.17. The Potter and Codornices Watersheds were selected because they represent the full range of the urban drainage spectrum in Berkeley.[97] The modeling identified locations of predicted overflows.

Map 3.17 Berkeley Area Watersheds



Potter Watershed

The Potter Watershed is the largest in the City. It experiences localized flooding in many areas, and contributes runoff to the Aquatic Park Lagoons. Localized flooding can be expected in varying degrees in the following locations:

- San Pablo Avenue between Ward and Murray
- California Street between Woolsey and Harmon
- Woolsey Street between California and Adeline
- Woolsey Street at Dana
- Ashby Avenue between California and King
- Martin Luther King, Jr. Way between Russell and Woolsey
- Parker Street between Seventh and Fourth
- Fulton Street at Derby
- Ellsworth Street between Blake and Parker
- Telegraph Avenue between Ashby and Woolsey
- Telegraph Avenue at Stuart
- College Avenue at Dwight

Many of these locations were confirmed as chronic nuisance flooding sites by PW Maintenance staff and correspond well with City experiences during the storms of February 25, 2004 and the El Nino events of the 2005-06 rainy season.

Additionally, tidal effects from the Bay compound Potter Watershed's flooding problems as far upland as Adeline/Woolsey. This is due to the water surface of the Bay effectively reducing the discharge ability of the storm drain trunk line. Thus 10-year frequency storms in combination with high tides will cause flooding in the Potter Watershed.

Codornices Watershed

The Codornices Watershed is regionally significant as Codornices Creek is one of the least culverted creeks in the East Bay; and is one of the few with a salmonid population. Localized flooding can be expected in varying degrees (including surface ponding at street sags) in the following locations:

- Second Street, Creek corridor to Gilman
- Railroad tracks, Creek corridor to Gilman and to Albany

- Gilman Street between Sixth and Second
- Codornices Creek at Sixth, at most street crossings east of San Pablo, at Glen
- Ninth Street between Harrison and Creek Corridor
- Monterey Ave between Posen and Hopkins
- Hopkins Street at Carlotta
- The Alameda between Napa and Yolo
- Sonoma Ave between Fresno and Hopkins
- Spruce Street, Eunice to Creek corridor
- Euclid Ave, Cragmont to Codornices Park
- Cragmont, Euclid to Regal
- Various locations on LaLoma, Glendale, Campus Drive, Queens, Shasta Road

Seventy-five percent of expected flooding is predicted to occur in the Creek Corridor at Second Street. This model result is confirmed by chronic flooding at the site.

The City plans to develop hydraulic models of the remaining eight watersheds within Berkeley.

Hazardous Materials

Many of the structures in or near the flood zone have hazardous materials on their properties. The hazardous materials at the sites include many chemicals that could harm health or the environment. The City has no regulations requiring hazardous materials be stored above expected flood levels in existing properties, but there may be adequate warning time for companies to protect or elevate these materials when the next flood occurs. Of the 436 sites regulated by the City's Toxics Management Division (See Section 3.9: *Hazardous Materials Release*), none reside in the 100-year floodplain; 41 reside in the 500-year floodplain.[98]

Watershed Management Plan

In October 2012, Council adopted the Watershed Management Plan (WMP). The mission of the WMP is to promote a healthier balance between the urban environment and the natural ecosystem, including the San Francisco Bay. One of the WMP's four goals is to reduce urban flooding, with associated objectives as follows:

- Maintain and operate appropriately sized storm drain pipe infrastructure.
- Reduce peak runoff volumes and velocities.

- Keep storm water inlets free of obstructions.
- Collect/analyze data to better understand issues and plan accordingly.

To this end, the WMP recommends analysis and rehabilitation of existing storm drain pipes, along with landscape-based retrofits within the public right-of-way or open space areas. Studies have indicated that when these landscape-based retrofits are combined with other traditional approaches, a number of WMP goals can be met for a capital cost similar to merely upsizing storm drain pipes to convey flow. The WMP's unfunded capital needs citywide are $208 million.

Implementation of the WMP will depend on available funding and would require 30+ years due to its cost and scope.

3.6.4 Flood Risk and Loss Estimates

FEMA has developed standard loss curves to determine the percent of replacement value of damage caused by various heights of flooding. These curves are based on years of data from flood losses on insured properties around the country. Single-story structures with one foot of floodwater are estimated to have structural damage equal to 14% of their replacement value and damage to 21% of the structures contents. Single-story structures with three feet of water on average experience 27% loss of their replacement value and 40% loss to their contents.

Berkeley structures in the floodplain vary in size, ranging from single-family homes to large, industrial workspaces. Basements are uncommon, and few structures in these areas are multi-story. This analysis assumes that all structures are one story with no basement, which may overestimate the actual losses that could occur during flooding. Structures that have more than one story generally experience less overall damage than one-story structures, because upper story contents and structural elements remain free from damage. Structures with basements, however, experience more damage, as basements flood before any other portion of a structure.

The estimated losses to properties in Berkeley from a 100-year flood total $148 million.[99] Approximately $62 million is damage to the building structures, including walls, finishes, etc. $86 million is losses to contents, including damage to furniture in homes and equipment and inventory in commercial and industrial properties. Few Berkeley homeowners are known to carry flood insurance, presumably because of negligible flood damage in recent decades, so those losses would be borne almost entirely by building owners. Some of these losses could be avoided if property owners were able to protect properties through sandbagging or other activities, particularly in areas expected to receive one foot or less of flood water. The City offers free sandbags to city occupants. Remediation activities like sandbagging require property owners to have adequate warning time and manpower.

Due to the small watersheds and paved, urban environment, floodwaters in Berkeley are likely to both rise and recede quickly. This means residents and business owners may have a short warning period for impending floodwaters, but they should be able to begin

the cleanup and repair process quickly. Building cleanup will occur within a handful of days; repairing and replacing furniture and equipment will take weeks to months.

It is possible that key underpasses and roads accessing Interstate 80 could be inaccessible during high floodwaters. This could cause significant traffic problems regionally.

Because much of Berkeley's industrial area is located in the floodplain, some hazardous materials could spill during flooding. The most dangerous hazardous materials are protected by berms and secured against spilling in earthquakes, which may prevent spills in floods as well. Any spills would complicate cleanup efforts.

3.7 *Tsunami*

3.7.1 Historical Tsunamis

The most recent tsunami to impact Berkeley was associated with the March 2011 earthquake off the coast of Japan. As a result of the tsunami, a half-meter-tall surge was observed nearby in Oakland with 4-6 knot current[100]. The tsunami surge entered the Berkeley marina, causing $158,000 of damage to docks and boats.

Tsunamis generally impact the Pacific Coast of California, and reports of tsunamis entering the San Francisco Bay are rare. Tsunamis, or seiches as they are called when they occur within an enclosed body of water, can also be generated within the Bay by the Hayward fault, which passes under San Pablo Bay. The Great 1868 Earthquake on the Hayward fault is reported to have created a seiche within the Bay. It is unknown whether the seiche impacted the City of Berkeley. The 1964 Alaska earthquake caused extensive tsunami damage that flooded and heavily damaged coastal northern California near Crescent City.

3.7.2 Tsunami Hazard

A tsunami occurs in a body of water when a rapid disturbance vertically displaces the water, causing a series of surges. These changes can be caused by an underwater fault rupture (that generates an earthquake) or underwater landslides (typically triggered by earthquakes).

Tsunamis affecting the Bay Area can result from offshore earthquakes within the Bay Area, or from very distant events. While it is most common for tsunamis impacting the Bay Area to be generated by faults in Washington and Alaska, local tsunamis can be generated from local faults running underwater (such as the small tsunami that was triggered by the 1906 earthquake). The San Andreas Fault runs along the coast off the Peninsula and the Hayward fault runs partially through San Pablo Bay.

The 2013 Science Application for Risk Reduction (SAFRR) Tsunami Scenario[101] outlines multiple mechanisms of tsunami damage, which are described below:

- Buildings affected by tsunamis can be damaged by either the inflow or outflow of water, which can affect building finishes, carpets, carpets, electrical wiring, computers and other contents. Tsunamis may deposit soil or other water-borne debris in or around buildings. Tsunamis can erode soil around the building, especially at corners. In more severe cases, the pressure of the moving water can damage a building's structural components, and can even displace the entire building. Additionally, buoyancy can lift and move a building off its foundation.
- Tsunami damage to coastal infrastructure can release complex debris, crude oil, various fuel types and other petroleum products, cargo, and diverse other pollutants into nearby coastal marine environments and onshore in the inundation zone.

- Fires often occur within the inundation zone of a tsunami. Ignitions can occur when spilled liquid fuels mingle with waterborne debris, which can spark when jostled.
- Tsunamis can damage roads though erosion ("scour") of the land beneath the roadway, especially if the roadway is on a levee or embankment.
- Tsunamis can damage railroad embankments and tracks, which can be submerged, washed out-of-line, or washed out completely. Rolling stock can be overturned or derailed.
- Deaths are possible if individuals choose not to evacuate hazardous areas, do not understand tsunami warnings, or are unable to evacuate for various reasons. Injuries and illness can result from contact with tsunami surges, such as drowning and/or trauma from being struck by debris in the tsunami flow. Post-tsunami, mold can develop in inundated houses, buildings, and debris piles. Secondary infections can result from injuries or from living conditions following the disasters, such as an increase in pneumonia from water aspiration, as well as cellulitis from exposure of breaks in the skin to contaminated water.
- Physical damages, debris, and contamination can have short- and longer-term impacts on the environment and the health of coastal marine and terrestrial ecosystems. Marine habitats in intertidal zones, marshes, sloughs, and lagoons can be damaged by erosion or sedimentation, and can receive an influx of debris, metal and organic contaminants, and sewage-related pathogens. Debris and re-exposed contaminated sediments could pose chronic toxicity threats to ecosystems.

3.7.3 Exposure and Vulnerability

Given the known history of tsunamis within the San Francisco Bay, tsunamis are considered to be possible, but the severity of their impacts on Berkeley cannot be determined at this time.[102]

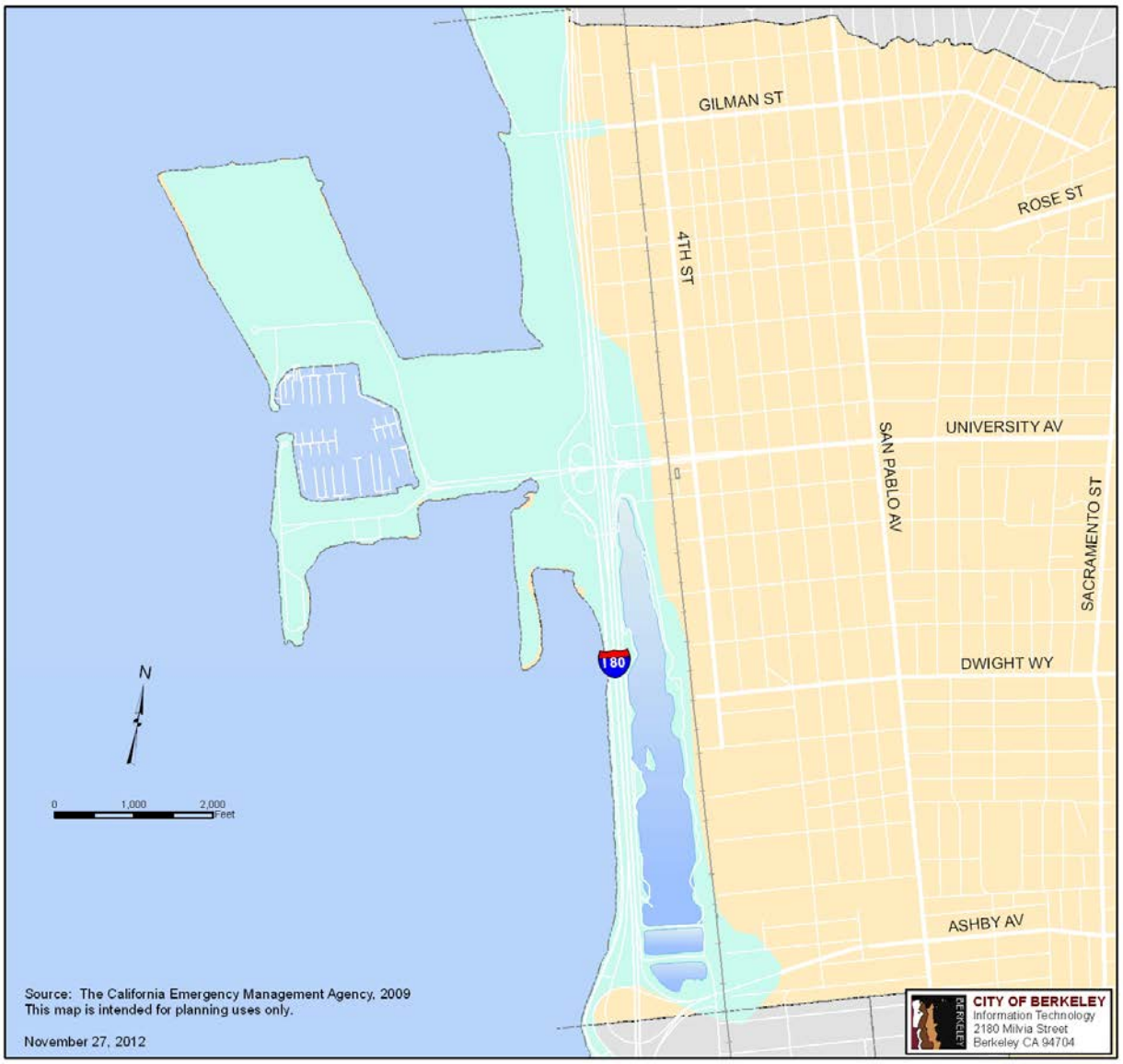
In December 2010, the California Emergency Management Agency released the first ever tsunami inundation map within the San Francisco Bay, shown in Map 3.18. This map is based on current sea levels and land elevation. This map shows in light blue the area of potential tsunami inundation in Berkeley. It does not reflect the inundation area from any singular tsunami. Rather, it depicts the worst-case scenario run-up heights from all potential tsunami sources across the Pacific Rim. This map is intended to be used to evacuation planning purposes only.

Given Berkeley's sloping terrain and the Bay's waters at their current levels, tsunami inundation will not extend far inland from the shoreline. According to Map 3.18, the tsunami inundation zone extends along the entire shoreline of the Bay. Starting at the city's northern border, the zone stretches east from the Bay until it meets the western edge of Interstate 80. At Virginia Street, the edge of the zone crosses Interstate 80 and stretches as far east as Second Street. The edge of the zone runs south along Second Street and the eastern edge of Aquatic Park to Ashby/CA-13. In this area, the edge of the zone extends further east to Fifth Street and Hollis.

According to Map 3.18, the zone captures Golden Gate Fields, the Tom Bates Regional Sports Complex, Eastshore State Park, the Berkeley Marina, the Dona Spring Animal Shelter, portions of Interstate 80 and the frontage roads beside it, the San Francisco Bay Trail, and Aquatic Park.

Sea-level rise associated with climate change will increase the zone of potential inundation, but the future boundaries of the zone are not yet clear.

Map 3.18 Berkeley Tsunami Inundation



USGS Exposure Study[103]

A USGS study of community exposure to tsunami hazards in California found that in Berkeley:

- Approximately 47 residents (23 households) live in the tsunami inundation zone.
    - Eight of the residents are over 65 and one is under five. Elderly and young residents as well as those in group homes may have a particular challenge evacuating from tsunamis.
    - Seven of the households are non-institutionalized group quarters, 20 households are owner-occupied, and 3 are rented.

The study also found that:

- 77 businesses and 4 government offices with 1,664 employees are located in the tsunami inundation zone.
    - 80% of these businesses are estimated to have high visitor potential, including the DoubleTree hotel. Visitors may not be aware of what to do in case of a tsunami warning.

While this study examined the Berkeley Marina, its information on residents at the Marina and surrounding park area is not as detailed or accurate as City of Berkeley data.

Berkeley Marina

Of primary concern to the City is the Marina, which is primarily used for recreational purposes, with relatively few homes or businesses. Despite the area's low density, the area's people, infrastructure, and businesses will be vulnerable to a tsunami:

- Marina residents: The Berkeley Marina has 1,000 boat slips. Approximately 200 residents live onboard boats in these slips. An additional estimated 25 live on board houseboats, and regulations permit people to periodically spend the night on their boats.
- Marina businesses and visitors: A number of Marina restaurants, such as Skates on the Bay and HS Lordships, often have large numbers of customers. The DoubleTree Hotel has 387 rooms, and regularly hosts events with 500-600 attendees, potentially making it the City's most densely-populated location with tsunami exposure.
- Infrastructure and roadways: Inundation maps show overtopping of parking areas and inundation of buildings in the Marina. The University Avenue access road is also within the inundation zone. The University Avenue overpass over Interstate 80 is also shown to be within the inundation zone. It is unlikely that the overpass itself would be inundated due to its height and its limited extent beyond Second Street. However, if water extends to Second Street, the access ramps on either end of the overpass would be covered, making the overpass impassable.

Evacuation Challenges

The numbers of people and assets exposed to a tsunami are relatively low as compared with other hazards presented in this Plan. However, evacuation routes for Marina residents and visitors are limited. Interstate 80 runs north-south along the eastern edge of the Marina, bisecting the area from the rest of the city. There are six access/egress routes from the Marina into Berkeley:

1. Via the University Avenue Bridge
2. Via the frontage road north to Gilman Street
3. Via the frontage road south to Ashby Avenue/CA-13
4. Via Interstate 80
5. Via the I-80 Bicycle/Pedestrian overcrossing[104]

In the event of a distant-source tsunami, where the underlying earthquake does not impact Berkeley, warnings can be issued before the tsunami arrives onshore in Berkeley. However, the limited number of egress routes will slow evacuations.

An earthquake occurring in the waters close to Berkeley could cause a near-source tsunami, which would allow for little to no time to provide warning to people in the inundation area. A near-source tsunami could severely compound evacuation challenges for individuals in the Marina: all of the above listed routes lie within the tsunami inundation zone.

3.7.4 Tsunami Risk and Loss Estimates

Estimating losses from tsunami inundation is difficult given that the inundation maps do not represent inundation from a single scenario event. Inundation from any single event will almost certainly be less severe than depicted in Map 3.18, which is intended to be used for evacuation planning purposes only.

The 2013 SAFRR tsunami scenario[105] depicts a hypothetical but plausible tsunami, created by an earthquake offshore from the Alaska Peninsula. The study projected impacts on the California coast, which included:

- Pilings in the Berkeley Marina will not be overtopped by tsunami waters, but over one-half of the docks in California coastal marinas will be damaged or destroyed
- One-third of boats in California coastal marinas will be damaged or sunk
- In Alameda County, tsunami inundation will create $20 million in building damage and $164.4 million in damage to building contents
- Wastewater treatment plants in Alameda County will be inundated and could release raw or partially-treated sewage and wastewater-treatment chemicals.

City of Berkeley Assets

The most significant financial losses to the City of Berkeley in the event of a tsunami would be inundation of the following structures, which are listed below with their estimated replacement costs:

Structure	Estimated Replacement Value
City Animal Shelter[106]	$7.8 million
Marina Boat Docks	$25 million
Berkeley Yacht Club	$1.6 million
Shorebird Nature Center	$1 million
Marina Corporation Yard	$790,000
Marina Administration Building	$1,000,000

Other City- and privately-owned facilities of significant value sit in the tsunami inundation zone. These facilities host a number of businesses and community recreation assets. Tsunami damage could also lead to a drop in revenue to the City from the buildings it leases to others, as well as a drop in tax revenue from businesses operating in the area.

Further research is needed to fully assess Berkeley's tsunami hazard, including the following:

- Definition of Berkeley's different areas of inundation for different tsunami scenarios;
- Vulnerabilities of each evacuation route to tsunami inundation;
- Structural assessment of buildings and infrastructure in the inundation zone, to determine if they are designed and constructed with the strength and resilience needed to resist the effects of tsunami surges.

The City will leverage ongoing research and coordinate with regional, State and federal partners to help answer these questions.

3.8 *Climate Change*

Climate change is a global issue with local impacts. Like regions across the globe, the San Francisco Bay Area is experiencing and will continue to increasingly experience the impacts of the changing climate, including rising temperatures and sea-level rise. These impacts affect our natural environment, our built infrastructure, and the health and safety of the people in our community, especially people of color and the poor.[107] The impacts of climate change also exacerbate every one of this plan's natural hazards of concern, including flooding[108], wildland fire,[109] and landslides.[110]

This section identifies the main impacts of climate change, which Berkeley is experiencing or is projected to experience in the future. This section also describes how climate change exacerbates each of this plan's natural hazards of concern. Where possible, the information provided here is specific to Berkeley, the Bay Area, and/or the state of California. For each climate impact, associated historical events, hazard description, exposure and vulnerability analysis, and risk and loss estimates are presented as available.

A discussion of local climate impacts, and recommendations for mitigating those impacts, are also included in the Berkeley Climate Action Plan (CAP). The CAP was adopted by the Berkeley City Council in 2009, and is designed to guide community-wide efforts to achieve deep and sustained reductions in global warming emissions, and to help the community prepare for the impacts of the changing climate. Additional information on the CAP and its implementation is included at the end of this section. Ongoing updates on the CAP are available at www.CityofBerkeley.info/climate.

3.8.1 Direct and Secondary Climate Change Impacts

Human activities have and continue to release large quantities of GHG emissions into the atmosphere. The majority of the emissions come from burning fossil fuels to create energy, although other activities, such as deforestation and solid waste disposal, also play a role. GHG emissions trap heat in the atmosphere and cause the planet to warm. This is known as the greenhouse effect. The greenhouse effect is a natural phenomenon, but it is being exacerbated by a dangerous buildup of GHG emissions in the atmosphere. This dangerous buildup of emissions is changing the climate.

Temperature/Heat Events

Climate change is already happening. The earth is warming. Earth's average temperature has increased by over 1° F over the past century. Average temperatures in California increased 1.7°F between 1895 and 2011.[111] Because global emissions will likely continue to increase for some time, scientists predict under a range of scenarios that it is likely that average global surface temperature will rise between about 3.6° and 10.8° F by the end of the century.[112] For the Bay Area in particular, scientists estimate that average temperatures will increase between 3.5-11° F by century's end, compared to the average temperature during the historical period 1961 - 1990.[113]

The U.S. Environmental Protection Agency defines extreme heat events as "periods of summertime weather that are substantially hotter and/or more humid than typical for a

given location at that time of year."[114] As a result of increasing temperatures, scientists expect that by 2050, Berkeley will experience 1-2 more heat waves each year.[115] By 2100, scientists expect 6-10 additional heat waves per year.[116] Public health impacts associated with these heat events include premature death, cardiovascular stress and failure, and heat-related illnesses such as heat stroke, heat exhaustion, and kidney stones.[117] The elderly and children under five are the most likely to suffer from heat-related illnesses and heat events.[118] Research indicates that communities of color and the poor also suffer more during extreme heat events because of lack of access to air conditioning, or to cars that allow them to escape the heat.[119] Across California, the highest risk of heat-related illness actually occurs in the usually cooler regions found in coastal counties. Because of a lack of acclimatization, the largest mortality rate increases in California are expected in coastal cities.[120]

In addition to public health impacts, heat events increase demands on infrastructure and lead to a need for additional infrastructure maintenance, particularly for roadways.[121]

Precipitation and Drought

In California, no consistent trend is detected to date in the overall amount of precipitation. For the Bay Area, a moderate decline in annual rainfall is projected: 1 to 3 inches by 2050 and 4 to 5 inches by 2090.[122]

If GHG emissions continue to increase, more precipitation is projected to fall as rain instead of snow, and the snow that does fall will melt earlier.[123] This has significant implications for the Sierra Nevada spring snowpack. The water distribution system for the state, including Berkeley and many other parts of the Bay Area, depends on the snowpack for water during the dry spring and summer months. Rising temperatures and more precipitation falling as rain instead of snow could reduce the snowpack by as much as 70 to 90 percent by century's end.[124] A shrinking snowpack poses significant challenges for water managers and for all communities that depend on this vital source of the state's water. The loss of snowpack also poses challenges for hydropower generation, which is a significant portion of the state's energy supply mix.

While the Bay Area can expect moderately less rainfall overall, climate change causes more extreme rainfall events. These intense rainstorms may cause flooding, which is discussed further below.

Sea-Level Rise

Warmer temperatures associated with climate change are causing global sea levels to rise through two processes:

1. Warmer temperatures are increasing the amount of ice melt from the world's glaciers and ice caps. This melted ice increases the volume of water in the ocean.

2. In a process termed "thermal expansion," warmer temperatures cause ocean water to increase in volume.

Sea-level rise is an ongoing challenge for communities surrounding the San Francisco Bay. It is estimated that the Bay has already risen approximately 7.9 inches during the

past century.[125] San Francisco Bay sea levels are projected to rise considerably in the coming decades. Relative to their 2000 levels, it is estimated that by 2050, sea level rise will range from 11-19 inches; and by 2100, sea level rise will range from 30 - 55 inches.[126]

The National Oceanic and Atmospheric Administration (NOAA) developed a web-based Sea Level Rise and Coastal Flooding Impacts Viewer[127] that enables users to identify lands that are vulnerable to various levels of sea-level rise. The Viewer depicts sea-level rise in 12-inch increments. According to the Viewer, at 12 inches of sea-level rise, low-lying areas around Berkeley Aquatic Park are potentially vulnerable to inundation. At 48 - 60 inches of sea-level rise, other areas become vulnerable to inundation, including land around the Berkeley Marina and infrastructure east of the highway along 2nd Street.[128]

It is possible that key underpasses and roads accessing Highway 80 could flood more often or be permanently inundated as sea-level rises, impacting transportation on this major regional artery. Other infrastructure that is vulnerable to inundation includes Berkeley's stormwater pipes and the East Bay Municipal Utility District's wastewater treatment plant, located near the Bay Bridge trouch-down. The combination of sea-level rise, storm surges, and high tides pose significant risk to low-lying infrastructure around the San Francisco Bay.

More comprehensive vulnerability assessments are necessary to clearly define the structures and infrastructure that will be affected with particular levels of sea-level rise.

More generally, sea-level rise means that beaches and shoreline habitats will be permanently inundated, erosion will increase, and levees and storm walls will have to endure increasing loads and may be susceptible to overtopping. Traditional measures for addressing sea-level rise, such as the use of levees and storm walls, may no longer be adequate or financially feasible.

The groundwater table and stream water levels will also rise, increasing areas subject to flooding. These changes will have impacts on the natural environment. According to the San Francisco Bay Conservation and Development Commission[129], these changes are "expected to substantially alter the Bay ecosystem by inundating or eroding wetlands and transitional habitats, altering species composition, changing freshwater inflow, and impairing water quality. Changes in salinity from reduced freshwater inflow may adversely affect fish, wildlife and other aquatic organisms in intertidal and subtidal habitats. The highly developed Bay shoreline constrains the ability of tidal marshes to migrate landward, while the declining sediment supply in the Bay reduces the ability of tidal marshes to grow upward as sea-level rises." With many miles of natural shoreline in Berkeley, these impacts on habitats are of significant concern.

Also, as with many other climate change impacts, sea-level rise may disproportionately affect those in our community that can least afford to plan for or respond to it. For example, low income residents would likely face greater difficulty relocating should their home or neighborhood be impacted by flooding.

Map 3.19 Berkeley Shoreline Areas Prone to Sea Level Rise[130]

Source: NOAA Sea Level Rise and Coastal Flooding Impacts Viewer

The above map depicts areas in Berkeley (and surrounding areas) potentially vulnerable to inundation from 48 inches of sea-level rise. Levels represent inundation at high tide. Areas that are hydrologically connected are shown in shades of blue, where darker blue shows a greater depth. Areas in green are at or below sea level at 48 inches of sea-level rise. They are determined solely by how well the elevation data captures the area's hydraulics.

A more detailed analysis of these areas is required to determine the susceptibility to flooding.

Food-, Water-, and Vector-Borne Diseases[131]

Climate change may also accelerate the incidence and geographic distribution of diseases and conditions that are transmitted through food, water, and animals such as deer, birds, mice, and insects. Increases in air temperature and change in precipitation may expand the territory of many pests. In California, three vector-borne diseases are of particular concern: West Nile virus, human hanta virus, and Lyme disease. Salmonella and other bacteria-related food poisoning also grow more rapidly in warm environments, causing gastrointestinal distress and, in severe cases, death.

3.8.2 Climate Change Impacts to Natural Hazards of Concern

Climate change is expected to exacerbate the natural hazards of concern identified in this plan. The ways that climate change affects Berkeley's natural hazards of concern are described below.

Earthquake (Section 3.3)

Sea-level rise will cause the groundwater table and stream water levels to rise, increasing the areas subject to liquefaction risks in the event of an earthquake.

Wildland-Urban Interface Fires (Section 3.4)
The incidences of large wildfires in California could more than double by century's end,[132] and higher summer temperatures will likely lengthen the fire season in our region.[133] Due to Berkeley's biophysical setting, climate, and other jurisdictional characteristics, scientists project little change to Berkeley's fire risk.[134] However, development that expands Berkeley's wildland urban interface area may increase the vulnerability to property losses due to wildfire.[135]

Landslides (Sections 3.3 and 3.5)

Increases in the intensity and frequency of winter storms will lead to more frequent landslides in the Berkeley hills.

Floods (Section 3.6)

Climate change will increase the frequency of flood events, and will expand the areas of Berkeley that are subject to flooding. A confluence of factors contributes to these changes:

- More extreme rainfall events; [136]
- Frequent and more hazardous storms, combined with a sea-level rise and high tides, can lead to more frequent and amplified storm surge events;
- Outfalls in Berkeley go directly to the Bay, and are influenced by tidal effects. As the sea level rises, it will require less rain to cause upstream flooding.

These factors will likely cause more frequent and extensive flooding events long before sea-level rise leads to permanent inundation of the shoreline.[137] FEMA's National Flood Insurance Rate Maps are currently being revised to account for areas that may become flood zones in the future due to sea-level rise.[138] Potential public health impacts of flooding include contamination of potable water, wastewater, and irrigation systems, resulting in an increase of water- and food-borne diseases.[139] [140]

Tsunami (Section 3.7)

Rising sea levels will extend tsunami inundation areas in Berkeley, putting more people and property at risk.

Notable Climate Change Mitigation and Adaptation Activities

The Berkeley Climate Action Plan provides policy and project recommendations designed to advance community-wide efforts to reduce, or mitigate, global warming emissions and to prepare for and adapt to the climate change impacts identified above.

CAP recommendations are implemented through the efforts of several City departments and community stakeholders. Outlined below are examples of specific CAP recommendations related to both mitigating global warming emissions and adapting to climate change impacts, and some explanation of how each of the identified recommendations is being implemented.[141]

Water Efficiency and Recycling

The CAP recommends proactive efforts mitigate the impacts of climate change on precipitation and the region's water supply, including the following:

In preparation for the impacts of climate change on the region's water resources, partner with local, regional, and State agencies to encourage water conservation and efficiency and expand and diversify the water supply (see CAP, Adapting to a Changing Climate, Goal 1, Policy B).

Water efficiency and reuse reduces global warming emissions and helps the community prepare for potential future water resource constraints. The City is advancing water efficiency and water recycling efforts in several ways. For example, in 2010 the City developed its *Guide to Conserving Water through Rainwater Harvesting and Graywater Reuse for Outdoor Use*. The purpose of the guide is to give homeowners the information they need to install effective, safe, and legal rainwater and/or graywater irrigation systems. Rainwater and graywater systems can help residents save water (and money) by reducing demand for potable water.

The City also provides in-person assistance to buildings committed to achieving a high level of green building, including installing water-efficient technologies to increase indoor and outdoor water efficiency.

Key Partner: United States Forest Service[142]

The U.S. Forest Service is charged with sustaining the health and productivity of the nation's forests for the benefit of the public. A primary reason that national forests were set aside a century ago was to protect the source of water for a growing nation. Water is the most important product of our public forests. In California, the Forest Service manages 20.8 million acres for the good of the public, and fully half of the state's water supply arises from those national forests. When people turn on the tap or the garden hose in Berkeley, they are using water from the Eldorado and the Stanislaus National Forests.

Ninety percent of the water that East Bay Municipal Utility District (EBMUD) conveys to Berkeley customers comes from the Mokelumne River in the Sierra foothills. The Mokelumne is fed by tributaries high in the Sierra Nevada mountains on 352,000 acres of the Eldorado and Stanislaus National Forests. The forests and meadows of these two national forests collect, filter, and store this water in the form of snowpack and groundwater. The storage capacity of the healthy ecosystem has helped make it possible for EBMUD to deliver clean, high quality water throughout the year, even throughout the annual summer droughts. However, that is already changing.

Climate change is a major threat to the health of these headwater forests, and their capacity to provide these vital storage and filtration services to East Bay residents into the future. The Sierra Nevada is predicted to receive more of its annual precipitation in the form of rain instead of snow, and the snowpack will melt earlier in the year. Both of these effects will make spring runoff occur earlier in the year and make it more challenging for EBMUD to physically store enough clean water to provide to Berkeley residents and businesses throughout the annual summer droughts.

There is a pressing need to restore the headwater forests of the Mokelumne River to a more resilient and healthy state, so they can withstand future stresses of climate change, benefit from regular forest fires, and continue to store and filter water for downstream users. These forests can be rehabilitated by mechanically removing small-diameter trees and by using prescribed fire to clear out underbrush. Fire scientists and modelers are currently working to determine areas at highest risk of severe wildfire in the upper Mokelumne River watershed so that restoration efforts have the highest positive impact.

If the upper Mokelumne Watershed is returned to a healthy state and the headwater forests are not allowed to become overly dense, Berkeley residents and businesses and other EBMUD customers will likely continue to enjoy high quality, reliable, and low-cost water throughout the 21st century, even in the face of climate change. If the upper watershed is not managed so that it can fulfill its natural hydrologic functions, EBMUD will eventually need to consider manmade, "gray infrastructure" storage and filtration options, such as additional dams, reservoirs, and filters, at a cost to water ratepayers, in order to ensure future water supplies.

Mitigating Impacts of Flooding and Coastal Erosion

The CAP recommends proactive efforts to prepare for potential flooding associated with climate change impacts, including:

In preparation for rising sea levels and more severe storms, partner with local, regional, and State agencies to reduce the property damage associated with flooding and coastal erosion (see CAP, Adapting to a Changing Climate, Goal 1, Policy C).

West Berkeley is particularly low-lying and potentially vulnerable to sea-level rise, especially when rising seas are compounded with severe storms. For all City-owned development projects, the City reviews and works to mitigate any risk from coastal flooding. The City will continue to analyze the latest data on the risk of sea-level rise in Berkeley, and to address the risk to new and existing infrastructure as necessary.

The City's urban forestry program mitigates global warming emissions through a process called carbon sequestration. It also mitigates the impacts of climate change, such as flooding and extreme heat events. For example, one of the benefits of the City's ongoing urban forestry program is stormwater management. Trees store rainwater, reducing runoff and delaying peak flows. Tree roots also loosen the soil around the base of the tree and increase water penetration. Berkeley's urban forest also helps to mitigate the impacts of extreme heat events by shading buildings and paved and dark-colored surfaces, such as roads and parking lots that absorb and store heat.

Another strategy designed to assist with stormwater management is installation of green roofs. As part of the City's education and outreach efforts, the City developed a Permit Guide to Living Roofs, which is designed to assist residents and businesses to understand the benefits and permitting requirements associated with installing a green roof. A green roof, also known as a "living roof" or "vegetated roof," is a planted rooftop garden that offers an attractive and energy-saving alternative to a conventional rooftop. One of the many benefits of green roofs is that they help filter and retain rainwater onsite.

In order to ensure accountability and progress on its emissions reduction and climate adaptation efforts, the City regularly reports on the status and outcomes of CAP implementation (see www.CityofBerkeley.info/climateprogress). Effectively monitoring and reporting progress and working to engage the community in advancing CAP-related actions is fundamental to achieving the CAP goals. Actions outlined in this plan are designed to be consistent with CAP goals.

SECTION C: ADDITIONAL HAZARDS

The focus of this mitigation plan is on natural hazards as emphasized in the Disaster Mitigation Act of 2000 (DMA 2000).[143] Hazardous materials release is addressed in this mitigation plan as a potential impact from a natural hazard. Terrorism is identified as a hazard of concern but is not analyzed in-depth.

3.9 *Hazardous Materials Release*

Because this plan is concerned with natural disasters, hazardous materials release is considered primarily as a secondary impact of the hazards presented in Sections 3.3 – 3.7. This section will identify how the natural hazards discussed in the plan can trigger the release of hazardous materials, as well as the potential impacts of those hazardous materials releases.

3.9.1 Historical Hazardous Materials Releases

Berkeley has not recently experienced significant hazardous materials releases secondary to a natural disaster. However, the city has experienced industrial accidents from both mobile and fixed sources. Truck accidents involving potentially harmful materials have occurred in the western part of the City, on Interstate 80 and its ramps. Industrial sites have released small amounts of dangerous substances, such as anhydrous ammonia from an ice rink and a sake brewery.[144] In 2011, an uncontrolled release of 1,600 gallons of diesel on the UC Berkeley campus resulted in diesel entering the stormwater system, and discharging into Strawberry Creek.[145]

3.9.2 Hazardous Materials Release Hazard

Hazardous materials release could harm community members by exposing people to vapors that are toxic, suffocating, cause burns or are irritating. Hazardous materials release can threaten not only life and property, but also the environment, in areas such as creeks, the Aquatic Park lagoons and the San Francisco Bay.

The impacts of a release depend on its chemical characteristics, the amount and rate of substance spilled, the location, and its dispersion. Flammable and combustible materials can cause fires in areas that are largely constructed of wood; they may also cause explosions. Wind speed and direction, as well as topography, can greatly impact the dispersion plume of a release.

The City's Toxics Management Division (TMD), within the Department of Planning and Development, maintains the Hazardous Materials Area Plan, which identifies facilities that, in the event of a regional disaster, may pose the greatest risk to human health or the environment.

The Fire Department is the first responder for hazardous materials incidents within the City, and has access to chemical inventories, locations and emergency planning for all these facilities.

The Department of Public Works manages the City's hazardous materials emergency response to spills on the right-of-way and also manages the hazardous materials emergency response contractor.

3.9.3 Exposure and Vulnerability

Hazardous Materials Sites

There are 436 facilities[146] within Berkeley that are regulated by TMD.[147] TMD has grouped these facilities into Hazard Levels 1, 2 and 3:

- Level 1: Facilities that have substantial quantities of hazardous materials onsite, and/or have hazardous materials that can easily disperse or explode, and are toxic or pose other special hazards to human health and the environment.

- Level 2: Facilities that have medium to large quantities of hazardous materials onsite, and/or materials with known hazards.

- Level 3: Facilities for which Berkeley Fire Department engine companies can handle incidents without additional facility storage information, because the hazards are known or familiar (e.g., gas station without welding cylinders, or a facility with motor oil).

The majority of the 436 facilities in Berkeley are Level 3 automotive- or medically-related facilities with limited quantities of hazardous materials.

Fifteen Hazard Level 1 facilities hold sufficiently large quantities of toxic chemicals to pose a high risk to the community.[148] TMD works directly with each of these sites to make sure they meet stringent safety requirements. Facilities in Table 3.13 are at the highest risk level.

Table 3.13 Berkeley industrial sites with large quantities of extremely hazardous substances

Site	Location
Alta Bates Summit Medical Center	2450 Ashby Avenue
Atlas Welding Supply, Inc.	1224 Sixth Street
Bayer Healthcare LLC	800 Dwight Way
Electro Coatings, Inc.	893 Carleton Street
Howlett Machine Works	746 Folger Avenue
Henkel Corporation	742 Grayson Street
PE-Berkeley, Inc.	1 Frank Schlessinger Drive
Pacific Coast Chemicals Co.	2424 Fourth Street
Precision Technical Coatings Inc.	1220 Fourth Street
UC Berkeley Environmental Health & Safety	University Hall (Oxford at University)
XOMA Corporation	804 Heinz
Berkeley Lab	1 Cyclotron Road
TPMG Regional Lab (Kaiser)	1725 Eastshore Highway
Davlin Coatings	700 Allston Way
DSM	2810 Seventh Street

Hazardous Materials Sources Outside of Berkeley

Airborne toxic plumes, including smoke, can travel into Berkeley from surrounding cities. Petrochemical refineries and other large chemical facilities in Contra Costa County could release hazardous materials that could impact the Berkeley community.

Hazardous Materials Transportation

Hazardous materials also travel through Berkeley by truck and rail. Specific routes known to carry hazardous chemicals are:

- Interstate 80

- San Pablo Avenue and the industrial areas to the west
- State Highway 13/Ashby Avenue
- Gilman Avenue
- University Avenue
- Union Pacific Railroad
- Fuel pipelines in the western edge of the City (see Map 3.11 *Seismic Hazard Planning Zones, Gas Transmission Lines and Jet Fuel Line*)

Transportation accidents have occurred with trucks carrying dangerous materials. These accidents will undoubtedly occur in the future.[149] A release on the freeway or railway would most immediately impact the western industrial area of the city. Winds typically blow from the west to the east, meaning that a gaseous release could easily spread to the City's eastern residential areas.

The City recently completed a Hazardous Materials Commodity Flow Study with a grant from the California Office of Emergency Services and the federal Department of Transportation. This study retrieved or collected data on bulk chemicals being transported on freeways, major city streets, the railroad and through pipelines.

Links to Berkeley's Hazards of Concern

In the wildland-urban interface (WUI) in the Berkeley hills, there are two major sources of dangerous chemicals: UC Berkeley and the Berkeley Lab. Both have significant amounts of flammable and toxic chemicals, including radioactive chemicals. While both sites have active disaster preparedness programs, WUI fires are notoriously difficult to fight and hazardous materials could be released in a major conflagration.

Map 3.20 identifies the locations of Hazard Level 1 Industrial Sites, along with key hazardous materials transportation routes, in relation to earthquake and flooding hazard exposure areas. Level 1 industrial sites are identified as building icons on the map. The Union Pacific Railroad is identified as a black hatched line. Interstate 80 and State Highways 24 and 13/Ashby Avenue are identified with red lines. Gilman Street, San Pablo Avenue and University Avenue, and Seventh/Sixth Streets between Ashby Avenue and University Avenue are identified in maroon, as key hazardous materials transportation routes.

Map 3.20 shows that eleven Hazard Level 1 Industrial Sites are located in west Berkeley, which is potentially susceptible to liquefaction in an earthquake. While business owners are required to secure and isolate hazardous chemicals, this may not prevent spills from causing fires or health hazards after an earthquake.

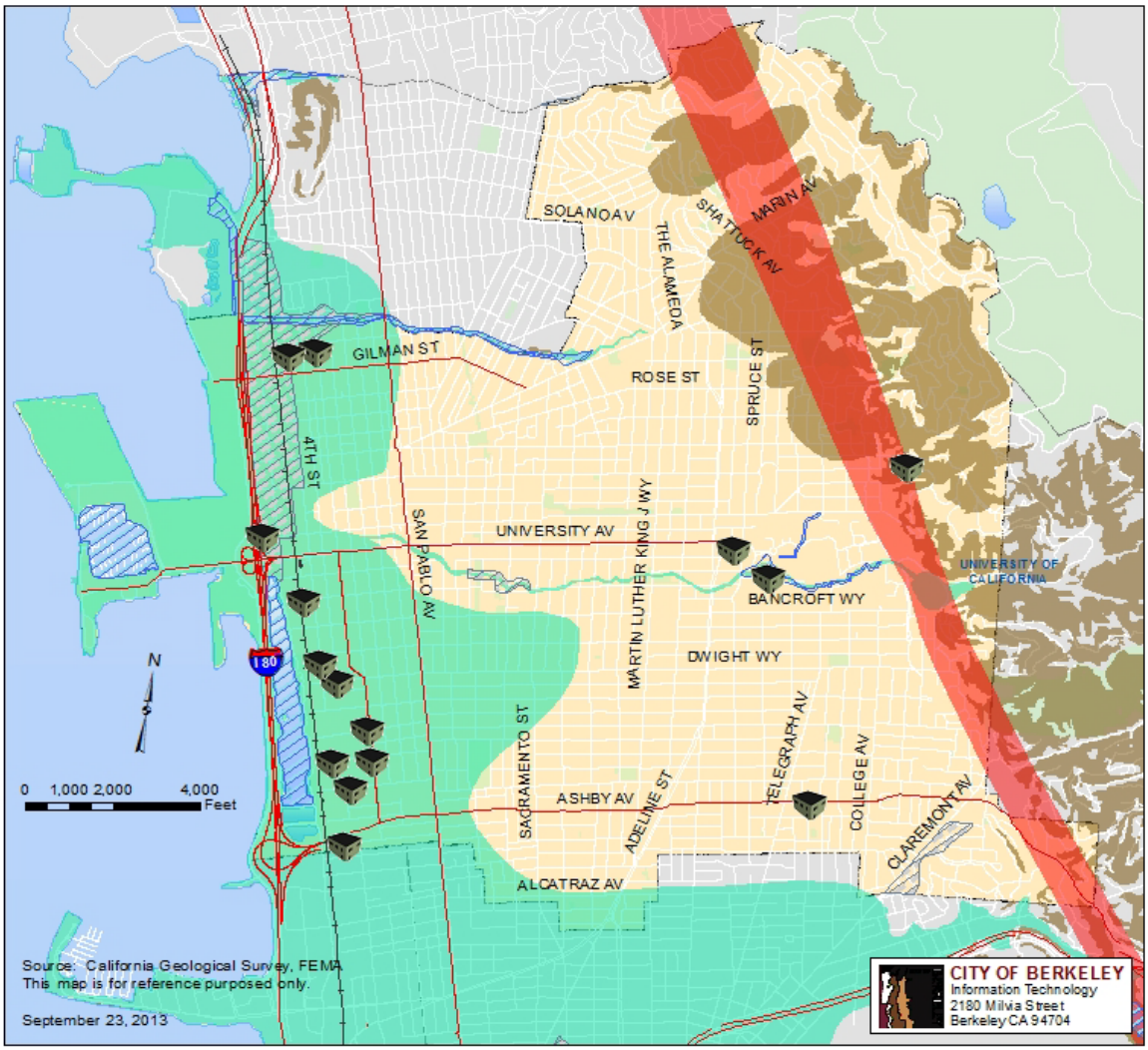
This map shows that the Berkeley Lab sits in the planning zone for earthquake-induced landslides and fault rupture; however, hazardous materials at the Lab are not considered vulnerable to these hazards.

Flooding could cause hazardous materials release. The City has very limited requirements for elevation and security of hazardous materials, although some must be surrounded by berms to contain any spills. The Berkeley Municipal Code[150] requires development in

flood-prone areas to be protected against flood damage at the time of initial construction. This requirement applies to future businesses but does not address existing facilities.

Map 3.20 shows that none of these sites sits in the 100-year flooding zone. However, three sites sit in or closely border the 500-year flooding zone, meaning in an unlikely flood, without proper elevation or floodproofing, these facilities could release hazardous materials.

Map 3.20 Level 1 Hazardous Materials Facilities, Transportation Systems and Primary Natural Hazards



Notable Mitigation Activities

The State of California requires engineering studies for facilities exceeding threshold quantities of extremely hazardous substances (EHS).[151] EHS regulations may also require mechanical and structural improvements to the respective facilities. Implementing State laws over the past twenty years has resulted in the decline of the number of EHS-regulated facilities in Berkeley by over 90 percent.

The City's Toxics Management Division regulates use and management of non-radioactive[152] hazardous materials at UC Berkeley and Berkeley Lab.[153] Both of these sites provide lists of the substances used in campus research to the TMD, which makes the information available to the Berkeley Fire Department in accordance with California Health and Safety Code. The TMD also makes these chemical types and volumes publicly available as part of its Community Right-to-Know program; however, locations of these chemicals are not disclosed to the public.

Key Hazardous Materials Partners

University of California at Berkeley

Hazardous materials are dispersed throughout many laboratories on the UC Berkeley campus, which has comprehensive programs to secure hazardous materials during and after disasters. The UC Berkeley campus relies on the City for fire and search and rescue services.

Berkeley Lab[154]

Berkeley Lab is a member of the national laboratory system supported by the U.S. Department of Energy through its Office of Science. It is managed by the University of California (UC) and is charged with conducting unclassified research across a wide range of scientific disciplines such as genomics, physical biosciences, life sciences, fundamental physics, accelerator physics and engineering, energy conservation technology, and materials science. The Laboratory's research is conducted in close collaboration with many UC campuses, especially UC Berkeley, UC San Francisco, and UC Davis.

Berkeley Lab contains significant amounts of hazardous substances. The Lab meets stringent federal requirements on environmental management and control of hazardous materials. The Berkeley Lab site map and Community Right to Know chemical information are available online.[155]

Bayer Corporation[156]

Bayer's headquarters for biotechnology manufacturing is located in Berkeley and employs over 1,200 workers. Bayer has been proactive in managing its disaster risk, focusing on both reducing risks to buildings and equipment and preparing for a robust emergency response. The entire site has been assessed for earthquake risk; buildings and other structures are currently being retrofitted on a risk-basis. Seven buildings have been

structurally strengthened to date, including the ammonia-based refrigeration facility. New buildings have been designed to exceed code requirements.

Bayer also trains its own emergency response team each year with the following capabilities:

- Industrial Firefighting
- Hazardous Materials Response (including 'level A' response)
- Emergency Medical Technicians
- Confined space rescue
- Rescue Systems-1 training

Bayer has a type-1 fire engine to bolster City's fire suppression capabilities. Bayer conducts at least annual joint training sessions with the Berkeley Fire Department, which allows the two groups to understand the capabilities of each other's organizations. Bayer has created plans and entered into contracts with vendors in order to mitigate the damage associated with earthquakes or other disasters. Internal and community-based communications plans are being updated to assure timely communications in the event of a range of emergencies.

3.9.4 Hazardous Materials Release Risk and Loss Estimates

Because of the uncertain nature of industrial accidents, loss estimates are not presented in this plan. City staff uses the CAMEO/ALOHA software suite to plan for and respond to chemical emergencies.

3.10 *Terrorism*

The City considers terrorism to be a hazard of concern. However, because this plan is concerned with natural disasters, an in-depth analysis of terrorism is not included, and mitigation actions for terrorism will not be identified.

It is not possible to estimate the probability of a terrorist attack. Experts prioritize terrorism readiness efforts by identifying critical sites and assessing these sites' vulnerability to terrorist attack. Critical sites include those that are essential to the functioning of the City, that contain critical assets, or which would cause significant impacts if attacked (e.g., a chlorine gas release). Vulnerability of these sites is determined subjectively by considering factors such as visibility (e.g., does the public know this facility exists in this location?), accessibility (e.g., is it easy for the public to access this site?) and occupancy (e.g., is there a potential for mass casualties at this site?)

City officials are currently working with State and regional groups to prevent and prepare for terrorist attacks. This effort involves the City's Police, Fire, Public Works, Public Health and Toxics Management groups. This team has identified critical sites in the city and their vulnerability. The City is now working to refine these assessments and create an updated plan to assess the City's needs and improve its capability to prevent and respond to terrorism. The City also participates in the federal BioWatch program, designed to allow early detection of release of bioterrorism agents in the City.

The City's emergency response teams actively train to detect Pre-Incident indicators for all types of terrorist events including, but not limited to, bomb scenarios, hostage situations, infrastructure damage and a multitude of other terror-associated threats. Since any terrorist event has the potential to significantly impact the city and the region, City emergency response teams regularly conduct training with emergency response teams from neighboring jurisdictions to ensure seamless integration of resources and personnel should such a need arise.

Buildings and other structures constructed to resist earthquakes and fires usually have qualities that also limit damage from blasts and resist fire spread and spread of noxious fumes in the event of a terrorist attack.

3.11 *Hazard Analysis and Actions Summary*

This section links this plan's hazard analysis to its mitigation actions. First, this section summarizes the relative likelihood and severity of impact of each of the hazards identified in Sections 3.3 – 3.8. Next, Berkeley's key vulnerabilities to each hazard are summarized. Last, these vulnerabilities are linked to the mitigation actions outlined in Section 1.

3.11.1 Hazard Analysis Summary

Sections 3.3 – 3.8 present hazards in Berkeley, describing their likelihood and detailing their potential consequences. Using a structure outlined by Saunders, Beban and Kilvington (2013 draft), the table below summarizes these hazards, their relative likelihoods, and the relative severities of their potential consequences.

Table 3.14 Summary of Hazard Analysis

Hazard	Likelihood[157]	Severity of Impact[158]
Earthquake	Likely	Catastrophic
Wildland-Urban Interface Fire	Likely	Catastrophic
Rainfall-Triggered Landslide	Likely	Moderate
Floods	Likely	Minor
Tsunami	Possible	Unknown*
Climate Change	Likely	Unknown*

**Consequence levels for climate change and tsunami have not been assigned values, as adequate information to make this determination is not yet available.*

Hazardous materials release is described only as a cascading impact of a natural hazard. Because this plan focuses on natural hazards as emphasized in DMA 2000, likelihood and consequence levels for hazardous materials release and terrorism are not defined.

3.11.2 Vulnerabilities and Actions Summary

For each hazard presented in Sections 3.3 – 3.8, the following table summarizes Berkeley's key vulnerabilities, along with the mitigation actions identified in Section 1 to reduce these vulnerabilities. For each hazard, the following information is identified:

- The *Category*, in gray, identifies the category of vulnerability being described. If the City of Berkeley does not own or control the category, the responsible entity is included.

- *Vulnerability* describes the vulnerability.
- *Mitigation Action(s)* provides the title(s) of mitigation action(s) identified to reduce the described vulnerability.

This chart identifies both primary and cascading vulnerabilities. Primary vulnerabilities are directly related to the primary natural hazard, such as building vulnerabilities to earthquake shaking. Cascading vulnerabilities are listed in *italicized text*. Cascading vulnerabilities result from primary vulnerabilities. For example, structures that are not seismically sound have increased vulnerability to fire following earthquake. This structure demonstrates how mitigating primary vulnerabilities can also mitigate cascading impacts.

This table highlights key vulnerabilities identified through this planning process; but it is not all-inclusive.

Table 3.15 Summary of Vulnerabilities and Actions

Vulnerability	**Mitigation Action(s)**
Earthquake (Including shaking, surface fault rupture, liquefaction, seismically-triggered landslides, and fire following earthquake)	
Structures	
City buildings vulnerable to collapse from exposure to earthquake shaking: Old City Hall Veterans Memorial Building Center Street Garage	Strengthen and Replace City Buildings
Un-assessed City buildings may be vulnerable to earthquake shaking and ground failure (See Appendix B for reference)	Building Assessment
158 unretrofitted soft-story buildings with 1,611 units vulnerable to damage/collapse from exposure to earthquake shaking	Soft-Story
19 unretrofitted unreinforced masonry (URM) buildings vulnerable to collapse from exposure to earthquake shaking. 274 retrofitted URM buildings vulnerable to moderate or greater damage from exposure to earthquake shaking	URM

Vulnerability	**Mitigation Action(s)**
Buildings vulnerable to damage from exposure to liquefaction, landslide-induced earthquake and fault rupture Approximately 6,000 structures vulnerable to damage/destruction from exposure to landslide	Single-Family Residences
Concrete tilt-up buildings vulnerable to collapse from exposure to earthquake shaking (specific number unknown, nearly all in west Berkeley, many may also be exposed to ground failure from liquefaction)	
If buildings are damaged/collapse from exposure to earthquake shaking or ground failure: • *Buildings are more vulnerable to gas line rupture at service connections* • *Buildings are more vulnerable to fire following earthquake* • *People more vulnerable to injury/death from exposure to building damage/collapse* • *People are more vulnerable to illness from exposure to asbestos or encapsulated asbestos, which may dislodge in an earthquake*	Buildings Soft-Story URM Gas Safety Partnerships
Water system (EBMUD)	
Water pipes vulnerable to rupture from exposure to liquefaction, landslide-induced earthquake and fault rupture	EBMUD Partnerships
If water pipes rupture due to earthquake shaking or ground failure, structures more vulnerability to damage/destruction from fire following earthquake	
Sanitary Sewer System	
Sanitary sewer system vulnerable to blockage/pipe rupture/damage from exposure to liquefaction, landslide-induced earthquake and fault rupture	
If sanitary sewer system is blocked/ruptured/damage from seismic ground failure, roads and buildings more vulnerable to sinkhole	

Vulnerability	**Mitigation Action(s)**
Storm Drain System	
Storm drain system vulnerable to blockage/rupture/other damage from exposure to liquefaction, landslide-induced earthquake and fault rupture	Stormwater System
Electricity System (PG&E)	
Utility poles vulnerable to toppling from exposure to earthquake shaking and from exposure to liquefaction, landslide-induced earthquake and fault rupture Aboveground utility lines vulnerable from exposure to falling trees and structure collapse from earthquake shaking and from exposure to liquefaction, landslide-induced earthquake and fault rupture PG&E Electrical substations vulnerable to damage from exposure to earthquake shaking and from exposure to liquefaction, landslide-induced earthquake and fault rupture Underground cables vulnerable to rupture from exposure to liquefaction, landslide-induced earthquake and fault rupture	Partnerships
If power is lost, there will be many impacts to vulnerable City and private infrastructure.	Energy Assurance
Natural Gas System (PG&E)	
Gas transmission pipeline, distribution lines and service lines and valves in west Berkeley vulnerable rupture from exposure to liquefaction Gas distribution lines, service lines and valves vulnerable to rupture from exposure to earthquake-induced landslides and fault rupture	Gas Safety
If gas system ruptures occur, fire following earthquake is more likely, and: • *Infrastructure/buildings are more vulnerable to damage/destruction* • *People are more vulnerable to injury/death*	
Aviation Fuel Pipeline (Kinder Morgan)	
Exposed to liquefaction (specific vulnerability unknown)	Partnerships

Vulnerability	Mitigation Action(s)
Railroad (Union Pacific)	
Railroad infrastructure vulnerable to damage from exposure to earthquake shaking and liquefaction (specific vulnerability unknown)	Partnerships
If railroad infrastructure is damaged due to earthquake shaking and/or liquefaction: • *Trains more vulnerable to accidents* • *People more vulnerable to illness/injury from exposure to hazardous materials, if trains carrying hazardous materials*	
Highways and Interstate (Caltrans)	
Interstate 80 vulnerable to damage from exposure to liquefaction Parts of Highways 13 and 24 vulnerable to damage from exposure to liquefaction Overpasses at Ashby and University Avenues vulnerable to damage from exposure to earthquake shaking (but are not expected to collapse)	Partnerships
If roads are damaged from earthquake shaking and/or liquefaction: • *People in vehicles more vulnerable to injury/death in accidents* • *People vulnerable to injury/death from exposure to hazardous materials, if transportation accidents occur involving vehicles carrying hazardous materials*	
Streets/Curbs/Solano Tunnel	
Solano Tunnel vulnerable to isolation if fault rupture or earthquake-induced landslide in surrounding areas cause road blocks Streets and curbs vulnerable to damage from exposure to liquefaction, fault rupture and earthquake-induced landslides	

Vulnerability	Mitigation Action(s)
If significant street damage impedes access by emergency responders to fight fires, perform rescues, access utilities or perform other emergency response actions: • *People vulnerable to additional injuries/death* • *Structures and infrastructure vulnerable to additional damage*	Hills evacuation
Communication Infrastructure (AT&T, Verizon, Comcast and other providers)	
Land line telephone distribution system and cable system use utility poles, which are vulnerable to toppling from exposure to earthquake shaking and ground failure Underground communication lines vulnerable to rupture from exposure to earthquake-induced landslides, fault rupture and liquefaction Mobile phone system antennae vulnerable to: • Damage from earthquake shaking • Power outage from damage to electrical infrastructure (vulnerability increased if generators not onsite)	Partnerships
If communication systems are damaged due to earthquake shaking and ground failure: • *Cellular voice communication may be unusable due to earthquake impacts, combined with high demand. Voice communication is more vulnerable than SMS text messaging systems.* • *Cable customers may experience a total loss of video service, and total loss or severe network congestion of voice and data services.*	
Healthcare Facilities (Alta Bates Summit)	
Five Alta Bates Campus buildings vulnerable to damage from exposure to earthquake shaking Four buildings on the Herrick campus are vulnerable to major damage from earthquake shaking	Partnerships
People in and around four buildings on the Herrick campus are vulnerable to injury/death from exposure to seismic building damage	

Vulnerability	**Mitigation Action(s)**
Structures (Berkeley Unified School District)	
Unreinforced Masonry Building at BUSD Corporation Yard vulnerable to damage from earthquake shaking	Partnerships
People in and around Unreinforced Masonry Building at BUSD Corporation Yard are vulnerable to injury/death from exposure to seismic building damage	
Transportation Infrastructure (BART)	
BART tracks in Berkeley vulnerable to damage from earthquake shaking	Partnerships
Hazardous Materials	
If earthquake shaking causes lab spills, storage tank failures and/or industrial equipment problems, people in Berkeley vulnerable to injury/death from exposure to hazardous materials release	
Wildland-Urban Interface Fire	
Structures	
8,300 properties in Fire Zones 2 and 3 vulnerable to damage/destruction from exposure to WUI fire	Vegetation Management Fire Code
215 dwelling units in Fire Zone 3 - Panoramic Hill area (280 including Oakland units) especially vulnerable to damage/destruction from exposure to WUI fire, due to undersized water main and limited access routes for firefighters	
Wooden buildings with narrow side yards and dense vegetation in Fire Zone 1 vulnerable to damage/destruction from exposure to a WUI fire beginning in Fire Zone 2 or 3	
People	
Residents and firefighters in Fire Zone 2 vulnerable to injury/death from exposure to WUI fire	Vegetation Management Hills Evacuation Fire Code
520 residents in Panoramic Hill area (620 including Oakland residents) especially vulnerable to injury and death from exposure to WUI fire, due to limited access/egress routes	

Vulnerability	**Mitigation Action(s)**
Berkeley residents and visitors vulnerable to eye and respiratory illnesses from exposure to air pollution caused by large WUI fires	
Electricity system (PG&E)	
If exposed to extreme heat from WUI fire: • Utility poles vulnerable to toppling • Aboveground utility lines vulnerable to burning • Underground cables vulnerable to melting	Vegetation Management Partnerships
Natural Gas System (PG&E)	
Gas service connections vulnerable to rupture in buildings exposed to WUI fire	Vegetation Management Partnerships
Structures, Infrastructure and People/Natural Gas System (PG&E)	
People, structures and infrastructure in areas exposed to gas line rupture vulnerable to additional fire exposure	Vegetation Management Partnerships Gas Safety
Communication Infrastructure (AT&T)	
Land line telephone distribution system uses utility poles, which are vulnerable to toppling if exposed to heat from WUI fire	Vegetation Management Partnerships
Streets and curbs	
Streets and curbs in Fire Zones 2 and 3 vulnerable to damage/destruction from exposure to WUI fire	Vegetation Management
Storm drain system	
Drainage structures in Fire Zones 2 and 3 vulnerable to damage/destruction from exposure to WUI fire	Vegetation Management

Vulnerability	**Mitigation Action(s)**
Structures and Infrastructure	
Structures and infrastructure in fire-burned areas in Fire Zones 2 and 3 vulnerable to damage/destruction from exposure to landslide and flooding	Vegetation Management
Rainfall-triggered landslides	
Structures and Infrastructure	
Approximately 6,000 structures vulnerable to damage/destruction from exposure to landslide	Single-Family Residences
Water system (EBMUD)	
Water pipes vulnerable to rupture from exposure to landslide	Partnerships
Sanitary Sewer System	
Sanitary sewer system pipes vulnerable to rupture from exposure to landslide	
Storm Drain System	
Storm drain system vulnerable to blockage/rupture/other damage from exposure to landslide	
Electricity System (PG&E)	
Utility poles and aboveground utility lines vulnerable to toppling from exposure to landslide Underground cables vulnerable to rupture from exposure to landslide	Partnerships
Natural Gas System (PG&E)	
Gas distribution and service lines and valves in Berkeley hills vulnerable to rupture from exposure to landslide	Partnerships Gas Safety

Vulnerability	Mitigation Action(s)
Floods	
Structures	
475 structures vulnerable to damage to first floor and basement finishes, contents and appliances from exposure to up to 1 foot of flooding. 200 additional structures, also primarily in the City's west, are vulnerable to damage from exposure from up to two feet of flooding.	Stormwater System NFIP Severe Storms
Streets, Structures and Infrastructure	
Streets, structures and infrastructure in the Potter Watershed are vulnerable to damage from exposure to localized flooding in the following locations: • San Pablo Avenue between Ward and Murray • California Street between Woolsey and Harmon • Woolsey Street between California and Adeline • Woolsey Street at Dana • Ashby Avenue between California and King • Martin Luther King, Jr. Way between Russell and Woolsey • Parker Street between Seventh and Fourth • Fulton Street at Derby • Ellsworth Street between Blake and Parker • Telegraph Avenue between Ashby and Woolsey • Telegraph Avenue at Stuart • College Avenue at Dwight	Stormwater System NFIP Severe Storms

Vulnerability	Mitigation Action(s)
Streets, structures and infrastructure in the Cordonices Watershed are vulnerable to damage from exposure to localized flooding in the following locations: • Second Street, Creek corridor to Gilman • Railroad tracks, Creek corridor to Gilman and to Albany • Gilman Street between Sixth and Second • Codornices Creek at Sixth, at most street crossings east of San Pablo, at Glen • Ninth Street between Harrison and Creek Corridor • Monterey Ave between Posen and Hopkins • Hopkins Street at Carlotta • The Alameda between Napa and Yolo • Sonoma Ave between Fresno and Hopkins • Spruce Street, Eunice to Creek corridor • Euclid Ave, Cragmont to Codornices Park • Cragmont, Euclid to Regal • Various locations on La Loma, Glendale, Campus Drive, Queens, Shasta Road	
Hazardous Materials	
People and environment exposed to potential flood-induced hazardous materials release from 41 toxics sites within the 500-year floodplain. Specific vulnerability unknown.	Stormwater System NFIP HazMat Floods Severe Storms
Transportation	
Regional transit vulnerable to severe traffic impacts from exposure to flooding at key underpasses and roads accessing Interstate 80	Stormwater System NFIP Severe Storms

Vulnerability	Mitigation Action(s)
Tsunami	
Structures	
City buildings exposed to tsunami inundation: • Dona Spring Animal Shelter • Marina Boat Docks • Berkeley Yacht Club • Shorebird Nature Center • Marina Corporation Yard • Marina Administration Building The extent of each building's vulnerability is unknown.	Tsunami
Privately-owned structures in the Marina and on the western edge of Berkeley exposed to tsunami inundation. The extent of each building's vulnerability is unknown.	
People	
Estimated 23 traditional households and over 225 individual Marina boat residents are exposed to tsunami inundation. Specific vulnerability is unknown.	Tsunami
Estimated that staff/customers at 77 businesses are exposed to tsunami inundation. Staff and guests at the DoubleTree hotel alone may account for 600+ people. Estimated that 1,664 employees at four government offices are exposed to tsunami inundation. Specific vulnerability unknown.	

Vulnerability	**Mitigation Action(s)**
Streets	
Key roads exposed to tsunami inundation: 1. Ramps to University Avenue Bridge 2. Frontage road north to Gilman Street 3. Frontage road south to Ashby Avenue/CA-13 4. Interstate 80 5. Ramps to I-80 Bicycle/Pedestrian overcrossing Specific vulnerability is unknown.	Tsunami
Boats	
1,000 boats in Marina slips exposed to tsunami inundation. Specific vulnerability unknown.	Tsunami
Climate Change	
People	
Elderly and children under 5 (especially poor) will be vulnerable to public health impacts of heat-related events (premature death, cardiovascular stress and failure, and heat-related illnesses such as heat stroke, heat exhaustion, and kidney stones) from increased exposure to heat waves. *People vulnerable to increased incidences of West Nile virus, human hanta virus, and Lyme disease from increased exposure to disease vectors, caused by increases in air temperature and changes in precipitation.*	Extreme Heat Climate Change Integration

Vulnerability	**Mitigation Action(s)**
People, structures and infrastructure	
Buildings and infrastructure in low-lying areas around Berkeley Aquatic Park, as well as land around the Berkeley Marina and infrastructure east of the highway along 2nd Street, are exposed to sea level rise. Specific vulnerability is unknown. *Sea-level rise will cause the groundwater table and stream water levels to rise, increasing the people, structures and infrastructure exposed to liquefaction in an earthquake. Specific increase in vulnerability unknown.* *Rising sea levels will increase the people, structures and infrastructure exposed to tsunami inundation. Specific increase in vulnerability unknown.*	Sea-Level Rise Climate Change Integration
Increases in the intensity and frequency of winter storms due to climate change will increase exposure to landslides for people, structures and infrastructure in the Berkeley hills. Specific increase in vulnerability unknown.	Climate Change Integration
Structures and infrastructure	
More structures and infrastructure will become vulnerable to damage from exposure to flooding, and flooding events will also become more frequent. This is due to: • *Rise in groundwater table and stream water levels* • *More extreme rainfall events and more hazardous storms* • *Sea level rise causing more upstream flooding.*	Severe Storms Climate Change Integration
Environment	
Wetlands and transitional habitats vulnerable to inundation/erosion from sea level rise. Species composition vulnerable to alteration following sea level rise. Freshwater inflow vulnerable to change from sea level rise. Water quality vulnerable to sea level rise. Fish, wildlife and other aquatic organisms in intertidal and subtidal habitats vulnerable to changes in salinity from reduced freshwater inflow due to sea level rise.	Water Security Climate Change Integration

3.12 *Endnotes*

[1] Human action directly influences the probability that climate change will occur. Climate change is referenced as a natural hazard here because of its potential to exacerbate natural hazards described in this plan.

Chapter Three: Analysis of Hazards in Berkeley

[2] Documentation is on file at the Berkeley Planning Department

[3] Public Law 106-390

[4] Analyses by the US Geologic Survey (USGS) and California Earthquake Prediction Evaluation Council: http://pubs.usgs.gov/fs/2008/3027/fs2008-3027.pdf

[5] Southern California Earthquake Center. *A Comparison of the February 28, 2001, Nisqually, Washington, and January 17, 1994, Northridge, California Earthquakes*. http://www.scec.org/news/01news/feature010313.html

[6] Information adapted from the United States Geological Survey: http://earthquake.usgs.gov/learn/topics/mag_vs_int.php

[7] The Alquist-Priolo Earthquake Fault Zoning Act of 1972 was passed by the legislature as a result of the 1971 San Fernando earthquake in southern California, which damaged numerous homes, commercial buildings, and other structures. This Act is intended to prevent the construction of most structures intended for human occupancy across active faults. The Act was not retroactive; therefore, structures intended for human occupancy built before 1972 within the fault zone may be impacted by surface fault rupture.

The Act requires that the California Geological Survey (CGS) designate zones approximately ¼-mile wide along known active faults (known as Alquist-Priolo Earthquake Fault Zones). To comply with this Act, the City regulates most development projects within the zones, except for single-family wood-frame and steel-frame dwellings up to two stories not part of a development of four units or more, or projects not involving structures intended for human occupancy. Alternations and additions to non-residential property that exceed 50% of the property value are also covered by this Act. Cities can be more restrictive than state law requires. Before a permit can be issued within a fault zone, site-specific geologic reports must be prepared to demonstrate that proposed buildings will not be constructed across active faults. Typically, structures intended for human occupancy cannot be placed within 50 feet of an active fault trace.

The Seismic Hazards Mapping Act of 1990 requires the preparation of site-specific geotechnical reports for development proposals in areas identified as Zones of Required Investigation for earthquake-induced landslides or liquefaction as designated by CGS. Cities and Counties are also required to incorporate the Official Seismic Hazard Zone Maps into the Safety Elements of their General Plans. The Seismic Hazards Mapping Act requires sellers of real property to disclose to buyers if property is within a Zone of Required Investigation. Cities and counties containing Zones of Required Investigation are required to enforce the preparation of these reports and condition project approval on

the incorporation of necessary mitigation measures related to site remediation, structure and foundation design, and/or avoidance.

Effective June 1, 1998, the Natural Hazards Disclosure Act requires that sellers of real property and their agents provide prospective buyers with a "Natural Hazard Disclosure Statement" when the property is being sold lies within one or more State-mapped hazard areas, including Earthquake Fault Zones and Zones of Required Investigation.

[8] California Geological Survey Regulatory Maps can be viewed at http://www.quake.ca.gov/gmaps/WH/regulatorymaps.htm

[9] Charles Real, California Geological Survey

[10] U.S. Geological Survey, Miscellaneous Field Studies Map MF-2378. http://pubs.usgs.gov/mf/2001/2378/

[11] Jibson, R.W., Harp, E.L., and Michael, J.A., 1998, A Method for Producing Digital Probabilistic Seismic Landslide Hazard Maps: An Example from the Los Angeles, California area: U.S. Geological Survey Open-File Report 98-113, 17 p., 2 pl., http://www.csulb.edu/~rodrigue/quake/jibson.html

[12] Miles, Scott B., Keefer, David K. 2001, Seismic Landslide Hazard for the City of Berkeley, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-2378, USGS. 2001. http://pubs.usgs.gov/mf/2001/2378/

[13] Estimated each structure at 1,900 square feet and multiplied by $350/sq ft replacement cost. $350/sq ft is the Berkeley Fire Department's formula for building replacement cost.

[14] Yasuhara K., Komine H., Murakami S., Chen G., Mitani Y. (2010) Effects of climate change on geo-disasters in coastal zones. Journal of Global Environmental Engineering, JSCE 15, 15–23.

[15] ATC 52-1. 2010. San Francisco Department of Building Inspection, Community Action Plan for Seismic Safety (CAPSS) Project. *Here Today Here Tomorrow: The Road to Earthquake Resilience in San Francisco.* http://www.sfgsa.org/modules/showdocument.aspx?documentid=9753.

[16] http://www.sfmuseum.org/conflag/underwriters.html

[17] City of Berkeley Budget Book FY2012-2013,Community Profile Data

[18] 2010 American Community Survey.

[19] The City has adopted Standard Plan Set A for wood frame homes of two stories or less that provides typical details and other guidance. This plan set simplifies the design of cripple wall retrofits for many homes in Berkeley.

[20] Information per Building and Safety Division as of March 2012.

[21] Association of Bay Area Governments, 2003. *Preventing the Nightmare. Note: The remaining uninhabitable housing losses come from mobile homes, unreinforced masonry buildings and non-wood frame multi-family residences.*

[22] See "Post Earthquake Housing Issue Paper B" published by the Association of Bay Area Governments. Study of this issue is ongoing, but after the Loma Prieta earthquake, red-tagged multifamily units in San Francisco took longer to repair and reoccupy than single-family homes. In San Fernando, after the Northridge earthquake, after 2 years, multi-family units showed significantly slower rates of repair than single-family homes.

[23] Information provided by Bill Cain, Elizabeth Bialek, Jose Rios, Janetta Johnson, Mike Ambrose, Michelle Blackwell, EBMUD.

[24] Information provided by Manuel Ramirez, City Environmental Health Division Manager, and Dr. Janet Berreman, City Health Officer, as of November 2012

[25] EBMUD Press Release, February 27, 2007, "Claremont Tunnel Earthquake Retrofit Completed, Mandatory Rationing Alert System Ended."

[26] EBMUD Claremont Corridor Seismic Improvements Project Environmental Impact Statement, State clearinghouse #2003022140.

[27] Interceptors are sewer pipes, as large as 10 feet in diameter, which form the backbone of the wastewater transport system.

[28] Information provided by Stuart Nishenko, Senior Seismologist, and PG&E

[29] National Transportation Safety Board, 2011. *Pipeline Accident Report: Pacific Gas and Electric Company Natural Gas Transmission Pipeline Rupture and Fire San Bruno, California, September 9, 2010*, Washington D.C.

[30] Information provided by Nicole Stewart, Area Manager Brisbane Terminal & Richmond Station of the Kinder Morgan Corporation, as of March 2012.

[31] Nabil Al-Hadithy, City Toxics Management Division, as of March 2012.

[32] Evacuation routes are designated in the City's General Plan, Transportation Element policy T-28: Emergency Access.

[33] Information provided by Craig Whitman, Office of Earthquake Engineers, Steve Prey, Energy Conservation Program Coordinator, and Robert Braga (January 2012), Branch Chief Maintenance Services/Emergency Management: Planning & Training, all at Caltrans.

[34] BART information provided by Tracy Johnson, Seismic Engineering Manager, BART, June 2013. BART earthquake early warning system information provided by John McPartland, BART Board of Directors.

[35] P-waves are non-destructive, earthquake-generated waves. They travel faster than secondary waves (S-waves), which create the strong shaking responsible for structural damage in earthquakes.

[36] Information provided by Lori Kingshott, Universal Account Manager for AT&T, in March 2012.

[37] Information provided by Ken Fattlar, Director of Network Operations for Verizon Wireless in Northern California, in April 2013.

[38] Bryan Byrd, Comcast, Director, Communications, June 2013

[39] A "headend" is a master facility for receiving television signals for processing and distribution over a cable television system.

[40] In a hierarchical telecommunications network, the "backhaul" portion of the network comprises the intermediate links between the core network, or backbone network and the small sub-networks at the "edge" of the entire hierarchical network.

[41] Carl Scheuerman, Director of Regulatory Affairs, Sutter Health Facility Planning & Development, personal communication February 23, 2012

[42] These buildings are categorized as SPC-2 according to the Hospital Seismic Safety Act. Structural Performance Category (SPC) 1 is the most vulnerable ranking for buildings. Many SPC 1 hospitals pose significant collapse risks. SPC 5 hospitals pose the least structural risk. Significant changes impacting life safety were made to the Building Code in 1973, particularly regarding reinforced concrete buildings. These changes built on lessons learned in California earthquakes, including the 1971 San Fernando earthquake. According to state law, SPC-2 buildings must comply with standards intended to keep hospitals open and providing medical care following a severe earthquake by 2030.

[43] These buildings are categorized as SPC-3 and SPC-4. Structural Performance Category (SPC) 1 is the most vulnerable ranking for buildings. Many SPC 1 hospitals pose significant collapse risks. SPC 5 hospitals pose the least structural risk.

[44] These buildings are categorized as SPC-1. Structural Performance Category (SPC) 1 is the most vulnerable ranking for buildings. Many SPC 1 hospitals pose significant collapse risks. SPC 5 hospitals pose the least structural risk.

[45] The Tang Center is no longer considered to be an alternate Emergency Operations Center site for the UC Berkeley campus.

[46] Janice Edwards, Communications Manager/Project Manager, LifeLong Medical

[47] California Seismic Safety Commission. *The Field Act and Public School Construction: A 2007 Perspective.* February 2007.

[48] California Seismic Safety Commission. *Seismic Safety in California's Schools: Findings and Recommendations on Seismic Safety Policies and Requirements for Public, Private, and Charter Schools.* December 2004.

[49] Lew Jones, Berkeley Unified School District Maintenance Department Director, March 2013

[50] Shirley Slaughter, Berkeley City College Business Officer and Safety Committee Chair, March 2012.

[51] Figures are from the UC Berkeley website and the Berkeley Downtown Association.

[52] Camerio, Mary. "The Economic Benefits of a Disaster Resistant University: Earthquake Loss Estimation for UC Berkeley." April 12 2000, Institute of Urban Design and Regional Development.

[53] See http://www.berkeley.edu/administration/facilities/safer/index.html for more information on UC Berkeley's SAFER program.

[54] www.berkeley.edu/administration/facilities/safer/

[55] Office of the Vice Provost and the Disaster Resistant University Steering Committee. Strategic Plan for Loss Reduction and Risk Management: University of California, Berkeley. Working Paper 2000-03. University of California, Berkeley, July 2000.

[56] Information provided by Sara Wynne, Emergency Services Specialist, Berkeley Lab, as of March 2012.

[57] Per July 8, 2010 "Geologic Hazard Mitigation" presentation, available at

http://www.lbl.gov/Community/CAG/docManager/1000000031/WDM_July%208_Geotech.pdf

[58] As of October 2013; includes budgeted, career and at-will, positions only (including Library and Rent Board)

[59] Includes both Adeline/Shattuck and Heinz Avenue stores

[60] The 2004 scenario was calculated using HAZUS-MH. The program's default data on buildings (types and economic values) and soils (for liquefaction and landslides) were used. 2004 shelter figures are taken from a previous analysis conducted by the Association of Bay Area Governments. HAZUS estimates of shelter populations were lower. Special thanks to Rich Eisner for help preparing these estimates.

[61] This 2013 LHMP Update includes impacts described in the 2008 FEMA/Cal EMA (Cal OES) Catastrophic Earthquake Incident Scenario. This scenario is based on a HAZUS-MH™ study completed by Charles A. Kircher, Hope A. Seligson, Jawhar Bouabid, and Guy C. Morrow as part of a series of papers presented at the 100th Anniversary Conference on the 1906 San Andreas Fault Earthquake. Descriptions of damage in this scenario is based on impacts expected from a magnitude 7.7 to 7.9

earthquake on the San Andreas fault, but the general level and type of impacts are expected to be similar for a Hayward fault event. The report was based on the most accurate data available at the time and the results were reviewed by peers. Additional analysis and data were prepared by Kircher, et al. for Golden Guardian 2006.

[62] About 20% of ignitions typically occur within the first hour after the earthquake, 50% within about 6 hours and almost all ignitions occur within the first day.

Risk, S. P. A. "Enhancements in HAZUS-MH Fire Following Earthquake, Task 3: Updated Ignition Equation pp. 74pp. *SPA Risk LLC, Berkeley CA. Principal Investigator C. Scawthorn. Prepared for PBS&J and the National Institute of Building Sciences, San Francisco* (2009).

[63] Estimation derived from Ch. 10, particularly Eqn. 10-1, of HAZUS Earthquake Tech Manual MR 4:

FEMA, 2003. Multi-hazard Loss Estimation Methodology, Earthquake Model, HAZUS-MH MR4 Technical Manual. Developed by: Department of Homeland Security, Federal Emergency Management Agency, Mitigation Division, Under a contract with: National Institute of Building Sciences Washington, D.C., p. 712.

[64] In 2004, estimate was $20 million damage from 5 estimated fires. This plan estimates 6-12 fires. If $4 million/ignition assumed, $24 million - $48 million damage is estimated in 2004 dollars. This figure was then updated for 2013 to $30 million - $60 million using Consumer Price Index Inflation Calculator at http://data.bls.gov/cgi-bin/cpicalc.pl.

[65] In 2004, estimate was $1.5 billion. Updated for 2013 using Consumer Price Index Inflation Calculator at http://data.bls.gov/cgi-bin/cpicalc.pl.

[66] Information provided by Bill Cain, EBMUD

[67] Information provided by Bill Cain, EBMUD

[68] In 2004, estimate was $215 million. Updated for 2013 using Consumer Price Index Inflation Calculator at http://data.bls.gov/cgi-bin/cpicalc.pl.

[69] City of Berkeley. *Fire Hazard Mitigation Plan*. February 25, 1992.

[70] Updated for 2013 using Consumer Price Index Inflation Calculator at http://data.bls.gov/cgi-bin/cpicalc.pl.

[71] City of Berkeley. *Fire Hazard Mitigation Plan*. February 25, 1992.

[72] City of Berkeley. *Fire Hazard Mitigation Plan*. February 25, 1992.

[73] United States Fire Administration. *The East Bay Hills Fire, Oakland-Berkeley, California (October 19-22, 1991): Report 60 of the Major Fires Investigation Project.*

[74] City of Berkeley. *Fire Hazard Mitigation Plan*. February 25, 1992.

[75] California Department of Public Health. 2008. Public Health Climate Change Adaptation Strategy for California. http://resources.ca.gov/climate_adaptation/docs/Statewide_Adaptation_Strategy.pdf

[76] Pacific Institute. (2010). A Review of Social and Economic Factors that Increase Vulnerability to Climate Change Impacts in California.

[77] 2010 CBC Chapter 7A: Materials and Construction Methods for Exterior Wildfire Exposure, and 2010 CRC Section R327: Materials and Construction Methods for Exterior Wildfire Exposure

[78] Per Dan Gallagher, Senior Forestry Supervisor, City of Berkeley: The Fire Fuel Chipper Program collected green waste vegetation in the following amounts in the following years:

- 2005: 264.35 tons
- 2006: 237.59 tons
- 2007: 189.06 tons
- 2008: 175.16 tons
- 2009: 167.17 tons
- 2010: 161.31 tons
- 2011: 187.24 tons

[79] Information provided by Andrew Schneider, Recycling Program Manager, City of Berkeley, as of March 2012.

[80] Information provided by Andrew Schneider, Recycling Program Manager, City of Berkeley, as of March 2012.

[81] Information provided by Doug McDonald, Senior Landscape Supervisor, City of Berkeley as of March 2012.

[82] East Bay Municipal Utility District Staff: William R. Kirkpatrick, Manager, Water Distribution Planning Division (WDPD); Michael Ambrose, Manager of Regulatory Compliance; Jose L. Rios, Senior Civil Engineer in WDPD; Tim McGowan, Associate Civil Engineer in WDPD, via David Rehnstrom, Senior Civil Engineer; Heidi Oiol, Associate Civil Engineer in Wastewater Engineering Division, via Vincent De Lange, Senior Civil Engineer

[83] http://firecenter.berkeley.edu/

[84] Information provided by Sara Wynne, Emergency Services Specialist, Berkeley Lab, as of March 2012.

[85] Per Section IV.M.2.1 of Berkeley Lab's 2007 Long Range Development Plan Environmental Impact Report.

[86] Total square footage of buildings in burn area is 9,386,281 square feet. That number was multiplied by $350/square foot, the Berkeley Fire Department's formula for building replacement cost, resulting in $3.3 billion.

[87] In 2004, estimate was $500 million. Updated for 2013 using Consumer Price Index Inflation Calculator at http://data.bls.gov/cgi-bin/cpicalc.pl.

[88] Ellen et al. "Map showing principal debris-flow source areas in Alameda County, California." USGS Open-File Report 97-745 E.

[89] Pike et al. "Map and map database of susceptibility to slope failure by sliding and earth flow in the Oakland area, California." USGS MF-2385.

[90] The City uses a 10-year design storm as representation of a rainfall event that reflects local conditions. Design storms are defined by their duration, total rainfall depth, and temporal patterns. A 10-year storm has a probability of 0.1 or 10% of being equaled or exceeded in any one year.

[91] California Adaptation Planning Guide, July 2012.

[92] Confalonieri, U., and B. Menne. 2007. Human health. Climate Change 2007. Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, O. F. C. M. L. Parry, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson, eds. Cambridge, UK.: Cambridge University Press 391–431.

[93] USGCRP. 2009. Global Climate Change Impacts in the United States: A State of Knowledge Report from the U.S. Global Change Research Program, T. R. Karl, J. M. Melillo, and T. C. Peterson, eds. New York: Cambridge.

[94] California Adaptation Planning Guide, July 2012.

[95] The DFIRM map was created by the Federal Emergency Management Agency (FEMA) for the National Flood Insurance Program. Data current as of 2009.

[96] Repetitive loss properties are those that have submitted claims for flood reimbursement through the National Flood Insurance Program at least twice in the last ten years. The goal of mapping these properties is to identify what locations flood repetitively and seek to mitigate the problem to reduce flood damage. Data from FEMA, current as of March 2011.

[97] The Potter Watershed drains approximately one-third of the land area of the City through storm drain pipe infrastructure. The Codornices Watershed drains about one-tenth of the City through open watercourses and creek culverts. Findings from these two watersheds could be extrapolated to the other watersheds, but it is preferable to continue hydraulic modeling of the remaining watersheds.

[98] Information based on 2009 mapping of 100- and 500-year flood plain identified in Federal Emergency Management Agency (FEMA) for the National Flood Insurance Program. Data current as of 2009, overlayed with the City's May 2012 inventory of facilities regulated by the Toxics Management Division.

[99] In the 2004 plan, flood losses were estimated using the following calculations:

	Three Feet Flood Waters			One Foot Flood Waters			*Totals*
	Value	% Damage	Damage	Value	% Damage	Damage	
Structures	$70 mill	27%	$19 mill	$250 mill	14%	$35 mill	$54 mill
Contents*	$35 mill	40%	$14 mill	$250 mill	21%	$53 mill	$67 mill
Totals	$105 mill		$33 mill	$500 mill		$88 mill	**$121 mill**

*Contents were assumed to be worth 50% of the total structural replacement value for single-family homes and 100% of the total structural replacement value for commercial and industrial properties. The majority of structures in the zone with up to 3 feet of floodwaters are residential, so contents for all structures in this zone were estimated at 50% of structure value. The majority of structures in the zone with up to 1 foot of water are commercial or industrial, and contents value was assumed to equal structure value for these properties.

In 2013, loss estimates quoted in the narrative were updated using Consumer Price Index Inflation Calculator at http://data.bls.gov/cgi-bin/cpicalc.pl.

[100] Wilson, R., Ewing, L., Dengler, L., Boldt, E., Evans,T., Miller, K., Nicolini, T., and Ritchie, A. Effects of the February 27, 2010 Chilean Tsunami on the Harbors, Ports, and the Maritime Community in California With Comparison to Preliminary Evaluation of March 11, 2011 Tsunami. Proceedings from ASCE Coasts, Oceans, Ports, and Rivers Institute Conference, Alaska, June 2011.

[101] The SAFRR Tsunami Modeling Working Group, 2013, Modeling for the SAFRR Tsunami Scenario—Generation, propagation, inundation, and currents in ports and harbors, chap. D in Ross, S.L., and Jones, L.M., eds., The SAFRR (Science Application for Risk Reduction) Tsunami Scenario: U.S. Geological Survey Open-File Report 2013–1170, 136 p., http://pubs.usgs.gov/of/2013/1170/d/.

[102] A team of scientists from California Geological Survey, US Geological Survey and the California Office of Emergency Services are in the process of developing a methodology for estimating tsunami hazard to the west coast. In 2013 they expect to begin two pilot studies to test the methodology in Crescent City and Huntington Beach. Following validation of the pilot studies, probabilities for the rest of the state will be developed.

[103]Wood, N., Ratliff, J., and Peters, J., 2013, Community exposure to tsunami hazards in California: U.S. Geological Survey Scientific Investigations Report 2012-5222, 49p.

[104] Overcrossing provides non-automobile access between the residential and business districts on the east side of I-80 and the Berkeley waterfront, Bay Trail and Eastshore State Park (Addison St and Bolivar Drive) to the west of the freeway (West Frontage Road and University Avenue).

[105] The SAFRR Tsunami Modeling Working Group, 2013, Modeling for the SAFRR Tsunami Scenario—Generation, propagation, inundation, and currents in ports and harbors, chap. D in Ross, S.L., and Jones, L.M., eds., The SAFRR (Science Application for Risk Reduction) Tsunami Scenario: U.S. Geological Survey Open-File Report 2013–1170, 136 p., http://pubs.usgs.gov/of/2013/1170/d/.

[106] The Dona Spring animal shelter, opened in 2012, is built above the 100-year flood plain but is still in the tsunami inundation zone

[107] Morello-Frosch, R; Pastor, M; Sadd, J; Shonkoff, S. The Climate Gap: Inequalities in How Climate Change Hurts Americans & How to Close the Gap. May 2009.

[108] Moser, S, Ekstrom, J. and Franco, G. 2012.Our Changing Climate 2012. California Climate Change Center. http://www.energy.ca.gov/2012publications/CEC-500-2012-007/CEC-500-2012-007.pdf

[109] McKenzie, D.; Heinsch, F.A.; Heilman, W.E. 2011. Wildland Fire and Climate Change. (January 17, 2011). U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. http://www.fs.fed.us/ccrc/topics/wildland-fire.shtml

[110] Moser, S, Ekstrom, J. and Franco, G. 2012.Our Changing Climate 2012. California Climate Change Center. http://www.energy.ca.gov/2012publications/CEC-500-2012-007/CEC-500-2012-007.pdf

[111] Moser, S, Ekstrom, J. and Franco, G. 2012.Our Changing Climate 2012. California Climate Change Center. http://www.energy.ca.gov/2012publications/CEC-500-2012-007/CEC-500-2012-007.pdf

[112] *Climate Change Scenarios for the San Francisco Region*, July 2012. California Climate Change Center.

[113] Ibid.

[114] U.S. EPA. 2006. *Excessive Heat Events Guidebook*. EPA 430-B-06-005. U.S. Environmental Protection Agency, Washington, DC.

[115] Heat wave is defined as five days over 72°F to 77°F. Source: Public Interest Energy Research, 2011. Cal-Adapt. Retrieved from http://cal-adapt.org.

[116] Public Interest Energy Research, 2011. Cal-Adapt. Retrieved from http://cal-adapt.org.

[117] California Adaptation Planning Guide, July 2012.

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[128] See http://www.csc.noaa.gov/digitalcoast/tools/slrviewer. Website viewed on April 8, 2013.

[129] San Francisco Bay Conservation and Development Commission, 2011, p. 5

[130] The data in the map do not consider natural processes such as erosion or marsh migration that will be affected by future sea level rise. There is not 100% confidence in the elevation data and/or mapping process. It is important not to focus on the exact extent of inundation, but rather to examine the level of confidence that the extent of inundation is accurate. The data may not completely capture the area's hydrology, such as canals, ditches, and stormwater infrastructure.

[131] California Adaptation Planning Guide, July 2012.

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[141] Recommendations related to mitigating climate change impacts are contained in Climate Action Plan Chapter 5 (p. 101).

[142] Amanda Cundiff, Regional Partnership Office, U.S. Forest Service

[143] Public Law 106-390

[144] Both of these accident sites no longer store anhydrous ammonia.

[145] UC Berkeley and Berkeley Lab have since evaluated their storm water systems as potential hazardous materials conduits to the creeks.

[146] Of the 436 facilities indicated, 380 meet chemical minimums; the remainder are smaller hazardous waste only generators that do not meet volume thresholds quotes. There are many more facilities that have some sort of hazardous materials on their sites, but they are not regulated by the City's Toxics Management Division (per Carrie Estadt, City Toxics Management Division, May 2012).

[147] These facilities have a minimum of 55 gallons of aggregate liquid chemicals, 500 pounds of aggregate solid chemicals, or 200 cubic feet of aggregate gaseous chemicals, or they may generate hazardous waste.

[148] City Toxics Management Division, as of September 2013.

[149] The Northridge earthquake derailed a train carrying 2,000 gallons of sulfuric acid that began leaking. Firefighters were on the scene within two hours and the situation was stabilized with three and a half hours.

[150] Berkeley Municipal Code Section 17.12.030.C.2 requires uses vulnerable to floods, including facilities which serve such uses, be protected against flood damage at the time of initial construction. This requirement applies to future businesses but does address existing facilities. BMC 17.12.030 does not recognize areas exposed to sea-level rise in the flood exposure area.

[151] Per Nabil Al-Hadithy (March 2012), the engineering study is a Risk Management Plan, which includes safety information, process hazard analysis/hazard review, operating procedures, training, maintenance, compliance audits and incident investigations, along with documents and records showing that the facility is implementing the program. Scenarios for release including earthquake, operator error and fire are studied and corrections are made. The technical severity of these studies depends on the quantity and type of hazardous substances at the facility.

[152] The City has limited regulatory authority over radioactive material use and management. Radioactive materials are managed by the federal Department of Energy and Nuclear Regulatory Commission.

[153] Per Nabil Al-Hadithy, Toxics Management Division, City of Berkeley: Per the State's Unified Hazardous Waste and Hazardous Materials Management Regulatory Program, the City's Toxics Management Division is the agency responsible for administering six of the State's hazardous materials and waste programs for Berkeley. The City of Berkeley regulates both UC Berkley and Berkeley Lab for the following six State programs:

> 1. Hazardous Materials Release Response Plans and Inventories (HMBP) Program, Health and Safety Code, Division 20, Chapter 6.95, Article 1, with supplemental regulations in California Code of Regulations Title 19, Sections 2620-2732.
>
> 2. California Accidental Release Prevention (CalARP) Program, Health and Safety Code, Division 20, Chapter 6.95, Article 2, with supplemental regulations in California Code of Regulations, Title 19, Sections 2735-2785.
>
> 3. Underground Storage Tank (UST) Program, Health and Safety Code, Division 20, Chapter 6.7, with accompanying regulations in the California Code of Regulations, Title 23.

4. Aboveground Petroleum Storage Act Requirement for Spill Prevention, Control and Countermeasure (SPCC) Plans, Health and Safety Code, Division 20, Chapter 6.67, Section 25270-25270.13.

5. Hazardous Waste Generator and Onsite Hazardous Waste Treatment (tiered permitting) Programs, Health and Safety Code, Division 20, Chapter 6.5, with accompanying regulations in the California Code of Regulations, Title 22.

6. California Fire Code: Hazardous Materials Management Plans (HMMP) and Hazardous Materials Inventory Statements, California Code of Regulations, Title 27, Division 2, Chapter 4.5.

The Toxics Management Division also enforces City codes regarding hazardous materials and waste. These codes are often more stringent than CUPA codes.

[154] Information provided by Sara Wynne, Emergency Services Specialist, Berkeley Lab, as of March 2012.

[155] Site Map and Community Right-to-Know Information available at : http://www.lbl.gov/ehs/esg/Reports/assets/HazardousMaterialsBusinessPlanMainSite2013_web.pdf

[156] Information provided by James C. Breitlow, CHMM, REA, Bayer Corporation - Health, Environment, Safety and Security.

[157] Using a structure outlined by Saunders, Beban and Kilvington (3 July 2013 draft), relative degrees of likelihood are described as:

- *Likely*: The event may occur several times in your lifetime, up to once every 50 years
- *Possible*: The event might occur once in your life time, Once every 51 – 100 years
- *Unlikely*: The event does occur somewhere from time to time, once every 101 – 1,000 years
- *Rare*: Possible but not expected to occur except in exceptional circumstances, once every 1,001 to 2,500 years
- *Very rare*: Conceivable but highly unlikely to occur, once every 2,500+ years

[158] Using a structure outlined by Saunders, Beban and Kilvington (3 July 2013 draft), relative severity of hazard impacts is described using the following terms, which are defined by matrix of factors, including Social/Cultural, Buildings, Critical Buildings, Lifelines, Economic and Health and Safety:

- *Catastrophic*
- *Major*
- *Moderate*
- *Minor*
- *Insignificant*

4. Current Mitigation Programs and Resources

This section identifies the regulatory authorities, policies, programs and funding structures that support the Berkeley community's hazard mitigation efforts.

Section 4.1 describes the public works resources supporting mitigation efforts. Section 4.2 describes emergency management structures in Berkeley. Section 4.3 describes taxing authorities in Berkeley. Section 4.4 describes the City of Berkeley budget. Section 4.5 describes the resources supporting mitigation efforts for City buildings and systems. Section 4.6 describes the resources supporting mitigation of privately-owned buildings. Section 4.3 describes the regulatory authorities, policies and programs supporting fire risk reduction in Berkeley. Section 4.7 highlights State and federal requirements related to hazard mitigation, and describes how Berkeley complies with these requirements. The timeline in section 4.8 identifies key mitigation activities and disaster events that impacted Berkeley's mitigation programs and resources.

4.1 *Public Works*

The City of Berkeley's Public Works Department is the largest department in the City and provides both direct services to the community, as well as critical support services to the City organization. Public Works is responsible for maintaining the City's physical assets and infrastructure in a safe and serviceable condition. Public Works provides services ranging from refuse and recycling collection, diversion and disposal, to property management, infrastructure improvements, and improving safety in the public rights-of-way.

Public Works Divisions and staffing allocations (measured in Full Time Equivalent (FTE) positions) are as follows:

- Office of the Director (6 FTE)
- Operations, Deputy Director (137 FTE)
- Engineering (33.75 FTE)
- Zero Waste (87 FTE)
- Transportation (13 FTE)
- Administrative & Fiscal Services (10 FTE)

Significant objectives expected to be accomplished by the department during FY 2014 include executing Sewer System Asset Management Implementation Plan and implementing computerized maintenance management system for sewers; beginning construction for accelerated street rehabilitation; initiating implementation of the Watershed Management Plan; contracting with Project Manager and develop design and financial plan for Center Street Garage replacement; and completing building assessment for all City buildings under the Public Works and Parks, Recreation & Waterfront Departments, and developing a long-term Capital Improvement Program.

Four publicly-staffed commissions provide community oversight over Public Works activities:

- Commission on Disability
- Community Environmental Advisory Commission Public Works Commission

- Transportation Commission
- Zero Waste Commission

4.2 *Emergency Management*

The City's Fire Department - Office of Emergency Services (OES) works to increase the Berkeley's readiness through community education, staff support to the Disaster and Fire Safety Commission, and coordination of the City's emergency management activities. OES staff meets regularly with City's designated emergency response staff to provide training and coordination. OES develops, maintains and exercises the City's Emergency Operations Plan.

OES has four FTE positions.

Emergency management is a shared responsibility among all City departments. Department Directors are responsible for ensuring their respective departments' readiness to contribute to disaster response activities. All City staff members are Disaster Service Workers and are required to provide services in the event of an emergency or disaster.

The Disaster and Fire Safety Commission provides community oversight over emergency management activities. The Commission participates in the review of emergency, disaster and mutual aid plans and agreements and makes recommendations to the City Council regarding legislation and regulations needed to implement such plans and agreements.

4.3 *Taxing Authorities*

The City's General Fund gets the majority of its money from: a) property taxes and property-based revenues; b) economically sensitive revenues such as sales tax, business license tax, transient occupancy tax, etc.; and c) interest and fees such as ambulance fees; and parking and traffic fines. The balance of the City budget is comprised of other funding sources such as grants, special tax revenue (e.g. parks, libraries and paramedic services), and fees for specific services (marina berth fees, garbage and sewer fees, building permits, etc.).

California property taxes are set at 1% of the assessed value of the property. The City receives about a third of every property tax dollar collected in Berkeley, and schools get 43% of every property tax dollar. These proportions have been about the same since 1979.

Sales tax is 9.75 cents on every dollar. Of that, the State gets 7 cents, Alameda County gets 1.75 cents, and the City gets a penny. Berkeley's sales tax revenue has decreased during the economic downturn, but is expected to remain steady going forward because of the City's efforts to retain its diverse retail mix.

The decline in property transfer tax is an example of the impact of the economy on City budgets. Property tax revenue goes into the General Fund. This revenue is dependent on the fluctuating real estate market, and can vary dramatically from year to year (note the $9.2 million drop from FY 2007 to FY 2009). To protect City services from this volatility, much of this revenue is used for one-time infrastructure needs, such as streets and transportation projects.

4.4 *City Budget*

The City's budget process assigns resources to address the goals, objectives, and community priorities set by the City Council. The City's FY 2014 & FY 2015 Biennial Budget was adopted

on June 25, 2013. It includes a combination of $3 million in recurring General Fund expenditure reductions and new revenues in FY 2014, which allowed the FY 2014 & FY 2015 Biennial Budget to balance, assuming costs and revenues remain as projected.

The City's General Fund is $146 Million. The balance of the City's budget is made up of special funds ($172 million combined), which are dedicated to specific services. While special fund revenue is dedicated, it is not guaranteed. Special funds also shrink in tough economic times. There are three broad categories of special funds:

- Special Revenue and Grant Funds are legally restricted to a specific service, e.g.: Federal transportation funds, State public health funds, and the Parks, Library, and Paramedic Tax Funds.
- Special Assessment Funds are for the financing of public improvements or services, such as the Clean Storm Water Fund and the Streetlight Assessment District Fund. Those two funds are examples of special funds where the revenues have not kept pace with the cost of delivering the service.
- Enterprise Funds come from the collection of the fees associated with providing the service or program. For example, the Refuse Fund pays for the pickup and collection of garbage, recycling, and green waste. Services in this category include the Permit Service Center, the Sanitary Sewer Fund, and the Marina Enterprise Fund.

Over the past few years, staff and the Council have implemented reductions that minimized cuts to services, while at the same time controlling costs in response to declining revenues. These strategies included reducing the size of the City organization each year over the last five years, and that approach is to continue into FY 2014. The cumulative effect of these reductions is the elimination of over 200 full time equivalent (FTE) positions throughout the City.

Additionally, the City has deferred maintenance on much of its capital infrastructure. As the economy begins to slowly recover, the City is being mindful of the need to address deferred maintenance, as well as to remain prepared to address the impacts of future cost increases in areas such as health and pension benefits.

The City Council has adopted budget development policies that have served Berkeley well over the long term, including:

- Focusing on the long-term fiscal health of the City by adopting a two-year budget and conducting multi-year planning;
- Building a prudent reserve;
- Developing long-term strategies to reduce unfunded liabilities;
- Controlling labor costs while minimizing layoffs;
- Allocating one-time revenue for one-time expenses;
- Requiring enterprise and grant funds to balance and new programs to pay for themselves; and
- Any new expenditure requires either additional revenue or expenditure reductions.

The City also used the "fix it first" approach in developing the budget, through which current capital improvements are funded before funding new projects.

4.5 *City Buildings and Systems*

Municipal Building Improvements. The City, supported by an active public, local and State bond measure funding and FEMA grants, has strengthened and rebuilt numerous key buildings in the city. Since 2004, the City has strengthened the historic Ratcliff building, an effort supported by a FEMA grant. The Ratcliff building is home to the Public Works Department Operations Center, which will be a key facility supporting the City's response to disasters. In 2006, the City constructed a new Fire Station 7, which is the only fire station east of the Hayward Fault. The City has also constructed a new animal shelter.

Additionally, the City has strengthened or rebuilt all seven of the City's fire stations, all public school buildings, the Civic Center (which houses many key government functions), the Public Safety Building, and all libraries. The City is currently assessing vulnerabilities of other key City buildings and is developing funding strategies to upgrade buildings with known vulnerabilities.

Emergency Water Supply for Firefighting. In 2010, the City put into operation an aboveground, portable water system that can pump water from any source, including the San Francisco Bay, in the event of drained tanks or damaged pipelines. This system is designed to carry up to 20,000 gallons of water per minute for a distance of one mile and elevation gain of 100 feet; it will also carry smaller flows to higher elevations.

4.6 *Privately-Owned Buildings*

The City offers a comprehensive suite of programs to encourage the community to strengthen buildings to be more hazard-resistant.

Building Codes. The City enforces disaster-resistant development through the application of the California Building Code, as well as more stringent local code amendments. The Provisions of the California Building Code are applicable to all new construction, additions, alterations and repairs.

City Transfer Tax Rebate Program. By ordinance, the City created a program to rebate up to one-third of the transfer tax amount to be applied to earthquake upgrades on homes. The process begins once the homeowner makes seismic safety improvements. When the owner wishes to sell the house and the sale amount has been determined, the buyer and seller place a portion of the real estate transfer tax amount in an escrow account to be drawn down after improvements are complete. Since July 2002, the City has distributed over $9 million to homeowners through this program.

Home Rehabilitation Loan Program. The Senior and Disabled Home Rehabilitation Loan Program assists very-low-income senior and disabled homeowners in repairing their homes, to eliminate conditions that pose a threat to their health and safety, and to help preserve the City housing stock. Qualified borrowers can receive interest-free loans of up to $35,000. Financial assistance is in the form of a deferred payment loan that is due and payable upon the sale or transfer of title to the property.

Technical Assistance. The City has developed more options and technical standards to seismically strengthen single-family homes and multi-unit apartment buildings. The City has

adopted International Building Code standards for seismic strengthening of wood-frame buildings. In addition, the City has implemented ABAG Standard Plan Set A as a guide that provides typical details and other recommendations for wood-frame homes of two stories or less. This plan set assists building owners and their contractors in the preparation of permit documentation and assists the City's plan checkers in their review of permit submittals. . The City has its own URM ordinance tailored specifically to Berkeley, which has structural engineering and prescriptive guidelines providing technical assistance for design professionals. The City has published guidelines for Transfer Tax Reductions to clarify the types of voluntary seismic strengthening work that qualify for a Transfer Tax Rebate.

Soft-Story Building Program. On December 3, 2013, City Council adopted Ordinance No. 7,318-N.S. amending Berkeley Municipal Code Chapter 19.39 to require property owners of soft, weak or open front buildings with five or more dwelling units to retrofit their buildings within the next five years. Owners have three years to apply for a building permit and two years to complete the work after submitting their permit application. The law applies to buildings constructed prior to 1978 and takes effect January 4, 2014. This is the second phase of the Soft Story Program.

Soft story buildings are characterized as wood-frame buildings with more than one story, typically with extensive ground story windows, garage doors, or open-air spaces such as parking with little or no enclosing solid wall, that lead to a relatively soft or weak lateral load resisting system in the lower story.

Under the first phase of the soft story program, since 2005, soft-story building owners have been required to submit an engineering evaluation report identifying their building's weaknesses and ways to remedy those weaknesses, to post an earthquake warning sign and notify their tenants of the building's potentially hazardous condition. Since 2005, thirty-five percent of soft-story building owners voluntarily retrofitted their buildings.

Unreinforced Masonry Building Program. The City instituted an Unreinforced Masonry (URM) Safety program that created an inventory of URM buildings and mandated retrofits by deadlines based on the use of the buildings. Since the program's original inception in 1991, over 90 percent of URMs on the City's Hazardous Building Inventory have been seismically retrofitted, demolished or demonstrated to have adequate reinforcement.

4.7 *Fire Risk Reduction*

The City, working together with key partners, is using a comprehensive strategy to aggressively mitigate Berkeley's wildland-urban interface (WUI) fire hazard. These approaches include prevention through development regulations; natural resource protection through vegetation management; improvement of access and egress routes; and infrastructure maintenance and improvements to support first responders' efforts to reduce fire spread.

Hazardous Fire Area Zones. Since before the 1920s, the City of Berkeley has established and adjusted fire zones in Berkeley. While the zones were initially established to address urban fire issues, they have evolved to designate the City's WUI fire hazard. Currently, the Berkeley Fire Department has divided the city into Fire Zones 1, 2, and 3, designated in order of ascending fire risk. Fire Zones 2 and 3 are in the hills area of the City and have the strictest fire prevention standards for issues such as building materials for new structures. The City also enforces vegetation management measures in these areas.

Fire Inspections. The Berkeley Fire Department annually inspects designated high fire risk zones for hazards such as excess vegetation. The Fire Department inspects over 1,200 parcels in Fire Zones 2 and 3, in addition to complaint-driven inspections throughout the City. Residents must clear combustible brush and vegetation adjacent to building property lines and roadsides. Tree branches must be cleared from any chimney, stovepipe or overhang over a building. All leaves, needles, and dead vegetation must be swept from roofs. This program is done in cooperation with the East Bay Regional Park District, which has programs to limit combustible material in the wildland-urban interface zone on its property.

Vegetation Management Programs. The City runs a number of vegetation management programs to reduce fuel loads. These programs include:

- The Fire Fuel Chipper Program, a popular yard waste collection service: The program serves properties in the hills from June through September each year. From 2005 to 2011, over 200 tons of vegetation was collected and recycled, on average, each year.[i]
- The Fire Fuel Debris Bin Program is coordinated by the Department of Public Works' Solid Waste Division The program delivers and removes 30 yard roll-off boxes from requesting neighborhoods, an effort effort yielding an average of 20 tons of plant debris per year.[ii]
- Additionally, 14,000 tons of residential plant debris is collected each year through weekly curbside collection. In 2007, the City switched curbside plant debris collection from every other week to weekly. This program enhancement doubled residents' capacity to help reduce the buildup of vegetation year-round.[iii]
- A fire fuel abatement program on public land: From mid-June to mid-August each year, an average of 125 tons of debris are removed from 95 public sites, including parks, pathways and medians. This effort is a joint effort of the City and the East Bay Conservation Corps.[iv]

4.8 *Community Readiness*

Community Emergency Response Team (CERT) Program. CERT classes are offered free through the Fire Department to all Berkeley residents and those who work in Berkeley. Trained volunteers can help douse small fires, conduct light search and rescue, help with first aid, and communicate with City emergency responders. Neighborhoods have organized response teams and conducted drills with City emergency responders. The 2013 CERT Citywide Exercise had over 900 community participants. Scale of activities ranged from basic phone contact with out-of-area emergency contacts and listening to emergency broadcasts from the City, to in-depth setup of neighborhood incident command posts to organize and conduct simulated CERT light search and rescue operations and practice emergency radio communications.

Neighborhood Caches. The Disaster Cache Program incentivizes community-building for disaster readiness. To date, the City has awarded 87 caches of disaster response equipment to neighborhoods, congregations, and UC Berkeley Panhellenic groups that have undertaken disaster readiness activities.

Community Oversight. The Disaster and Fire Safety Commission closely monitors the City's disaster readiness efforts. Members are safety advocates appointed by the Mayor and City Council.

4.9 *State and Federal Programs*

Many City ordinances and programs are based on State requirements. The State has numerous laws that regulate issues ranging from hospital seismic safety to coastal development. Table 4.1 highlights important State laws related to hazards, and describes how Berkeley complies with these laws.

Table 4.1 State Mitigation Requirement and Berkeley Implementation

Statewide Requirements	Berkeley Implementation
Mandatory Building Code. The State requires all communities to enforce the State-mandated building code. The building code applies to new buildings and additions, renovations and remodeling of existing buildings. The effectiveness of designs based on the code to resist earthquakes has improved incrementally over time. The code is not applied retroactively, meaning that building owners do not have to retrofit existing buildings to improve earthquake, fire or flood resistance unless the work proposed exceeds previously-defined thresholds. Certain types of buildings designed to early codes have characteristics that make them vulnerable to collapse in catastrophic earthquakes.	Berkeley enforces the State building code with additional local provisions for seismic and fire safety. The City has adopted the 2010 California Building Code and 2010 California Residential Code, including the WUI fire standards for analysis and retrofit. Berkeley's application of WUI fire standards exceeds current State requirements.
Essential Services Buildings. State law requires that new essential services buildings, such as police, fire, and emergency operation and communications centers, meet a higher safety standard than other buildings. The standards include backup utilities and design and construction checks by inspectors following State guidelines.	The Public Safety Building, which houses the 9-1-1 emergency communications center and Emergency Operations Center, along with all seven fire stations, the Fire Warehouse and the Ratcliff building, have all been built or retrofitted to meet essential services requirements.
Safety Element and General Planning Requirement. State law requires all cities and counties to prepare, adopt and keep current a general plan. Part of the plan is the "Safety Element" which defines the community approach to disaster preparedness and mitigation.	Berkeley completed updates to the General Plan, including the Disaster Preparedness and Safety Element, in 2003. One of the plan's key goals is to make a disaster-resilient community. The Safety Element has a mitigation approach and significant policy and action recommendations. The 2004 mitigation plan built directly from the General Plan, and this 2014 update continues to use the General Plan as a strategic guide.

Statewide Requirements	Berkeley Implementation
Environmental Review. The California Environmental Quality Act requires that government entities consider the environmental consequences of discretionary decisions having a substantial environmental impact. CEQA guidelines require evaluation of the effect of hazards on development and the resulting consequences for the environment. On occasion, certain emergency safety projects are exempted from the CEQA process.	The City of Berkeley complies with State CEQA requirements.
Fault Zones. Alquist-Priolo Earthquake Fault State requirements prohibit construction of public schools and buildings within the designated fault zones. Houses with three or fewer units are exempt from these provisions. Real estate law requires disclosure of the fault zone at the time of sale, and requires zone maps to be available for review by the public.	The California Geological Survey created maps that delineate a ¼-mile-wide fault zone through the east side of the city, where the Hayward Fault is located. Section 3.3 of this mitigation plan replicates these maps. Because of the well-defined surface expression of this fault, it is reasonable to expect ground surface rupture in this area during future earthquakes.
Seismic Hazards Maps. The California Geologic Survey mapped seismic zones where earthquake-induced landslides and liquefaction are likely. The State requires site-specific investigations for new building in these zones.	Liquefaction and seismically-induced landslide risk maps are available in Section 3.3 of this plan. The City enforces State requirements by requiring site-specific investigations and feasible mitigation measures.
Bayfront Development. The City of Berkeley abuts San Francisco Bay. All land inundated by the highest tides is within the jurisdiction of the San Francisco Bay Conservation and Development Commission (BCDC).	Developments within the City-owned and -operated Berkeley Marina require a permit from BCDC. The BCDC's Engineering Criteria Review Board subjected the restaurants, harbormaster building and piers to rigorous independent review before construction. Full consideration is given to the effects of deep-saturated, bay mud soils and fill material. All development in this zone must be elevated one foot over flood levels.

Statewide Requirements	Berkeley Implementation
Hospital Seismic Safety Act. The Office of Statewide Health Planning and Development (OSHPD) regulates hospital construction and renovation. By 2013, all hospital buildings built before 1973 must be replaced or retrofitted so they can reliably survive earthquakes without collapsing or posing threats of significant loss of life. By 2030, all existing hospitals (including those built after 1973) must be seismically evaluated and retrofitted, if needed, so they are reasonably capable of providing services to the public after disasters.	There is one acute care hospital in Berkeley, Alta Bates, owned and operated by the Sutter Health Corporation. The corporation is planning compliance renovations for the site.
Unreinforced Masonry Building Law. The State required all jurisdictions to identify unreinforced masonry (URM) buildings, to notify owners regarding the expected performance of these buildings, and to adopt a plan to deal with the threat.	Berkeley identified 700 URMs and designated a mandatory retrofit ordinance. To date, over 90 percent have been retrofitted, demolished or demonstrated to have adequate reinforcement.
Disclosure of Earthquake Risk. Four State laws work in tandem with State real estate requirements that mandate full disclosure of information pertinent to building purchase decisions. Owners of homes built before 1960 and certain commercial buildings are required to provide information on seismic vulnerability. Sellers must also disclose if the parcel is located in a mapped fault zone or seismic hazard area.	The City of Berkeley complies with this State law.
Dam Inundation Maps. Owners of dams and reservoirs are required to maintain their facilities according to standards of the Division of the Safety of Dams, and to file maps depicting areas that might be flooded if the reservoir suffered a catastrophic failure.	Per the East Bay Municipal Utility District: The Berryman Reservoir has been drained and decommissioned. The Claremont Reservoir will perform satisfactorily based on a magnitude earthquake of 7.25 on the Hayward Fault. The Summit Reservoir meets the stringent state safety requirements of the Division of State Dams; however, it will be replaced with a 3.5 million gallon water tank within the footprint of the existing reservoir basin by 2016.

Statewide Requirements	Berkeley Implementation
Emergency Response Plans. In the wake of the 1991 Tunnel Fire, the State requires that all jurisdictions practice the Standardized Emergency Management System (SEMS), a uniform approach to disaster response based on the fire service's Incident Command System (ICS).	The City complies with all State requirements.
Field Act. Originally passed in 1933, the Field Act regulates the design, construction and renovation of public school buildings, and the inspection of existing school buildings. Many subsequently adopted State laws, amendments to the Field Act, and supplementary laws, call for additional safety measures for all public K-12 schools in the state. California has the most stringent safety codes for school buildings in the U.S.	All public schools have been upgraded to the standards of the Field Act and its amendments.

4.10 *Berkeley Mitigation Activities and Key Events*

The timeline in the table below identifies key mitigation activities and disaster events that impact Berkeley's mitigation programs and resources. The table includes events occurring on the State or federal level, as well as major disasters outside of Berkeley. These events impacted Berkeley's mitigation programs and resources by developing public awareness or making statewide or national changes to the mitigation landscape.

Table 4.2 Timeline of Berkeley Mitigation Activities and Key Events

Date	Event	Notes
1868	UC Berkeley campus established	
1868	Hayward Earthquake	Impacts on Berkeley are unknown
1878	City of Berkeley incorporated	
1870	South Hall constructed with steel straps to resist earthquakes	An early example of seismic-resistant design.
1898	Mare Island Earthquake	Impacts on Berkeley are unknown
1906	Great Earthquake	Damage in Berkeley was significantly smaller than damage in San Francisco. Berkeley supported an influx of refugees from San Francisco.
1911	Damaging earthquake near San Jose	Impacts in Berkeley are unknown
1923	Berkeley Fire	Major wildland-urban interface fire burned 600 buildings and stopped at Shattuck Avenue.
1927	City of Berkeley adopts Uniform Building Code (UBC)	Community conforms to building regulations and safety codes.
1928	City of Berkeley adopts Ordinance 1,480-N.S.	Creates and establishes fire zones in the City of Berkeley. *Repealed and Amended in 1958.*

Date	Event	Notes
1933	Field Act Passed	Regulates design, construction and renovation of K-12 public schools in California
1933-1935	UBC updated	Masonry buildings must be reinforced, and mortar standards and seismic zones considering soils introduced.
1949	UBC updated	Standards introduced to strengthen tall buildings.
1958	City of Berkeley adopts Ordinance 3,663-N.S.	Reestablishes fire zones in the City of Berkeley based on Fire Zone Maps of 1958. *Repealed and Amended in 1976.*
1959	UBC updated	Calculation methods improve to better represent different types of structures.
1962	Flood	Damages build awareness about need for mitigation.
1970	Enacted floodplain ordinance	Flood Insurance Rate Maps were developed for the community.
1970	Fish Canyon Fire	Burns 39 structures; results in City Planning Department establishing Environmental Safety-Residential zone, which limits land use and occupancy size of residential structures in the area
1972	State Legislature passes Alquist-Priolo Earthquake Fault Zoning Act	Regulates development along earthquake faults in California
1973-76	UBC updated	Ductile elements introduced into reinforced concrete buildings to prevent catastrophic failure and improvements to wood frame design.

Date	Event	Notes
1975	UC Regent's policy on seismic safety adopted	Conducted first assessment of seismic safety of buildings at UC Berkeley. Launched early retrofit projects.
1976	City of Berkeley adopts Ordinance 4,886-N.S.	Reestablishes fire zones in the City of Berkeley based on Fire Zone Maps of 1976.
1978	Berkeley begins participation in National Flood Insurance Program	City currently in good standing with NFIP
1980	Grass fire in hills consumed several Berkeley houses	City regulated building materials in hills.
1986	Private Schools Building Act passed	Act intended to protect private school children like the Field Act did for public school children. However, differences between the two acts mean that private school buildings are not as safe as public school buildings.
1988	UBC updated	Soft and weak stories addressed and wood frame construction improved.
June/July 1989	Disaster Council established	Established monitoring and advocacy.
October 1989	Loma Prieta Earthquake	Magnitude 6.9 earthquake causes some damage to buildings in Berkeley. New cracks found in MLK Jr Civic Center building. Regionally, resulted in 62 deaths and major damage. Significant transportation system impacts.
December 1989	URM inventory established	700 URMs identified and owners notified of required retrofit.
1989	Berkeley Unified School District hires engineers to evaluate structural safety of buildings	Significant problems fount; District closes many schools and develops plan to correct safety problems

Date	Event	Notes
1990	Seismic Hazards Mapping Act passed	Regulates development, requires mapping and real estate disclosure in earthquake-induced landslide and liquefaction zones.
Mid- 1991	Fee waiver program established	Waives permit fees on residential seismic safety projects. **Program ended due to budget constraints in early 2000s.**
October 1991	Tunnel Fire	62 homes burned in Berkeley, more burned in neighboring Oakland. 25 deaths total and $1.5 billion total damage.
1991	Hills Emergency Forum established	Planning and coordination body formed to address East Bay fire hazards
December 1991	Established mandatory URM retrofit program	To date over 90% of URMs have improved seismic resistance
June 1992	Measure A approved	$158 million made available for school safety programs.
November 1992	Measure G approved	$55 million made available for municipal safety improvements.
1993	UC Berkeley Tang Center constructed	Facility constructed to essential facilities standard, to be ready to provide key support to Berkeley healthcare system in a disaster
1994	EBMUD allocates $189 million for seismic upgrades	Upgrades completed in 2006
1994	Northridge Earthquake	6.7 magnitude earthquake causes $28 billion in losses
March 1995	Seismic Technical Advisory Group convened	Assured City has appropriate technical information to make informed seismic safety policy decisions.

Date	Event	Notes
July 1996	Tilt-up building inventory developed	59 tilt-up structures identified.
November 1996	Measure S approved	$45 million made available for seismic retrofit of City buildings.
August 1997	The University of California's SAFER Program established	10-point action plan for the University's $1.2 billion reconstruction program. A review of UC Berkeley's buildings found that 27% need to be seismically upgraded.
1997	UBC updated	Requirements increased for buildings close to active faults.
Winter 1997-1998	Landslide in North Berkeley	1 home significantly damaged and has to be demolished
1998	Natural Hazards Disclosure Act passed	Requires sellers of property to provide "Natural Hazards Disclosure Statement" if property lies within State-mapped hazard area.
December 1999	Award from FEMA	Berkeley designated Project Impact Model Community of the Year.
July 2000	Tsukamoto Public Safety building complete	The City's hazard-resistant essential services building is constructed. It houses the City's primary Emergency Operations Center, emergency communications center and Police Department and Fire Department headquarters.
November 2000	Measures AA and Q approved	$116.5 million for school safety program; Tax measure for safety efforts.
2001	Martin Luther King Jr. Civic Center retrofit completed	Building housing key City government functions is base isolated for seismic safety.
2001	Magnitude 5.1 Napa earthquake	

Date	Event	Notes
2001	Soft-story buildings inventoried	City partners with UC Berkeley and outside experts; uses FEMA grant to inventory soft-story units
2002	Award from Disaster Resistant California	Berkeley rewarded for demonstrating significant commitment to pre-disaster mitigation.
2002	Main Library retrofit completed	Main library identified as location for City's emergency volunteer center
February 2003	Completion of the CGS hazard maps.	New buildings are required to meet strict design and construction standards if they are located in potential liquefaction or landslide areas.
2003	Award by California OES	Berkeley designated model community.
2003	New General Plan adopted	General Plan's Disaster Preparedness and Safety Element guides the 2004 and 2014 Local Hazard Mitigation Plans
2004-2005	Flooding in Codornices, Strawberry, Potter and Schoolhouse watersheds	
2005	City adopts soft-story ordinance	Berkeley requires owners of soft-story buildings with 5 or more units to conduct engineering studies and take other measures.
2006	Assembly Bill 127 passes	Provides California Community Colleges with the option to comply with local building codes in lieu of the Field Act
2006	All fire stations seismically safe	Berkeley completes the reconstruction of Fire Station 7. The other six were seismically upgraded in previous years.

Date	Event	Notes
2006	Disaster Council and Fire Safety Council combined	Continued monitoring and advocacy.
2006	EBMUD evaluates Claremont Reservoir Dam for seismic risk	Study concludes that dam will perform satisfactorily in 7.25 magnitude earthquake on Hayward Fault
2006	UC Berkeley opens Center for Fire Research and Outreach	Center focused on wildfire information and collaboration
2006	Alameda County Local Agency Formation Commission expands Berkeley's Sphere of Influence on Panoramic Hill to include Oakland	Action performed despite opposition letters from Berkeley and Oakland. Berkeley/Oakland homeowners will need to collaborate to fund a Specific Plan.
2007	Glendale Path completed	City, Path Wanderers and Boy Scouts partnered to use FEMA funding for pedestrian evacuation route in the Berkeley hills
February 2007	EBMUD Claremont Tunnel retrofit complete	
2008	Neighborhood disaster supply cache program begins	To date, the City has awarded 87 caches of disaster response equipment to neighborhoods, congregations, and UC Berkeley Panhellenic groups that have undertaken disaster readiness activities.
2008	Council adopts moratorium on development in Panoramic Hill	Moratorium repealed in 2010 and replaced with ordinance
September 2009	City updates Municipal Code Chapter 17.12 *Flood Zone Development Ordinance*	Update ensures Berkeley's continued compliance with National Flood Insurance Program
2009	City Council adopts Climate Action Plan	Climate Action Plan guides Berkeley's efforts to reduce carbon emissions and engage in climate adaptation planning

Date	Event	Notes
2009	Branch Library Improvement Program begins	By 2013, 3 of 4 branch libraries have completed retrofits for seismic safety
2010	BART completes work to upgrade Transbay Tube seismic joints	
2010	Berkeley voters approve Measure I	Funds improvements to school safety, including seismic work
2010	Aboveground Water Supply System operational	Portable system can pump water from any source to fight fires if tanks drained or pipelines damaged
2010	Council passes ordinance blocking establishment of any residential units on Panoramic Hill	Ordinance requires adoption of a Specific Plan for safety improvements to infrastructure
2010	City of Berkeley adopts Ordinance 7,157-N.S.	Adopts 2010 fire code with local amendments Adds addresses to fire zone two (to "combined hillside district") Designates Zones 2 and 3 to be Very high fire hazard severity zone(s) and Wildland-Urban Interface Fire areas
2010	City develops *Guide to Conserving Water through Rainwater Harvesting and Graywater Reuse for Outdoor Use*	Provides information to help homeowners be ready for impacts of climate change on regional water resources
2010	BMC Amended to require automatic gas shutoff valves	Automatic gas shutoff valves required for any existing building undergoing additions, alterations or repairs exceeding $50,000
December 2010	California Emergency Management Agency releases first-ever tsunami inundation maps within San Francisco bay	Map helps to inform tsunami readiness activities

Date	Event	Notes
2011	Diesel spill on UC Campus	Diesel enters Strawberry Creek; response requires coordination of City, State and federal agencies
2011	Public Works Engineering Division develops hydraulic models for Codornices and Potter watersheds	Models predict areas of likely overflows
March 2011	Earthquake off coast of Japan causes tsunami in Berkeley	Tsunami surge entered Berkeley Marina and caused $158,000 damage to boats and docks
October 2012	City Council adopts Watershed Management Plan	Plan goals include reducing urban flooding
2012	Berkeley Unified School District moves administrative offices	Moved out of seismically-unstable Old City Hall building and into newly-renovated building on Bonar and University
2012	Ratcliff Building retrofit complete	Retrofits made possible by $2.89 million FEMA grant
April 2012	Gas valve permit fee reduced	Permit fee for valve installation reduced. Established $50 flat rate permit fee for voluntary installation of gas shutoff valves in 2+ residences on a block.
2012	Dona Spring Animal Shelter opens	New animal shelter designed to governing seismic standards
2012	North Branch Library and Claremont Branch Library retrofits complete	Libraries seismically retrofitted to governing standards, fire sprinkler system added
2013	South Branch Library replaced	New building meets seismic codes, photovoltaic panels offset energy grid draws
January 2014	Soft-Story Phase II Ordinance takes effect	Owners of soft, weak or open front buildings with five or more dwelling units required to retrofit their buildings within the next five years

[i] Per Dan Gallagher, Senior Forestry Supervisor, City of Berkeley: The Fire Fuel Chipper Program collected green waste vegetation in the following amounts in the following years:

- 2005: 264.35 tons
- 2006: 237.59 tons
- 2007: 189.06 tons
- 2008: 175.16 tons
- 2009: 167.17 tons
- 2010: 161.31 tons
- 2011: 187.24 tons

[ii] Information provided by Andrew Schneider, Recycling Program Manager, City of Berkeley, as of March 2012.

[iii] Information provided by Andrew Schneider, Recycling Program Manager, City of Berkeley, as of March 2012.

[iv] Information provided by Doug McDonald, Senior Landscape Supervisor, City of Berkeley as of March 2012.

5 Community Profile and Trends

The people and structures of Berkeley are continually changing. This section examines changes that have occurred in hazard-prone areas and increased or decreased the vulnerability of Berkeley since 2004. First, this section discusses changes to the group of people who make up the Berkeley community, and how their characteristics will influence the population's hazard vulnerability, necessary approaches to mitigation and response. Next, changes in development are discussed, including description of recent and potential development throughout Berkeley. Next, the effects of this development of population and structures on Berkeley's vulnerability to natural hazards are discussed. Last, key City policies and goals that affect development are outlined.

5.1 *Community*[i]

The number of people living in Berkeley has grown by almost 10,000 in the last decade, to 112,580. As Berkeley's population of Berkeley has grown, the number of jobs in the city has increased from about 50,000 in 1970 to approximately 70,000 today[ii]. Additionally, UC Berkeley's Long Range Development Plan projects that as a result of growth in both education and research, by 2020 the total campus headcount during the regular academic year may increase to 51,260 – a 12% increase over 2001-2002 levels. These population increases means that more Berkeley residents and visitors will be exposed to the area's hazards.

Berkeley has a mobile population, with just 56 percent of current residents having lived in their homes for more than six years. This figure reflects people moving to Berkeley from out of the area, meaning that community disaster awareness activities need to be ongoing to penetrate the population. This figure also reflects community members moving within Berkeley, meaning that community-building activities must be constant as residents join new neighborhoods.

Much of Berkeley's mobility is due to its large college student population, which ranges from about 25 to 30 percent of city residents.

Students represent a significant portion of Berkeley's rental market and support a variety of local merchants. Large losses in rental units after an earthquake could force students to move to other nearby cities, which would profoundly affect Berkeley's character and economics. The University of California, Berkeley faces significant earthquake risks, and a closure of this campus for any length of time would greatly impact the city overall.

Over one quarter of Berkeley residents use a language other than English at home. It is critical for the city to make sure that emergency responders are prepared to communicate with limited-English speakers. This includes communicating emergency and evacuation warnings as well as mitigation strategies.

5.2 *Recent and Potential Development*

Berkeley is a densely-populated city with well-established land use patterns. Many private homes have been expanded and renovated, but few new lots have been developed due to Berkeley's already built-up state.

Nonetheless, development activity is ongoing. Since 2004, Berkeley has seen a significant increase in housing units. Typically, this development represents densification of commercial

areas, rather than development of new sites. Before the global recession of 2009, the City issued discretionary permits for many high-occupancy mixed-use commercial/ residential structures in commercial corridors on Shattuck, San Pablo and University Avenues. In the years that followed, these projects were not pursued. Now in 2014, many projects are once again moving forward.

2012 zoning changes from the City's new Downtown Area Plan have also added to the number of vulnerable buildings being upgraded or replaced with modern structures in the downtown area. In 2013, the City issued discretionary permits for three new 60-foot-tall mixed-use residential/ commercial buildings in the area. These three buildings will add 400 additional residential units to the area. Currently, another three buildings with another 600 residential units are in process for receiving conditional use permits. These six buildings alone could add 25,000 additional residents to Berkeley's downtown area in the coming two to three years.

1. Since 2004, the University of California, Berkeley expanded its facilities both on and off the campus. UC Berkeley's 2020 Long Range Development Plan projects space demands for campus academic and support programs may grow by up to 18%, or 2,200,000 GSF, over 2005 levels. This includes classrooms, libraries, research facilities and student services centers. These estimates of future space needs are both future growth and compensation for existing shortages.

5.3 *Effects on Berkeley's Risks and Vulnerabilities*

As more people join the Berkeley community, the city will have more people who are exposed to the area's hazards. However, Because of Berkeley's built-out nature, new development tends not to add new geographic areas of hazard exposure. All of Berkeley is exposed to earthquake shaking. While commercial corridors are becoming denser, density in the eastern hills, which are exposed to wildland-urban interface fire and landslides, is stable. The city's western edge will be exposed to sea-level rise from climate change. However, the actual areas of sea-level rise exposure, as well as the impacts of sea-level rise on the area's liquefaction and flooding hazards, are not yet clear.

New development generally reduces Berkeley's vulnerability to natural hazards. New construction adheres to modern design codes, including regulations for structural resistance to earthquakes, landslide mitigation efforts, fire-resistant materials, and elevation above flood levels. Replacing or significantly renovating older structures significantly increases the Berkeley community's protection from natural hazards. For example, pursuant to the Seismic Hazards Mapping Act codified in the Public Resources Code as Division 2, Chapter 7.8 and Guidelines for Evaluations and Mitigating Seismic Hazards in California (Special Publication 117), much of the new construction in the City's west must have site-specific geological and geotechnical investigations , due to the area's mapped potential liquefaction hazard. These investigations result in recommendations for design professionals to design new or rehabilitated buildings for human occupancy to mitigate the potential effects of liquefaction caused by earthquakes to a level that does not cause the collapse of the buildings . This means that a new or rehabilitated building will be equipped to better withstand potential liquefaction impacts than an old building.

5.4 *City Policies and Goals*

Many City policies shape Berkeley's growth. In addition to disaster resilience, City goals include protecting the environment, promoting sustainable development, providing low-income

housing, preserving historic structures, and maintaining City infrastructure. Key policies impacting development are detailed below.

Sustainable Development

Berkley promotes sustainable development policies. The General Plan includes policies to maintain sufficient land zoned for high- and medium-density residential development. These policies allow for sufficient new construction to meet Berkeley's fair share of regional housing needs. Policies are coordinated to ensure that all new development is sensitive to Berkeley's unique physical character and scale, and that new housing and future development occur in areas of the city that are best served by public transportation services.

Affordable Housing

Berkeley also promotes affordable, seismically-safe housing. The General Plan includes policies promoting access to quality housing for people at the lowest income levels, and inclusion of low-income groups in new housing development. The General Plan also encourages maintenance and improvements to prepare buildings for a major seismic event, with the expectation that improvements do not necessitate substantial rent increases for tenants. As of September 2013, the City is considering changing its Demolition Ordinance to require a one-for-one replacement of demolished rent controlled units with permanently affordable housing.

Down Zoning

In the 1970s, residential areas of the city surrounding the UC Berkeley campus became subject to "down zoning." Future developments in these areas are required to be less dense than existing development. This designation was given following the construction of dense, multifamily structures in neighborhoods without community support. Many of the multifamily structures from this era are particularly vulnerable to earthquakes. If they are destroyed in an earthquake, the down zoning requirement requires that they be replaced with single-family homes or less dense occupancies.

A 2006 Zoning Amendment allows residential buildings of four or fewer units to be replaced by right if the buildings are damaged in a natural disaster. However, buildings in the area with five or more residential units would still need to go through a public hearing process to receive conditional use permits. Maintenance of the area's density levels would be contingent on community support. Without this support, following a catastrophic earthquake, the City could lose much of its low-income housing. This threatens one of the General Plan's central goals.

Restoration of Natural Waterways

The General Plan's Environmental Management section encourages the restoration of natural waterways. Many Berkeley streams were culverted in the 1960s as a flood control measure. Any change in the status of these culverts, already in a weakened state, would alter the Berkeley's flood risk.

Preserving Historic Character

The City has a strong value for preserving historic character. Any hazard, and earthquakes and fires in particular, could destroy many historic structures, which tend to be more vulnerable to these hazards than newly-constructed buildings. The General Plan's Urban Design and Preservation Element encourages support of long-term protection of historically- or architecturally-significant buildings to preserve neighborhood and community character through

maintenance of the historic resources inventory, and use of the State Historical Building Code, Rehabilitation Tax Credits, and Mills Act contracts preservation incentives.

Disaster Resilience

The Berkeley community recognizes that disasters have the potential to undercut all of the City's goals. As stated in the General Plan:

The city's healthy environment with its unique character and quality of life based on cultural, social and economic diversity could be dramatically and enduringly altered by a serious hazard event. Berkeley must protect what we already have as well as what we build through employing sound development practices and building and planning code enforcement, and continuously working to reduce the vulnerability of existing buildings and infrastructure, to improve emergency response and to prepare for recovery. Without these measures, disasters will occur and the other goals of the General Plan will be lost.

[i] 2010 Census data was used when possible. When the 2010 Census data was not available, the data used is from the American Community Survey (ACS) 5-year estimates from 2007-11. The ACS is a nationwide survey conducted by the US Census Bureau, and while the survey gathers a wider variety of information than the official census, only a portion of the population is surveyed at a time. Because of this sampling, the data may be less accurate in some cases, and varies from the 2010 census count.
[ii] Plan Bay Area

Category	*Building Name*	*Address*	*Normal Use*	*Disaster Function (if different)*	*Seismic Retrofit Status*	*Comments on Condition & Construction*	*Square Feet*	*Building Replacement Value*
Animal Shelter	Animal Shelter	1 Bolivar Drive	Animal Shelter		Newly Constructed	2 stories New facility – Built in 2012 to 2010 Building Code	11,000	$7.8 million
Corporation Yard	Equipment Maintenance Building	1326 Allston Way	Equipment Maintenance Building			1 story Retrofit in approx. 2003.	12,922	$ 5.90 million
Corporation Yard	Fuel Island/ underground tanks	1326 Allston Way				All Steel, 1 story	1,200	$300,000
Corporation Yard	Office and Storage	1326 Allston Way				Concerns about eq vulnerability.	2,939	$730,000
Corporation Yard	Ratcliff Building	1326 Allston Way		Public Works Department Operations Center	Retrofitted	Retrofitted to essential serves standards in 2012	16,480	$6.0 million
Fire Station	Fire Department Warehouse	1011 Folger Avenue	Storage of Fire Response Equipment		Newly Constructed	Built in 2011 – to essential services standards	8021	$8.2 million
Fire Station	Fire Station #1	2442 8th Street	Fire Station		Newly Constructed/ Retrofitted	2 story Rebuilt 1999 - retrofitted to essential services standards.	5,260	$1.5 million
Fire Station	Fire Station #2	2029 Berkeley Way	Fire Station		Newly Constructed/ Retrofitted	2 story Rebuilt 1998 - retrofitted to essential services standards.	12,522	$3.6 million
Fire Station	Alarm Headquarters	2029 Berkeley Way			Newly Constructed/ Retrofitted	1 Story Rebuilt in 1998	840	$242,000
Fire Station	Fire Station #3	2710 Russell	Fire Station		Newly Constructed/ Retrofitted	2 story Rebuilt 1999 - retrofitted to essential services standards.	5,100	$1.5 million
Fire Station	Fire Station #4	1900 Marin	Fire Station		Newly Constructed/ Retrofitted	2 story Rebuilt 1999 - retrofitted to essential services standards.	5,341	$1.6 million
Fire Station	Gas Pump House	1900 Marin	Refueling facility		Newly Constructed/ Retrofitted	1 Story Rebuilt 1999	101	$29,5,00
Fire Station	Fire Station #5	2680 Shattuck Ave.	Fire Station		Newly Constructed/ Retrofitted	2 story Rebuilt 1998 - retrofitted to essential services standards.	9,302	$2.7 million
Fire Station	Fire Station #6	999 Cedar Street	Fire Station		Newly Constructed/ Retrofitted	1 story Rebuilt 1999 - retrofitted to essential services standards.	4,153	$1.2 million
Fire Station	Fire Station #7	3000 Shasta Road	Fire Station		Newly Constructed	New two story – incorporates state-of-the-art fire-resistant technology; Located in Fire Zone 2 Constructed in 2006 to essential services standards	24,200	$7 million

Category	*Building Name*	*Address*	*Normal Use*	*Disaster Function (if different)*	*Seismic Retrofit Status*	*Comments on Condition & Construction*	*Square Feet*	*Building Replacement Value*
Key Civic Building	Civic Center Building Annex	1947 Center Street	Public Works Engineering and Transportation Divisions		Seismic Evaluation Needed	6 stories, concrete frame structure. Determined by V. Bertero to meet "substantial life safety" and not be a collapse hazard building, but may have problems.	116,450	$45.7 million
Key Civic Building	Fire Dept. Training Building	997 Cedar Street	Alternate Emergency Operations Center		Newly Constructed	Built in 1998 – retrofitted to essential services standards	3,893	$1.42 million
Key Civic Building	Martin Luther King, Jr. Civic Center	2180 Milvia Street	City Hall		Newly Constructed/ Retrofitted	6 story Concrete frame Retrofit in 2001 Base isolated	89,075	$34 million
Key Civic Building	Public Safety Building	2100 MLK Jr. Way	Police Department Headquarters, Fire Department Headquarters, 9-1-1 Headquarters	Primary Emergency Operations Center	Newly Constructed	2 story Built in 2000 to essential services standards Base isolated	60,108	$15 million
Key Civic Building	PSB Accessory Building		Communication equipment, Emergency Generator Storage		Newly Constructed	1 story Built in 2000	2,738	$1.1 million
Leased by the City	Permit Center/Planning Department	2118-20 Milvia Street	Offices for Economic Development, Planning, and Building departments. Contains all building plans and records for City.	Building and Safety DOC	Seismic Evaluation Needed	Has had some seismic bracing. Vulnerability unknown.		n/a
Leased by the City	Police substation. BPD traffic control	841 Folger Ave	Offices		Seismic Evaluation Needed	Wood Frame		n/a
Library	Library – North Branch	1170 The Alameda	Library, public assembly	Public assembly	Retrofitted	Retrofitted in 2012 to 2010 Building Code. Vulnerable to damage but repairable.	9,390	$ 4.76 million
Library	Library – South Branch and Tool Library	1901 Russell Street	Library, public assembly	Public assembly	Retrofitted	Retrofitted in 2013 to 2010 Building Code. Vulnerable to damage but repairable.	8,656	$4.9 million
Library	Library – West Branch	1125 University Avenue	Library, public assembly	Public assembly	Retrofit in process 5/13	Retrofitted in 2013 to 2010 Building Code. Vulnerable to damage but repairable.	9,400	$5.55 million
Library	Library- Claremont Branch	2940 Benvenue Ave	Library, public assembly	Public assembly	Retrofitted	Retrofitted in 2012 to 2010 Building Code. Vulnerable to damage but repairable.	7,640	$3.3 million

Category	*Building Name*	*Address*	*Normal Use*	*Disaster Function (if different)*	*Seismic Retrofit Status*	*Comments on Condition & Construction*	*Square Feet*	*Building Replacement Value*
Library	Main Library	2090 Kittredge Street	Library, public assembly	Emergency Volunteer Center location	Retrofitted	Complete retrofit to seismic code with new underpinning and additional piles, and remodel completed in 2002. Vulnerable to damage, but repairable.	122,000	$45 million
Public Health	Mental Health Offices	2636-40 MLK Way	Mental Health Offices		Seismic Evaluation Needed	The City is having these two buildings' seismic resistance and vulnerabilities evaluated in Fiscal Year 2013. Actual improvements are in the initial evaluation and planning stage.	11,840	$3.0 million
Recreation and Parks	Frances Albrier Center	2800 Park Street	Recreation and public assembly	Shelter	Seismic Evaluation Needed		13,260	$3.68 million
Recreation and Parks	Grove Recreation Center	1730 Oregon Street	Recreation and public assembly - Young Adult Project (YAP)	Shelter	Seismic Evaluation Needed		10,600	$6.70 million
Recreation and Parks	James Kenney Community Center	1720 8th Street	Recreation and public assembly - MLK Jr Youth Service Center	Shelter			13,825	$9.2 million
Recreation and Parks	Live Oak Community Center	1301 Shattuck Ave.	Recreation and Assembly	Shelter	Retrofitted	URM structure retrofitted using a membrane designed by Pat Crosby. Remains vulnerable.	14,860	$9.9 million
Senior Center	North Berkeley Senior Citizens Center	1901 Hearst Street	Public assembly	Shelter	Seismic Evaluation Needed	Built in 1979. No seismic work done.	20,760	$14.57 million
Senior Center	South Berkeley Senior Citizens Center	2939 Ellis Street	Public assembly	Shelter	Seismic Evaluation Needed	Built in 1977	17,156	$12.04 million
Senior Center	West Berkeley Senior Citizens Center	1904 6th Street	Public assembly	Shelter	Seismic Evaluation Needed	Cl.D - 1982 - C/S fire alarm	10,245	$7.19 million
Solid Waste Transfer Buildings	Compressed Natural Gas Dispenser	1199 2nd Street	Compressed Natural Gas					$343,000
Solid Waste Transfer Buildings	Administration Building	1201 2nd Street	Offices			All Steel Constructed in 1984	3,750	$653,000
Solid Waste Transfer Buildings	Fuel Pumps and Tanks	1199 2nd Street	Fuel island/Wash Rack			All Steel Constructed in 1984	2,600	$465,000
Solid Waste Transfer Buildings	Hazmat Storage	1199 2nd Street	Storage					$1.5 million
Solid Waste Transfer Buildings	Tipping Building/Transfer Station	1199 2nd Street	Waste Transfer			Some maintenance problems. All Steel, 1984	21,000	$5.31 million

Category	*Building Name*	*Address*	*Normal Use*	*Disaster Function (if different)*	*Seismic Retrofit Status*	*Comments on Condition & Construction*	*Square Feet*	*Building Replacement Value*
Solid Waste Transfer Buildings	Underground Scales	1199 2nd Street				All Steel Constructed in 1984		$510,350
Solid Waste Transfer Buildings	Vehicle Maintenance Facility	1199 2nd Street	Maintenance Building			All Steel Constructed in 1984	6,280	$2.87 million
Solid Waste Transfer Buildings	Radio Transmitter	1199 2nd Street	Public Works Radio transmitter					
Wastewater Lift Stations	Marina Lift Station #1		Wastewater management					
Wastewater Lift Stations	Marina Lift Station #2		Wastewater management					
Wastewater Lift Stations	Marina Lift Station #3		Wastewater management					
Wastewater Lift Stations	Marina Lift Station #4	Corner of Marina	Wastewater management					
Wastewater Lift Stations	Marina Lift Station #5	Marina S.E. Entrance	Wastewater management					
Animal Shelter	Old Animal Shelter	3013 2nd Street	Office/ Kennel/ Cattery			Old Animal Shelter – To be sold	4,780	$857,087
Berkeley Housing Authority		1107-15 Francisco Street	Dwelling			Frame - 5 units	5,466	$1.4 million
Berkeley Housing Authority		1117-23 Francisco Street	Dwelling			Frame - 4 units	4,374	$1.1 million
Berkeley Housing Authority		1161-65 Francisco Street	Dwelling			Frame - 3 units	3,279	$820,000
Berkeley Housing Authority		1169-75 Francisco Street	Dwelling			Frame - 4 units	4,374	$1.1 million
Berkeley Housing Authority		1360-70 Dwight Way	Residential			Frame - 2 units	2,187	$550,000
Berkeley Housing Authority		1371 Dwight Way/ 2450 Valley	Dwelling			Frame - 2 units	2,187	$550,000
Berkeley Housing Authority		1402-08 MLK Way	Dwelling			Frame - 4 units	4,433	$1.1 million
Berkeley Housing Authority		1500-04 7th Street	Dwelling			Frame - 3 units	3,280	$820,000
Berkeley Housing Authority		1838-40 Rose Street	Dwelling			Frame - 2 units	2,067	$520,000
Berkeley Housing Authority		1903-09 Ward Street	Dwelling			Frame - 4 units	4,372	$1.1 million
Berkeley Housing Authority		1911-17 Ward Street	Dwelling			Frame - 4 units	4,374	$1.1 million
Berkeley Housing Authority		1921-27 Ward Street	Dwelling			Frame - 4 units	4,374	$1.1 million

Category	*Building Name*	*Address*	*Normal Use*	*Disaster Function (if different)*	*Seismic Retrofit Status*	*Comments on Condition & Construction*	*Square Feet*	*Building Replacement Value*
Berkeley Housing Authority		2024-30 Virginia Street	Residential			Frame - 4 units	4,659	$1.2 million
Berkeley Housing Authority		2032-36 Virginia Street	Residential			Frame - 3 units	3,389	$850,000
Berkeley Housing Authority		2374 West/1323 Channing Way	Residential			Frame - 2 units	2,200	$550,000
Berkeley Housing Authority		2725-27-29 Sojourner Ct.	Dwelling			Frame - 3 units	3,279	$820,000
Berkeley Housing Authority		2731-33 Sojourner Ct.	Dwelling			Frame - 2 units	2,187	$550,000
Berkeley Housing Authority		2735-37 Sojourner Ct.	Dwelling			Frame - 2 units	2,067	$520,000
Berkeley Housing Authority		2798 A/B Sacramento Street	Dwelling			Frame - 2 units	2,187	$550,000
Berkeley Housing Authority		2800 Sacramento Street	Dwelling			Frame - 1 unit	820	$200,000
Berkeley Housing Authority		870-80 Jones Street	Dwelling			Frame - 2 units	2,187	$550,000
Berkeley Police Department	BPD Pal Program	1255 Allston Way	Office			Unknown		$6,550
Corporation Yard	Assembly Building	1326 Allston Way	Assembly/Washroom			1 story Concerns about earthquake vulnerability.	2,405	$600,000
Corporation Yard	Equipment Shelter	1326 Allston Way	Equipment Shelter			1 story Metal shed	4000	$493,000
Corporation Yard	Guard Shack	1326 Allston Way				1 story	72	$18,000
Corporation Yard	Lumber/Pipe Storage	1326 Allston Way					774	$190,000
Corporation Yard	Nursery Assembly Room	1326 Allston Way					864	$220,000
Corporation Yard	Nursery Storage	1326 Allston Way					864	$67,450
Corporation Yard	NurseryStorage-1975	1326 Allston Way					240	$67,100
Corporation Yard	Quonset Warehouse	1326 Allston Way				All Steel, 1 story Concerns about earthquake vulnerability.	4,100	$380,500
Corporation Yard	Small Warehouse	1326 Allston Way				1 story	3,000	$750,000
Corporation Yard	Streets Storage & Office	1326 Allston Way					1300	$326,166
Corporation Yard	Traffic Maintenance	1326 Allston Way	TrafficSign/PaintShop			1 story Concerns about earthquake vulnerability.	4,320	$1.1 million
Echo Lake Camp and Toulumne Camp in the Sierras	(not included)	(not included)	(not included)			(not included)	(not included)	(not included)

Category	*Building Name*	*Address*	*Normal Use*	*Disaster Function (if different)*	*Seismic Retrofit Status*	*Comments on Condition & Construction*	*Square Feet*	*Building Replacement Value*
Fire Station	Drill Tower	999 Cedar Street	Training Facility		Newly Constructed	5 story Constructed in 1999	1,936	$558,500
Key Civic Building	Center Street Garage and Commercial space	2025 and 2033 Center Street	City and Public Parking and Offices		Seismic Retrofit or Replacement Required	5 story, concrete Frame Vulnerable to earthquake damage. Too expensive to retrofit. Will be replaced.	175,500	$29 million
Key Civic Building	Center Street Garage and Commercial space	2025 and 2033 Center Street	(LINKED)		Seismic Retrofit Required	5 story, concrete Frame Vulnerable to earthquake damage. Too expensive to retrofit. Will be replaced.	175,500	(LINKED)
Key Civic Building	Oxford Street Garage	2165 Kittredge Street	Garage/Offices		Newly Constructed	Basement Garage and Lot of 6 Story offices and housing project– Joint Project between City and UC Berkeley. Built in 2009 to seismic standards	46000 Garage only	$9 million
Key Civic Building	Telegraph/Channing (Sather Gate) Mall and Garage	2438 Durant Ave.	Public Parking and Retail		Retrofitted	Retrofitted about 1995. Still vulnerable to damage, but not collapse. Concrete Frame, 5 story	224,628	$56 million
Key Civic Building	Veterans Memorial Hall	1931 Center Street	Public assembly and Homeless Shelter		Seismic Retrofit Required	Collapse hazard building, study done, needs to be retrofitted	33,254	$27 million
Leased by the City	Berkeley Housing Authority	1901 Fairview Street	Offices					n/a
Leased by the City	Black infant health Building	1767 Alcatraz Avenue	health					n/a
Leased by the City	Martin Luther King, Jr. Center	1700 Hopkins Street	Pool, swim center			Field Act building on BUSD land. City pays for maintenance and may ultimately have full ownership.	3,329	n/a
Leased by the City	Rent Stabilization Board Office	2125 Milvia Street	Offices			Concrete frame. Should be evaluated. City leases only one floor.		n/a
Leased by the City	West Campus Center	2100 Browning Street	Pool, swim center			Field Act building on BUSD land. City pays for maintenance and may ultimately have full ownership.	2,567	n/a
Leased by the City	Willard Center	2771 Telegraph Avenue				Field Act building on BUSD land. City pays for maintenance and may ultimately have full ownership.	3,316	n/a
Leased to Others	Berkeley Adult Health Center	1890 Alcatraz Avenue	Berkeley Adult Health Center			Structural concerns. Leased for purchase.	4,000	$1.0 million
Leased to Others	Black Repertory Theater	3201 Adeline Street	Assembly		Seismic Evaluation Needed	2 story	24,150	$5.0 million
Leased to Others	Commonarts	2218 Acton Street	Residential/ Womens refuge				1,600	$400,000

Category	*Building Name*	*Address*	*Normal Use*	*Disaster Function (if different)*	*Seismic Retrofit Status*	*Comments on Condition & Construction*	*Square Feet*	*Building Replacement Value*
Leased to Others	Group Residence	2240 9th Street					2,052	$510,000
Leased to Others	Harrison House for men (B.O.S.S.)	711 Harrison Street	Residential shelter			One story		$1.4 million
Leased to Others	Japanese BBQ	235 University Avenue	Restaurant			2 story	12,755	$3.2 million
Leased to Others	McKinley House for women (B.O.S.S.)	2111 McKinley Avenue	Residential shelter			2 story, concrete block building	5,610	$1.4 million
Leased to Others	Old City Hall	2134 MLK, Jr. Way	Offices and Assembly		Seismic Retrofit Required	Collapse hazard building. Preliminary studies done. Needs funding for retrofit. BUSD has relocated offices to West Campus facility. Council Chambers will continue to be used by City Council through June 2013, while options are considered for temporary City Council chambers relocation.	38,400	$30 million
Leased to Others	Recycling	669 Gilman	Restroom				225	$45,100
Leased to Others	Recycling	669 Gilman Street	Recycling, some office space				18,000	$1.5 million
Leased to Others	Recycling		Office			Trailer	2,300	$580,000
Leased to Others	Recycling		Storage				1,350	$340,000
Marina	Berkeley Yacht Club	1 Seawall Drive	Berkeley Yacht Club		Seismic Evaluation Needed		6,100	$2.14 million
Marina	Boat Docks – Marina							$25 million (all docks)
Marina	Marina Administration Building	201 University Ave.	Offices		Seismic Evaluation Needed	2 story Some dry rot in piles, on liquefiable soils	2,529	$1,000,000
Marina	Marina Corporation Yard		Office/Storage/Meeting Rms			1 story	3,170	$2.23 million
Marina	North Hoist/boathouse					All Steel		$67,650
Marina	Restroom 1 - Marina	Marina, Fishing Pier					600	$227,000
Marina	Restroom 2 - Marina	Marina, Shorebird Park					600	$227,000
Marina	Restroom 3 - Marina	Marina, Marina Office					682	$258,000
Marina	Restroom 4 - Marina	Marina, Berth A-E					LINKED	LINKED
Marina	Restroom 4 - Marina	Marina, Berth A-E					600	$227,000
Marina	Restroom 5 - Marina	Marina, Berth N-O					400	$151,300
Marina	Restroom 6 - Marina	Marina, Berth L-M					400	$151,300
Marina	Restroom 7 - Marina	Marina, Berth F-I					400	$151,300
Marina	Restroom 8 - Marina	Marina, Berth A-E					600	$227,000

Category	*Building Name*	*Address*	*Normal Use*	*Disaster Function (if different)*	*Seismic Retrofit Status*	*Comments on Condition & Construction*	*Square Feet*	*Building Replacement Value*
Marina	Shorebird Nature Center	160 University Ave.				New building (1 story straw bale construction)	960	$1.0 million
Marina	South Hoist/boathouse					All Steel		$67,650
Public Health	Health Clinic	830 University Ave.	Health Clinic		Seismic Evaluation Needed	1 story building Interior upgraded and elevator added in 2011.	7,362	$6.79 million
Recreation and Parks	Aquatic Park – Bird Rescue Center	202 Bolivar Drive					1,400	$315,000
Recreation and Parks	Aquatic Park – Dreamland for Kids	80 Bolivar Drive						$211,500
Recreation and Parks	Aquatic Park – Sea Bird Sailing Center	80 Bolivar Drive					1,400	$315,000
Recreation and Parks	Aquatic Park – Storage House	80 Bolivar Drive					1,400	$315,000
Recreation and Parks	Aquatic Park – Storage House (Rod & Gun Club)	91 Bolivar Drive					1,400	$315,000
Recreation and Parks	Aquatic Park –Rowing Club	2851 W. Bolivar					1000	$162,100
Recreation and Parks	Art & Garden Center	1275 Walnut Street					1800	$1.14 million
Recreation and Parks	Cedar Rose Park Building	1300 Rose Street	Recreation and public assembly/ Child Care/ Center for disabled children		Seismic Evaluation Needed	Single story wood frame building	5,814	$3.06 million
Recreation and Parks	Codornices Park – Toilet Shelter	1201 Euclid Ave					2,600	$652,950
Recreation and Parks	Great Stone Face Park – Storage Shed	Thousand Oaks Blvd/Yosemite Rd					70	$3,680
Recreation and Parks	John Hinkle Park – Scout Building	Southampton Ave/ San Diego Road					480	
Recreation and Parks	John Hinkle Park Club House	Southampton Ave/ San Diego Road					2,100	$472,500
Recreation and Parks	Lawn Bowling Club House	2270 Acton Street					2,304	$580,000
Recreation and Parks	Live Oak Park – Toilet Shelter	1301 Shattuck Avenue					100	$18,350
Recreation and Parks	Parks Shelter	Queens Rd/Fairlawn					800	$80,350
Recreation and Parks	Restroom – Cragmont Park						600	$308,700

Category	*Building Name*	*Address*	*Normal Use*	*Disaster Function (if different)*	*Seismic Retrofit Status*	*Comments on Condition & Construction*	*Square Feet*	*Building Replacement Value*
Recreation and Parks	Restroom – La Loma Park	1339 La Loma Ave					600	$227,000
Recreation and Parks	Restroom – Peoples Park	2500 Haste Street					840	$317,800
Recreation and Parks	Restroom – Rose Garden						600	$227,000
Recreation and Parks	Restroom – San Pablo Park	2800 Park Street					1,092	$413,100
Recreation and Parks	Restroom - Strawberry Park	Allston Way/ West Street					600	$227,000
Recreation and Parks	Restroom – Willard Park	2702 Hillegass Ave					120	$45,400
Recreation and Parks	Skateboard Park Building	777 Harrison Street						$1.0 million
Recreation and Parks	Storage Shed	2270 Acton Street					100	$5,260
Redevelopment Agency		1646 5th Street	Dwelling			Frame, 2 unit, hard-wired smoke detectors	1,600	$400,000
Redevelopment Agency		1654 5th Street	Dwelling			Frame, 1 unit, hard-wired smoke detectors	1,425	$360,000
Redevelopment Agency		729-31 Virginia Street	Dwelling			Frame,1 unit, 2 Story Constructed in 1993	2,221	$560,000
Rental Housing Construction Program		1521 Alcatraz Street	Residential fourplex			Frame - 4 units - 1995	4,539	$1.1 million
Rental Housing Construction Program		1605 Stuart Street	Residential triplex			Frame - 3 units - 1995	3,280	$820,000
Rental Housing Construction Program		1812 Fairview Street	Residential triplex			Frame - 3 units - 1995	3,280	$820,000
Rental Housing Construction Program		2231 8th Street	Dwelling			Frame - 3 units - 1995	2,248	$560,000
Rental Housing Construction Program		3016 A and B Harper Street	Residential duplex			Frame - 2 units - 1995	2,398	$600,000
Solid Waste Transfer Buildings	Equipment Shelter	1199 2nd Street				Value incl. above	4,000	$400,000
Solid Waste Transfer Buildings	Old Storage Building	1231 2nd Street	Storage				1600	$314,700

Category	*Building Name*	*Address*	*Normal Use*	*Disaster Function (if different)*	*Seismic Retrofit Status*	*Comments on Condition & Construction*	*Square Feet*	*Building Replacement Value*
Solid Waste Transfer Buildings	Recycling Center	1201 2nd Street					18,326	$2,24 million
Solid Waste Transfer Buildings	Scale House	1199 2nd Street	Scale House			All Steel Constructed in 1984	360	$153,560
Solid Waste Transfer Buildings	Secondary Office	1231 2nd Street	Office				6,510	$1.6 million

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