Office of the City Manager

July 6, 2004

John Rowden, State Hazard Mitigation Officer
Governor's Office of Emergency Services
Hazard Mitigation Section
3650 Schriever Avenue
Mather, California 95655

Subject: Submission of the City of Berkeley's Local Hazard Mitigation Plan

Dear Mr. ~~Rowden~~ John

The City of Berkeley is pleased to transmit the Berkeley Hazard Mitigation Plan approved and adopted by the City Council on June 22, 2004. The City Council action represents the final step required to meet the planning requirements of the Disaster Mitigation Act of 2000.

In response to the recommendations made during the OES courtesy review of the plan, we have taken the following actions:

1. A copy of the signed resolution has been inserted into the plan directly behind the cover page.
2. We have clarified that annual workplan assignments referenced on page 22, under "Implementation and Tracking" are made under the direction of the City Manager's Office and staff are tasked by Department Heads.
3. Regarding input and coordination opportunities for adjacent jurisdictions to participate in mitigation planning, the City will continue to use existing forums, including the Hills Emergency Forum, the Disaster Resistant California forum, (previously Project Impact Communities), the Alameda County City Managers Association.

The City requests that the Governor's Office of Emergency Services formally review and approve the Berkeley Hazard Mitigation Plan and transmit the plan to the Federal Emergency Management Agency for their formal review and approval. Two hard copies and two CD's of the Berkeley Hazard Mitigation Plan, the Mitigated Negative Declaration, and the Crosswalk are provided per your request.

We greatly appreciate the assistance you and your staff have provided during the preparation of our plan, and we look forward to final approval from both OES and FEMA.

Sincerely,

Arrietta

Arrietta Chakos
Assistant City Manager

2180 Milvia Street, Berkeley, CA 94704 Tel: 510.981.7000 TDD: 510.981.6903 Fax: 510.981-7099
E-mail: manager@ci.berkeley.ca.us

City of Berkeley

Disaster Mitigation Plan

The Honorable Tom Bates, Mayor

City Council

The Honorable Linda Maio, Member, District 1

The Honorable Margaret Breland, Member, District 2

The Honorable Maudelle Shirek, Member, District 3

The Honorable Dona Spring, Member, District 4

The Honorable Miriam Hawley, Member, District 5

The Honorable Betty Olds, Member, District 6

The Honorable Kriss Worthington, Member, District 7

The Honorable Gordon Wozniak, Member, District 8

Phil Kamlarz, City Manager

***Project Team*:** City of Berkeley's Disaster Council; Arrietta Chakos, Assistant City Manager; Reginald Garcia, Fire Chief; Rene Cardinaux, Director of Public Works; Joan MacQuarrie, Building Official, Planning; Bill Greulich, Emergency Services Manager; Dan Lambert, Planning; Brian Quinn, Information Technology; Janet Kennedy, Housing; and Carol Lopes, Disaster Resistant Berkeley Coordinator

Seismic Technical Advisory Group Members: Professor Vitelmo V. Bertero and L. Thomas Tobin

Technical Advisors: James Russell, Laura Samant and Paula Schulz

Adopted June 22, 2004

RESOLUTION NO. 62,544–N.S.

ADOPTING THE DISASTER MITIGATION PLAN FOR THE CITY OF BERKELEY AND ENVIRONMENTAL INITIAL STUDY/MITIGATED NEGATIVE DECLARATION, IN ACCORDANCE WITH NEWLY LEGISLATED REQUIREMENTS ESTABLISHED BY PUBLIC LAW 106-390, THE DISASTER MITIGATION ACT 2000, AND AUTHORIZING THE CITY MANAGER TO SUBMIT THE PLAN TO FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA) FOR APPROVAL

WHEREAS, on October 10, 2000, Public Law 106-390 was enacted establishing new requirements for state and local government agencies to submit a comprehensive Disaster Mitigation Plan (the Plan) by November 1, 2004 in order to be eligible for pre- and post-hazard mitigation grant funding; and

WHEREAS Berkeley sits directly on top of the North Hayward faultline, with the USGS estimating a greater than 67% probability of a seismic event of 6.5 magnitude or greater occurring within the next 30 years; and

WHEREAS, the Plan formalizes the City's comprehensive efforts to make Berkeley safer by accomplishing damage prevention in the built environment; and

WHEREAS, the Plan builds on the objectives and actions established in the City's General Plan and Disaster Preparedness and Safety Element, revised in 2002; and

WHEREAS, for the last year, staff working with technical experts, using all available current technologies and historical documents, have conducted a thorough risk reduction analysis process; and

WHEREAS, on December 5, 2003, staff and representatives from UC Berkeley jointly hosted a community hazards forum at the City Club in order to hear from strategic sectors of the community, utilities, state agencies, other major institutions, community agencies; and

WHEREAS, the Disaster Mitigation Plan has been reviewed by all relevant boards and commissions established by the City; and

WHEREAS, during March and April staff conducted the Initial Study/Mitigation Negative Declaration for the Plan in accordance with CEQA; and

WHEREAS, the Mitigated Negative Declaration found that implementation of the Plan would not have a significant effect on the environment and that the Declaration reflects the lead agency's independent judgment and analysis; and

WHEREAS, approval of the Disaster Mitigation Plan by FEMA constitutes formal completion of the Plan and establishes eligibility for the City to pursue pre- and post-disaster hazard mitigation funds.

NOW THEREFORE, BE IT RESOLVED that the Council of the City of Berkeley adopts the Disaster Mitigation Plan and First Initial Study/Mitigated Negative Declaration in order to comply with the federally mandated Disaster Mitigation Act 2000 and be eligible for pre- and post-hazard mitigation grant funds.

The foregoing Resolution was adopted by the Berkeley City Council on June 22, 2004 by the following vote:

Ayes: Councilmembers Breland, Hawley, Maio, Olds, Shirek, Spring, Worthington, Wozniak and Mayor Bates.

Noes: None.

Absent: None.

Tom Bates

Tom Bates, Mayor

Attest: Sherry

Sherry M. Kelly, City Clerk

BERKELEY MITIGATION PLAN

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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. This Mitigation Plan starts an ongoing process to evaluate the risks different types of hazards pose to Berkeley, and to engage the City and the community in dialogue to identify which steps are most important to pursue to reduce these risks.

While the city and community members have been working together for years to address certain aspects of the risk – such as strengthening school structures, establishing emergency materials caches, and enforcing vegetation management measures in the hill zones – this Plan will formalize this process and make sure that these activities continue to be explored and improved over time. Over many years, this constant focus on disasters will make the city, its residents and businesses, much safer.

This Plan meets the requirements of the federal Disaster Mitigation Act of 2000, which calls for all communities to prepare mitigation plans. By preparing this plan, Berkeley is eligible to receive federal mitigation funding after disasters and to apply for mitigation grants before disasters strike.

Risks in Berkeley

A sound risk mitigation and preparedness program must be founded on reliable information about the types and scale of damage that different hazards could cause to the community. As part of developing this Plan, detailed research was conducted on the four major natural and two major "manmade" hazards that threaten Berkeley. These hazards are earthquakes, wildfires, landslides, floods, hazardous materials accidents, and acts of terror. The two hazards that are most likely to cause significant damage in the city are earthquakes and wildfires.

We do not know when the next major earthquake will strike Berkeley, but the USGS calculates that there is a 62 percent chance that a 6.7 earthquake will strike the Bay Area in the next thirty years and a 27 percent chance that it will occur on the Hayward/Rogers Creek fault system that runs directly through Berkeley. An earthquake of this size, the same size as the 1994 Northridge earthquake that caused $28 billion in losses, would cause significant damage throughout the Bay Area. A major earthquake on the Hayward Fault would cause very violent shaking in areas near the fault and along the waterfront's weak soils. Liquefaction and settlement, ground failures that can destroy pavements and dislodge foundations, are likely in the western part of the city and along streambeds. The ground surface could rupture along the fault, displacing by up to several feet. In a

magnitude 6.9 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. 1,000 to 4,000 families may need temporary shelter. Depending on the disaster scenario, which could include fire following earthquake, hundreds of people could be killed, and many more would be injured. Commercial buildings, utilities, and public roads will be destroyed or disabled. The earthquake could also spark numerous fires at a time when water systems may not be functioning and fire fighters are engaged in other important activities, such as search and rescue. Other secondary impacts could be landslides and hazardous materials spills. Economic losses to buildings in Berkeley alone could reach $1.5 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 the city.

The high risk of wildfires in Berkeley was clearly demonstrated in the 1991 Tunnel Fire that 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[1]. If a fire occurred today that burned the same area, thousands of structures would be destroyed, with losses for buildings alone exceeding $1.0 billion, nearly one-eighth of the total value of structures in Berkeley. Destruction of contents in all of the homes and businesses burned could increase the losses by another $500 million to $1.0 billion. 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.

Landslides and floods also could damage property and cause significant losses in Berkeley. These hazards, however, are likely to have smaller impacts and be confined to specific areas. Significant localized areas of the Berkeley hills face risk from landslide, particularly during wet weather, and a major slide could impact scores of properties and endanger lives. Flooding in Berkeley has the potential to affect about 675 structures, mainly in the western, industrial area of the city and along Codornices Creek. It is unlikely that floodwaters will reach higher than 3 feet. Damages to homes, businesses, and their contents could exceed $100 million. With few properties covered by flood insurance, these costs would be borne primarily by Berkeley residents and businesses.

Accidents involving hazardous materials and terror attacks are the two manmade hazards of largest concern that could impact Berkeley. The City carefully tracks all hazardous materials within its borders, works closely with companies using large amounts of potentially dangerous materials, and Fire Department teams have special training in managing hazardous materials incidents. In recent years, the city has placed significant focus on preparing for any terror incidents that occur in the city. Multi-disciplinary

teams continue to focus on assessing possible threats and training teams to respond to multiple scenarios.

Managing risk requires support and persistence from the community and government at all levels to identify and evaluate risks, and implement and maintain policies, practices and projects. The City of Berkeley has shown leadership in all of these areas. The City has strengthened its ability to serve its citizens in emergencies by seismically upgrading the buildings that house critical city functions, including the Martin Luther King Civic Center (City Hall) and six out of the seven fire stations in the city, and constructing the new, state-of-the-art Public Safety Building. The Berkeley Unified School District, supported by voter-approved bonds, has strengthened many of the City's schools. In wildfire risk areas, vegetation inspections and the popular chipper box program have helped reduce combustible materials. Berkeley has also developed innovative programs to encourage homeowners to strengthen their own structures, such as the Transfer Tax rebate program. These excellent programs, and many others, place Berkeley as a leader in disaster management. But these programs must be consistently maintained and improved for decades to make sure that the citizens of Berkeley truly see a safer future and a sustainable way of life.

Mitigation Plan Objectives and Actions

Berkeley aims to be a disaster-resistant community that can survive, recover from, and thrive after a disaster while maintaining its unique character and way of life. City government should be able to provide critical services in the immediate aftermath of a devastating event of any kind. The people, buildings and infrastructure in and serving Berkeley should be resilient to disasters. Our overall objective is to have basic government and commercial functions resume within thirty days of a damaging earthquake or other significant event.

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

A. Reduce the potential for life loss, injury and economic damage to Berkeley residents from earthquakes, wildfires, landslides and floods.

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.

The City will pursue sixteen actions to meet these objectives, presented in three categories of priority. The *Very High* and *High* priority actions will be conducted

actively in the next two years, although many of these actions will take years to complete. *Important* actions will be undertaken if opportunities arise. The availability of resources will have a strong impact on the pace of achievements. These actions were taken directly from the Disaster Preparedness and Safety Element of the City's General Plan and from staff recommendations. The implementation of all of these actions is dependent on outside sources of funding becoming available.

Very High Priority Actions:

- A-1. Strengthen or replace important city owned and used buildings that are known to have structural weaknesses. The four important buildings known to have severe structural weaknesses are the Ratcliff Building, Old City Hall, the Veteran's Memorial Building, and Center Street Garage.

- A-2. Increase efforts to reduce fire risk in existing development by improving vegetation management and appropriate code enforcement. This activity includes expanding vegetation inspections, improving enforcement mechanisms for fire safety measures in buildings, and developing sources of funding for these activities.

- A-3. Complete the ongoing program to retrofit all remaining non-complying Unreinforced Masonry (URM) buildings. Over 600 of the 700 URM buildings in the city have already been improved. This measure will require the remaining structures to meet compliance with city programs.

- A-4. Better inform residents about emergency preparedness options. This activity would expand existing programs to enable, encourage or require property owners, managers and realtors to provide information about disaster safety.

- A-5. Create a program to reduce risks for people and property for all potentially hazardous single-family, soft-story, and hillside residences. This action would recommend retrofit standards for certain types of structures, and investigate financial incentives and technical assistance that could be provided to homeowners.

- B-1. Establish pre-event planning for post-disaster recovery as an integral element of the emergency response planning of the City Council and each of the City departments. This activity would prepare a basic recovery plan for the city, establish roles for all City departments and establish recovery priorities prior to a damaging event.

- D-1. Encourage mitigation efforts with neighboring cities and counties and key institutions serving Berkeley. This action would promote discussion between the City, UC Berkeley, LBNL, key lifeline agencies and other key institutions, like hospitals and private schools, in or serving Berkeley. This includes holding a

Disaster Forum with residents and representatives of these groups. Additionally, the City will continue to use existing forums in neighboring cities, such as the Hills Emergency Forum, the Disaster Resistant California (previously Project Impact Communities) activities, and the Alameda County City Managers' Association to continue collaboration and joint mitigation planning.

High Priority Actions:

- A-6. Encourage the retrofit of commercial concrete tilt-up, non-ductile frame, and wood frame buildings to improve their ability to resist earthquakes and fires. This action calls for retrofit standards, financial incentives and technical assistance that could help owners of these typically commercial buildings to strengthen them.

- A-7. Reduce the vulnerability of residential areas located in the Hill Hazardous Fire Area to fires through implementation of the Subdivision Ordinance's merger provisions and through changes to the existing residential zoning laws and building code requirements. This action would consider altering review procedures when changes are made to existing structures in the high fire hazard zone.

- A-8. Perform appropriate seismic and fire safety analysis based on current and future use for all city-owned and leased facilities and structures. This activity would study the seismic and fire safety of all buildings owned or used by the City government.

- B-2. Review and revise the Disaster Preparedness and Safety Element of the City's General Plan biennially. The Mitigation Plan will be included as an appendix of the General Plan, and will be reviewed every two years.

- B-3. Rehabilitate the City's storm drain system to reduce local flooding caused by inadequate storm drainage. This action would identify the areas of the storm drain system most urgently requiring attention and would incorporate upgrading the system into routine maintenance. It would also investigate new funding mechanisms for this work.

- C-1. Encourage and support the long-term protection of historic and architecturally significant structures to preserve neighborhood and community character. This activity would develop incentives for owners to make these structures disaster-resistant and would improve post-disaster procedures for preserving these structures when damaged.

- D-2. Work with EBMUD and PG&E to ensure an adequate supply of water and power during emergency periods and during recovery. This activity includes monitoring and advocating for EBMUD's seismic safety upgrades impacting

Berkeley, overseeing the decommissioning of the vulnerable Berryman Reservoir, and targeting post-disaster power resumption to high risk communities.

Important Actions:

- B-4. Assess the feasibility and need to incorporate cost-effective terrorism-resistant design features when city owned buildings undergo major renovations. This activity would study reasonable alterations to buildings that could protect against terror attacks, such as improving air intakes, and consider whether and how the City should make such alterations.

- D-3. Update and revise flood maps for the city and consider applying to the Community Rating System (CRS) under the National Flood Insurance Program. This activity would modernize the city's flood maps, consider participating in FEMA incentive programs, and improve City flood management activities.

A Plan is only meaningful if it is implemented and kept up-to-date. Berkeley has developed effective processes for implementing, tracking and updating its disaster mitigation activities. Implementation and tracking are made under the direction of the City Manager's Office and staff are tasked by Department Heads. This Plan will be rolled into these already successful programs. *Very High* and *High* priority actions will be inserted into departmental work plans each year. Staff will track the progress of these actions through the Disaster Resistant Berkeley Program. The Disaster Council will serve as the advisory body on implementation of this Plan. Every two years, a complete review of the Plan and its priorities will be conducted as part of the annual review of the General Plan (this Plan will be an appendix to the Disaster Preparedness and Safety Element of the General Plan). Every four years, the Plan background materials, such as loss estimates, will be thoroughly reviewed and updated if needed.

1. Objectives and Actions

Objectives

Berkeley aims to be a disaster-resistant community that can survive, recover from, and thrive after a disaster while maintaining its unique character and way of life. City government should be able to provide critical services in the immediate aftermath of a devastating event of any kind. The people, buildings and infrastructure in and serving Berkeley should be resilient to disasters. Our overall objective is to have basic government and commercial functions resume within thirty days of a damaging earthquake or other significant event.

Berkeley will reach this level of resiliency by focusing on three approaches to disaster mitigation. First, 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. Second, the City will establish and maintain incentive programs and standards to encourage local residents to upgrade the hazard-resistance of their own properties. Third, 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 disastrous event.

This Plan focuses only on mitigation activities, meaning activities that occur prior to a hazard event that reduce damage when disasters strike. Damage prevention activities include strengthening structures, making land use decisions that will minimize damage, and reducing vegetation in high-fire areas, for example. They do not include emergency response activities, such as planning response mechanisms, purchasing equipment to use in emergency response, or conducting drills. Likewise, disaster preparedness activities, such as disaster awareness programs, sheltering plans, and storage of supplies for post-disaster relief, are not generally covered by this plan. The City has strong plans and programs focused on emergency response and disaster preparedness activities that are coordinated with but separate from this mitigation Plan.

This Plan has four objectives that specify the areas of focus for the City's mitigation activities:

A. Reduce the potential for life loss, injury and economic damage to Berkeley residents from earthquakes, wildfires, landslides and floods.

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.

Links to City General Plan

This Plan is part of an ongoing process to build a disaster-resistant Berkeley. 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 amply demonstrated in the General Plan. The General Plan, revised in 2002, directly guides the objectives and actions in this Plan. The thorough, community-driven process used to develop the General Plan is described fully in Appendix B. One of the General Plan's major goals is to make Berkeley a disaster-resistant 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 the Urban Design and Preservation Elements. The objectives in this plan flow from the major goals of the General Plan and the objectives of the Disaster Preparedness and Safety Element. Most of the actions in this Plan are directly taken from the Disaster Preparedness and Safety Element.

This mitigation plan builds on years of support by the City Council for the Disaster Resistant Berkeley program, and the larger effort to prepare for hazard events, prevent disasters from occurring, and reduce community risk. An interdepartmental staff team, in consultation with City commissioners, hazard safety experts, and state and federal agency staff, compiled and analyzed the data in this Plan. This collaborative endeavor started in 2000 at the direction of the City Council. A draft of this plan received community review through Berkeley's highly interactive commission process. In addition, a local summit meeting brought together a variety of Berkeley stakeholders from the community, City government, the University of California at Berkeley, and regional lifeline and other partner agencies to discuss the risk reduction priorities in this plan. The plan development process is chronicled in detail in Appendix A.

In recent years, the City has made good progress through efforts to reduce risk in City-used buildings, fire stations and major municipal buildings and public schools. This plan will continue these efforts and widen them throughout the community. In a generation's time, the City will significantly reduce the potential for community devastation from natural or human-generated hazards.

Identification of Actions

This Plan advocates sixteen actions. Table 1-1 summarizes all of the actions, identifies the hazard(s) and objective each one addresses, and indicates the assigned priority level of the action.

The set of actions in this Plan was developed through a multi-step, broadly inclusive process. To begin, an interdepartmental team of city staff developed a preliminary list of actions. This preliminary list included actions taken directly from the City's Disaster Preparedness and Safety Element as well as a few priority activities identified after the element was completed. This list was critiqued and edited by a diverse group of community members, city staff, UC Berkeley staff, regional lifeline representatives and others during the Disaster Mitigation Summit held in December 2003 (see Appendix A).

Prioritization of Actions

The actions were prioritized in the same process used to identify them. A multi-disciplinary group of city staff proposed an initial prioritization scheme, dividing the sixteen actions into categories of *Very High* priority, *High* priority, and *Important*. City staff, council members, commissioners, residents and other stakeholders in the Disaster Mitigation Summit, commission meetings, and a City Council meeting will review these categorizations.

Numerous factors were considered while assigning these priorities. First, only those actions with strong community support were given *Very High* or *High* priority ratings. This support, while not quantifiable, is essential for effective implementation and allocation of local resources.

Second, actions addressing the most critical hazards for Berkeley were given priority. The loss estimates presented in section five of this Plan clearly show that earthquakes and wildfires have, by far, the most potential to cause large human and economic losses. Actions focusing on preserving life and reducing injury were given highest priority. Actions strengthening the city's ability to provide essential emergency services to the entire community after a disaster were also weighted highly. Next, emphasis was given to actions aimed at ensuring that the city's economic, educational and governmental systems will resume normal functioning within 30 days of a major disaster.

The implementation of all of these actions is dependent on outside sources of funding becoming available.

Table 1-1. Overview of Actions in Mitigation Plan

Very High Priority

Ref.	Action	Hazard	Timeline
A-1	Strengthen or replace important city owned and used buildings that are known to have structural weaknesses.	Earthquake	5 – 7 years
A-2	Increase efforts to reduce fire risk in existing development by improving vegetation management and appropriate code enforcement.	Wildfire	5 – 7 years
A-3	Complete the ongoing program to retrofit all remaining non-complying Unreinforced Masonry (URM) buildings.	Earthquake	5 – 7 years
A-4	Better inform residents about emergency preparedness options.	Multi-hazard	Ongoing
A-5	Create a program to reduce risks for people and property for all potentially hazardous single-family, soft-story, and hillside residences.	Multi-hazard	5 – 7 years
B-1	Establish pre-event planning for post-disaster recovery as an integral element of the emergency response planning of the City Council and each of the City departments.	Multi-hazard	1 year
D-1	Encourage mitigation efforts with neighboring cities and counties and key institutions serving Berkeley.	Multi-hazard	Ongoing

High Priority

Ref.	Action	Hazard	
A-6	Encourage the retrofit of commercial concrete tilt-up, non-ductile frame, and wood frame buildings to improve their ability to resist earthquakes and fires.	Multi-hazard	5 – 7 years
A-7	Reduce the vulnerability of residential areas located in the Hill Hazardous Fire Area to fires through implementation of the Subdivision Ordinance's merger provisions and through changes to the existing residential zoning laws and	Wildfire	5 years

	building code requirements.		
A-8	Perform appropriate seismic and fire safety analysis based on current and future use for all city-owned and leased facilities and structures.	Multi-hazard	1 year
B-2	Review and revise the Disaster Preparedness and Safety Element of the City's General Plan biennially.	Multi-hazard	First review in 2006
B-3	Rehabilitate the City's storm drain system to reduce local flooding caused by inadequate storm drainage.	Flood	2 years
C-1	Encourage and support the long-term protection of historic and architecturally significant structures to preserve neighborhood and community character.	Multi-hazard	Ongoing
D-2	Work with EBMUD and PG&E to ensure an adequate supply of water and power during emergency periods and during recovery.	Multi-hazard	Ongoing

Important

Ref.	**Action**	**Hazard**	
B-4	Assess the feasibility and need to incorporate cost-effective terrorism-resistant design features when city owned buildings undergo major renovations.	Terrorism	1 year
D-3	Update and revise flood maps for the city and consider applying to the Community Rating System (CRS) under the National Flood Insurance Program.	Flood	1 year

Details of Actions

All of the imperative mitigation actions identified by the Berkeley community are presented below with initial suggestions for implementation, identification of lead departments in the City and expected outcomes, and preliminary estimates of resources required and schedule.

A. Reduce the potential for life loss, injury and economic damage to Berkeley residents from earthquakes, wildfires, landslides and floods.

A-1.	Strengthen or replace important city owned and used buildings that are known to have structural weaknesses.
Proposed Activities:	- Seismically strengthen the Ratcliff Building - Seismically strengthen Old City Hall - Seismically strengthen the Veteran's Memorial Building - Replace the Center Street Garage - Seek external funding for these projects
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[2].
Lead Organization:	Public Works Department, City Managers Office
Timeline:	5 – 7 years
Resources Required:	External funding required
Priority:	Very High

A-2.	Increase efforts to reduce fire risk in existing development by improving vegetation management and appropriate code enforcement[3].
Proposed Activities:	- Continue and expand existing vegetation management programs by several thousand properties annually. - Reduce fire risk in existing developed areas by requiring all existing buildings over 75 feet tall to install a sprinkler system and promote fire extinguishing systems in all buildings. - Create mechanism to enforce provisions of the building code that require the installation of smoke detectors as a condition of granting a permit for any work on existing residential and commercial buildings over $1000, and as a condition for the transfer of property. - Consider reestablishing a Fire Hazard Abatement District to fund reduction in fire risk in existing properties.

	- Create a mechanism to require the bracing of water heaters, flexible couplings in gas appliances and the anchoring of houses to foundations to reduce fire ignitions following earthquakes.
Special Environmental Concerns:	All activities occurring in biologically sensitive areas will take measures to protect sensitive habitats and species[4].
Lead Organization:	Fire Department, Building and Safety Division
Timeline:	5 – 7 years
Resources Required:	More fire department prevention staff, more building and safety enforcement staff.
Priority:	Very High

A-3.	Complete the ongoing program to retrofit all remaining non-complying Unreinforced Masonry (URM) buildings[5].
Proposed Activities:	- Work with owners of remaining potentially hazardous 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 penalties to owners who show inadequate effort to upgrade their URM buildings. - Maintain or improve program notification to building occupants and owners. - Improve program implementation for single-family homes and small multi-unit buildings.
Special Environmental Concerns:	All building upgrade activities will include efforts to minimize impacts to existing residential and commercial tenants[6].
Lead Organization:	Planning Department
Timeline:	5 – 7 years
Resources Required:	¼ to ½ FTE[7]
Priority:	Very High

A-4.	Better inform residents about emergency preparedness options.
Proposed Activities:	- Expand existing programs to enable, encourage, or require property owners, managers, and realtors to provide information to tenants and homebuyers about

	emergency preparedness, evacuation routes, and home safety[8]. - Develop a set of materials to provide relevant information. - Encourage owners of private schools and other privately owned high-occupancy structures to assess the safety of their buildings.
Lead Organization:	Planning Department, Office of Emergency Services, Department of Housing, and Rent Board
Timeline:	Ongoing
Resources Required:	To be determined
Priority:	Very High

A-5.	Create a program to reduce risks for people and property for all potentially hazardous single-family, soft-story, and hillside residences[9].
Proposed Activities:	- Recommend adoption of a retrofit standard for single-family homes, small multi-unit apartment buildings and soft-story buildings that includes standard plan sets and construction details. - Require engineered plans for single-family homes on hillsides and multi-unit residential structures to qualify for the transfer tax rebate. - Investigate and adopt financial, procedural, and land use incentives for owners of soft-story buildings to facilitate retrofit. - Explore development of an ordinance to require owners of soft-story structures to strengthen them. - Provide technical assistance in seismically strengthening these types of structures. - 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.
Special Environmental Concerns:	All building upgrade activities will include efforts to minimize impacts to existing residential and commercial tenants[10].
Lead Organization:	Planning Department
Timeline:	5 – 7 years
Resources Required:	Up to ½ FTE for program enforcement

Priority:	Very High

A-6.	Encourage the retrofit of commercial concrete tilt-up, non-ductile frame, and wood frame buildings to improve their ability to resist earthquakes and fires[11].
Proposed Activities:	- Recommend adoption of a retrofit standard for these types of buildings. - Investigate and adopt financial, procedural and land use incentive programs for owners of these types of buildings to facilitate retrofit. - Provide technical assistance in strengthening these structures.
Special Environmental Concerns:	All building upgrade activities will include efforts to minimize impacts to existing residential and commercial tenants[12].
Lead Organization:	Planning Department, Building and Safety Division
Timeline:	5 – 7 years
Resources Required:	Up to ½ FTE
Priority:	High

A-7.	Reduce the vulnerability of residential areas located in the Hill Hazardous Fire Area to fires through implementation of the Subdivision Ordinance's merger provisions and through changes to the existing residential zoning laws and building code requirements [13].
Proposed Activities:	- Consider fire safety, evacuation, and emergency vehicle access when reviewing secondary unit or other proposals to add residential units in these areas. - Promote the installation of early warning fire alarm systems. - Maintain City standards for minimum width and vertical clearance, and ensure that new driveways and roadways meet minimum standards of the Uniform Fire Code or subsequent standards adopted by the City. - Provide adequate water for fire suppression for new development in accordance with City standards for minimum volume and duration of flow. - Establish criteria for the installation of gas shutoff valves in new and existing construction, to reduce the risk of post-earthquake fires. - Assist the Panoramic Area Association to obtain funding

	to study the feasibility of building a fire trail on the south side of the Hill including evaluation of alternate routes.
Special Environmental Concerns:	All activities occurring in biologically sensitive areas will take measures to protect sensitive habitats and species[14].
Lead Organization:	Planning Department
Timeline:	5 years
Resources Required:	¼ FTE
Priority:	High

A-8.	Perform appropriate seismic and fire safety analysis based on current and future use for all city-owned and leased facilities and structures[15].
Proposed Activities:	- Analyze structures with important emergency response and recovery functions, first, and make recommendations for structural improvements. - Analyze remaining structures based on occupancy and structure type, and make recommendations for structural improvements. - Establish a prioritized program for seismic retrofit of the remaining seismically unsafe public structures. - Reduce the occupancy of and develop emergency guidelines for buildings with structural deficiencies prior to being upgraded.
Lead Organization:	City Manager's Office, Public Works, Capital Improvement Division
Timeline:	1 year
Resources Required:	½ FTE plus consultant time
Priority:	High

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.

B-1.	Establish pre-event planning for post-disaster recovery as an integral element of the emergency response planning of the City Council and each of the City departments[16].
Proposed Activities:	- Establish a framework and process for recovery planning

	that specifies roles, priorities, and responsibilities of various departments within the City organization, and that outlines a structure and process for policy-making involving elected officials and appointed advisory committee(s). - Prepare a basic Recovery Plan that outlines the major issues and tasks that are likely to be the key elements of community recovery. - Integrate recovery planning as an element of the Community-Based Disaster Response Plan. - Evaluate the feasibility of resuming most city government functions within 30 days of a major disaster. - Explore use of new technologies, such as early warning systems. - Review and improve City's short-term and intermediate-term sheltering plans.
Lead Organization:	City Manager's Office
Timeline:	1 year
Resources Required:	No additional resources required
Priority:	Very High

B-2.	Review and revise the Disaster Preparedness and Safety Element of the City's General Plan biennially.
Proposed Activities:	- Make the DMA 2000 Plan an appendix to the Disaster Preparedness and Safety Element and incorporate its review into the annual General Plan update.
Lead Organization:	Planning Department
Timeline:	First review in 2006
Resources Required:	No extra resources required
Priority:	High

B-3.	Rehabilitate the City's storm drain system to reduce local flooding caused by inadequate storm drainage[17].
Proposed Activities:	- Conduct a hydraulic analysis of runoff and drainage systems in the city to predict areas of insufficient capacity in the storm drain system. - Incorporate improving the system capacity and disaster resistance in regular maintenance activities. - Ensure that new development pays its fair share of improvements to the storm sewerage system necessary to

	accommodate increased flows from the development.
Special Environmental Concerns:	Any non-emergency construction work on the storm drain system will take steps to minimize impacts to riparian habitat[18].
Lead Organization:	Public Works Department
Timeline:	2 years
Resources Required:	1-½ FTE plus consultant time
Priority:	High

B-4.	Explore the feasibility and need to incorporate cost-effective terrorism-resistant design features when city owned buildings undergo major renovations.
Proposed Activities:	- Identify reasonable building alterations that could reduce vulnerability of terror attacks, such as moving air intake vents. - Study how the city could incorporate these alterations into ongoing building upgrades and maintenance. - Encourage other governmental agencies and the private sector to consider similar measures.
Lead Organization:	Public Works Department, Capital Improvements Division, City Manager's Office
Timeline:	1 year
Resources Required:	½ FTE
Priority:	Important

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

C-1.	Encourage and support the long-term protection of historic and architecturally significant structures to preserve neighborhood and community character[19].
Proposed Activities:	- Create incentives for owners of historic or architecturally significant structures to undertake mitigation to levels that will minimize the likelihood of damage during or demolition after a disaster. - Establish preservation-sensitive measures, including requirements for temporary shoring or stabilization where needed; arrangements for consulting with

	preservationists; expedited permit procedures for suitable repair or rebuilding of historically or architecturally valuable structures; and, where appropriate, provisions for replanting. - Require alterations to designated and potentially significant structures to conform to the federal Secretary of the Interior's Guidelines for Rehabilitation.
Lead Organization:	Planning Department
Timeline:	Ongoing
Resources Required:	To be determined
Priority:	High

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

D-1.	Encourage mitigation efforts with neighboring cities and counties and key institutions serving Berkeley[20].
Proposed Activities:	- Promote information sharing and seek to coordinate and implement collaborative mitigation and response planning and information gathering efforts with neighboring cities, Alameda and Contra Costa Counties, and the East Bay Regional Park District. - Coordinate mitigation efforts with UC Berkeley and LBNL for hazardous materials and natural hazards, especially flood, fire and landslide. - Support and encourage efforts of key lifeline agencies (e.g. PG&E, EBMUD, CalTrans, etc.) to plan for and finance seismic retrofit and other disaster resistant measures. - Conduct a Disaster Forum to bring these groups together with community members and stakeholders in Berkeley. - Work with the business community in Berkeley to identify ways to improve business resiliency to disasters. - Initiate joint planning effort for the Panoramic Hill area with the University of California and City of Oakland, who share responsibility for regulating development in this area. - Coordinate with and encourage mitigation actions in public and private schools and hospitals. - Coordinate with neighboring cities through existing forums such as the Hills Emergency Forum, the Disaster

	Resistant California (previously Project Impact Communities) activities, and the Alameda County City and Emergency Managers' Associations to continue collaboration and joint mitigation planning.
Lead Organization:	City Manager's Office, Planning Department, Office of Emergency Services, Public Works Department, Office of Transportation
Timeline:	Ongoing
Resources Required:	½ FTE engineer staff
Priority:	Very High

D-2.	Work with EBMUD and PG&E to ensure an adequate supply of water and power during emergency periods and during recovery[21].
Proposed Activities:	- Continue to work with the East Bay Municipal Utility District to complete the decommissioning of the Berryman Reservoir. - Encourage evaluation of EBMUD's north-south 48" water main and the sewer interceptors. - Coordinate with PG&E and EBMUD for mitigation post-disaster power resumption so that vulnerable communities, such as the disabled and elderly, are given priority. - Investigate upgrading water line capacity to neighborhoods at most risk of wildfire.
Lead Organization:	Public Works Department
Timeline:	Ongoing
Resources Required:	¼ FTE
Priority:	High

D-3.	Update and revise flood maps for the city and consider applying to the Community Rating System (CRS) under the National Flood Insurance Program[22].
Proposed Activities:	- Update and revise flood maps for the city using state of the art techniques. - Assess the cost-effectiveness of qualifying for the Community Rating System (CRS) evaluation under the National Flood Insurance Program (NFIP). - Incorporate FEMA guidelines and suggested activities

	into City plans and procedures for managing flood hazards. - Encourage private owners in the floodplain to undertake flood-proofing measures. - Explore legislation to require hazardous materials stored in the flood zone to be elevated or otherwise protected from floodwaters.
Lead Organization:	Public Works Department
Timeline:	1 year
Resources Required:	¼ FTE
Priority:	Important

2. Implementation, Monitoring and Updating Plan

A Plan is only meaningful if it is implemented and kept up-to-date. Berkeley has developed effective workplan processes for implementing, tracking and updating its disaster mitigation activities. The Office of the City Manager directs implementation of mitigation activities and staff is tasked by Department Heads. This Plan will be rolled into these already successful workplan processes. *Very High* and *High* priority actions will be inserted into departmental work plans each year. Staff will track the progress of these actions every month. Every two years, a complete review of the Plan and its priorities will be conducted. Every four years, the Plan background materials, such as loss estimates, will be thoroughly reviewed and updated if needed.

Implementing and Tracking Actions

Every year, starting in fiscal year 2005, the *Very High* and *High* Priority actions in this plan will be assigned to specific departments and staff members by the City Manager's office. These actions will be added to the annual Disaster Resistant Berkeley (DRB) work program. Implementation steps, schedules and budgets will be created in greater detail as part being incorporated into the DRB work program. The implementation of all of these actions is dependent on outside sources of funding becoming available.

This plan has been reviewed under the standards of the California Environmental Quality Act (CEQA) and any concerns identified for implementation of these actions has been noted in the actions themselves. The complete CEQA initial study and negative declaration are available for review.

All key disaster mitigation, preparedness, response and recovery activities of the City of Berkeley have been implemented and tracked through a multi-departmental process referred to as DRB since May of 2000. The DRB work program lists all disaster related activities that the city aims to accomplish in a given year, along with detailed schedules and activities. Every month, representatives from each key department (e.g. Housing, Public Works, Fire, Building and Safety, Planning, to name a few) meet to review the DRB work program. Each activity on the program is reviewed individually, discussing progress made and problems encountered, and reviewing whether the planned schedule and activities continue to be feasible. Focused subcommittee meetings are called to discuss any projects that lag behind schedule. This process, started through FEMA's Project Impact, has been very effective at both implementing a wide variety of disaster management programs and making city disaster management efforts truly inter-departmental and multidisciplinary.

The City's Disaster Council 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. Progress in meeting plan activities and objectives will be reviewed during the

council's regular meetings. The Fire Safety Council will also review implementation of actions in the Plan related to fire risk.

Updating the plan

This Plan will be incorporated into the City's Disaster Preparedness and Safety Element, a portion of the City's General Plan, as an appendix. In 2003, the City launched a program to annually review the complete General Plan. Appendices of the General Plan, such as this Plan, will be reviewed biennially. The review and revision of the City's Disaster Mitigation Plan will be included in biannual revisions of the Disaster Preparedness and Safety Element. These annual revisions will be spearheaded by the Planning Department, but will involve participation of all relevant departments. A thorough review of all loss estimates, objectives and other elements of this Plan will be conducted every four years.

The public will continue to be involved in the Plan implementation and revision process. All meetings of the Disaster Council and the Fire Safety Council are held in public, and there will be opportunities for input as these groups monitor implementation progress. The Plan will be updated as part of the update of the Safety Element of the City's General Plan. The City follows a structured, extensive public review process to update elements of the General Plan.

3. Analysis of Hazards in Berkeley

It is important for a community's risk mitigation and preparedness efforts to be founded on accurate information about the types and scale of damage that hazards could cause to the community. This section contains a description of the major hazards that threaten Berkeley – earthquakes, wildfires, landslides, floods, hazardous materials accidents and terror attacks – and the exposure and vulnerability of elements of the City to these hazards. It presents descriptions of probable damage and the consequences to the city's way of life.

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 a likely earthquake. For other hazards, past calamitous events or studies by local specialists were used to estimate possible impacts to the community.

Identification of Hazards

The City of Berkeley is exposed to a number of natural and human-caused hazards that vary in their potential intensity and impact on the City. This mitigation plan addresses four high-probability natural hazards and two human-caused hazards, which were selected because of their likelihood of occurrence and potential consequences. The natural hazards, earthquake, wildfire, flood and landslide, are of great concern because they can occur independently, or in combinations, and can trigger secondary hazards. The two human-caused hazards, hazardous materials accidents and terror attacks, are threats that are emerging or increasing in our modern world.

The natural hazards included in this plan were identified through a community-based process during the revision of the Disaster Preparedness and Safety Element, one section 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, close to 1,000 pages of policy suggestions submitted by Berkeley citizens, and the hard work and dedication of the Berkeley community and Berkeley Planning Commission[23]. 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. Other natural hazards that are extremely rare in Berkeley are not included in this plan[24].

City staff and community members identified the human-caused hazards as significant threats that could be lessened through mitigation activities or community preparedness programs. Following the terror attacks of September 11, 2001, the City conducted community meetings that contributed to defining terrorism as a high-priority hazard to the community. Other human-made hazards that could occur in Berkeley, such as contamination of ground water, 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 occurring at the same time. A major earthquake could trigger significant landslides, spark wildfires and release toxic chemicals. If an earthquake occurred during the rainy winter season, landslides would be worsened and flooding could occur, exacerbated by damaged stream culverts and storm drains. Possibly, terrorists could take advantage of hazard conditions and strike the city when at its most vulnerable. The City's emergency teams practice responding to similar, challenging, multi-hazard events. In addition to looking at each hazard individually, this Plan explores how the hazards interact, and how mitigation activities for each hazard impacts the overall disaster risk in Berkeley.

Components of the Hazards Analysis

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

- Historical Events. The city has experienced the effects of all hazards included in this Plan within the past two decades. Descriptions of the impacts of these disasters help illustrate some of the types of damage they can cause.

- Hazard. A discussion is given of the ways that each hazard can damage the community. The locations in Berkeley that are particularly prone to specific hazards, such as the "100-year" floodplain, are described and shown in maps. Areas that could experience secondary hazards, such as liquefaction, are also discussed.

- Exposure. *Exposure is* defined as the people, buildings and infrastructure that exist in hazard zones.

- Vulnerability. *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. The consequences of damage on city residents and their way of life are explored.

Federal Requirements

This Plan meets the requirements of the federal Disaster Mitigation Act of 2000, which calls for all communities to prepare mitigation plans to be eligible for federal mitigation funding. Risk assessments for each hazard must meet certain specifications to meet federal approval[25]. Those specifications and a description of how and where they are met in this plan appear in Table 3-1.

Table 3-1. Location of Federal Risk Assessment Requirements in This Plan

Federal Requirement	**How and Where Addressed**
Identifying Hazards	The process used to identify hazards is explained at the beginning of this chapter. Maps indicating areas impacted by each hazard appear throughout this chapter and are listed in the Table of Contents.
Profiling Hazard Events	The probabilities of future hazard events, when available, and a description of the types of damage each hazard can cause appear in the *Hazard* section under each of the six hazard headings in this chapter. Previous occurrences of each hazard are described in the *Historical* section under each of the hazard headings.
Assessing Vulnerability: Identifying Assets	The *Exposure and Vulnerability* section under each hazard discusses the types and numbers of existing buildings, infrastructure and critical facilities exposed to each hazard. The known weaknesses of particular city elements are also described.
Assessing Vulnerability: Estimating Potential Losses	Calculations of economic, physical and life losses are presented, along with a discussion of the methods used to obtain them, in the *Risk and Loss Estimates* section under each hazard in this chapter.
Assessing Vulnerability: Analyzing Development Trends	Land uses and development trends within the city are described in chapter 5, *Community Profile and Trends*.

3.1. Earthquakes

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. Region-wide impacts and disruption, however, had a sobering effect on city officials and residents, and led to an increased awareness of the high risk Berkeley faces from much closer earthquakes and prompted substantial local response.

Earthquake Hazard

Berkeley is surrounded by earthquake faults. The Hayward fault – of particular concern – runs directly beneath the city. A large earthquake could occur on any of the seven principal faults in the Bay Area, 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. Figure 3-1 shows the city of Berkeley and its proximity to the region's key faults.

There is a sixty-two percent chance that an earthquake of M 6.7 or greater will strike the Bay Area at least once over the next thirty years, and a twenty-seven percent chance that an event of this magnitude would occur on the Hayward/Rodgers Creek fault system during that time[26]. This means that current Berkeley residents are likely to experience a damaging earthquake during their lifetime. To provide a historical context, the 1994 Northridge earthquake, which caused $28 billion dollars in losses, was a Magnitude 6.7 earthquake[27]. 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.

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. 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. Shaking, particularly horizontal shaking causes most earthquake damage, because structures often have inadequate resistance to this type of motion. The strongest shaking is typically close to the fault where the earthquake occurs. Weak soils, such as bay mud and fill at the City's waterfront, also experience strong shaking in earthquakes, even from distant quakes.

Earthquakes can cause the ground to fail in several ways, such as surface fault rupture, liquefaction, or landslides. Surface 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 from its previous location, causing splits in any structures or pipelines crossing the area. Fault rupture on the Hayward fault, which may not occur in every earthquake on this fault, is likely to be concentrated in a narrow zone, but small parallel surface ruptures could occur over a wider area. Liquefaction is a phenomenon that occurs in wet, sandy soils. When shaken, the soil grains consolidate, pushing water towards the surface and causing a loss of strength in the soil. The soil surface may sink or spread laterally. Structures located on liquefiable soils can sink, tip unevenly, or even collapse. Pipelines and paving can tear apart. The potential for liquefaction in Berkeley exists primarily to the west of the railroad tracks and Interstate 80 in low-lying areas adjacent to San Francisco Bay[28]. There is also a potential for liquefaction along the banks of major creeks such as Strawberry and Codornices creeks. Seismically triggered landslides are primarily a concern in the hill areas. These slides could result in significant property damage, injury and loss of life. Figure 3-2 shows the areas at most risk of surface fault rupture. Figure 3-3 shows areas prone to liquefaction. Figure 3-4 indicates areas at risk of seismically induced landslides.

Fire often accompanies earthquakes, caused by breaks in natural gas lines, damaged electrical systems, or toppled appliances with pilot lights. Fire following an earthquake is a particular concern because of the likelihood of numerous simultaneous ignitions, broken water mains, blocked or damaged routes for evacuation and firefighter access, and other demands on fire personnel. This threat was tragically demonstrated in the 1995 Kobe, Japan earthquake and the San Francisco Marina District in 1989. Densely populated neighborhoods with wooden homes, such as most of the residential areas in Berkeley, are most at risk.

Exposure and Vulnerability

The next earthquake could affect all of the buildings and infrastructure in Berkeley. This section will look first at the buildings and infrastructure directly controlled by the City; second, the critical facilities and infrastructure *not* controlled by the City but key to its functioning; and, third, the other structures, including private residences and commercial buildings, that make up the community.

City-Owned Buildings and Infrastructure

The City of Berkeley owns or leases approximately 160 significant buildings. These buildings are used for various purposes, 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. A number of buildings have been assessed for seismic safety and, when warranted, strengthened. They include the Martin Luther King, Jr. Civic Center Building (City Hall), the Main Library, and six out of seven fire stations (the seventh is in the process of being replaced). Many City buildings essential for emergency response activities have been assessed and repaired or replaced, if needed.

However, several buildings that are known to be seismically dangerous have not been upgraded. These buildings are listed below:

- *Ratcliff Building*, 1326 Allston Way

  This building is used for park facilities and equipment maintenance. It is critical to City emergency response as the Public Works departmental operations center. It is also the location of the repeaters and antennae for the City's two-way radios and other communications support equipment. This URM structure is occupied by city employees despite being a collapse hazard building. It is recognized by the City as an historic landmark.

- *Old City Hall*, 2134 MLK, Jr. Way

  This building, used for offices, such as the office of the Berkeley Unified School District, and assemblies, including City Council meetings, is a potential collapse hazard that needs to be retrofitted. It is also a recognized historic building.

- *Veterans' Memorial Building*, 1931 Center Street

  This historically landmarked building, used for public assembly and as a homeless shelter, is a potential collapse hazard that needs to be retrofitted.

- *Environmental Impact Analysis of East Bay Hills*

  Assess potential environmental damage from seismically induced landslides and fire hazards in the urban wildland area.

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

  This building is vulnerable to earthquake damage. It is used for city and public parking. A retrofit would be prohibitively expensive, so this building should be replaced.

Other City buildings need to be better screened for their seismic vulnerability and may pose some risks to life and emergency operations. A complete listing of the City's buildings and known information about their disaster risk appears in Appendix C. Sixteen of these buildings have high occupancy or important uses and have not been evaluated for their seismic safety. These buildings appear in Table 3-2. No significant City buildings are located in the fault rupture or high landslide or fire risk zones, except for Fire Station #7 which is in the fire risk zone, but is scheduled for replacement in two years. Important city buildings, as well as critical facilities not owned by the city, are shown in Figure 3-5.

City of Berkeley-owned and maintained infrastructure consists of the following elements:

- Roads, curbs, paths and sidewalks
- Retaining walls
- Storm drains
- Creeks, open channels and culverts
- Sanitary sewer collection system that links to the EBMUD system
- Electric poles and above and below ground lines to feed street lights and signals from the PG&E system
- The Sutter Street – Solano Avenue tunnel
- I-80 Pedestrian Bridge
- The University Avenue interchange approach structure and railroad crossing
- The Transfer Center, city waste disposal and recycling, located at Second and Gilman streets
- City parks
- Traffic circles and islands

Much of the City-owned infrastructure was built before World War II when the City was growing and modernizing. After nearly 75 years in service, many of the elements require extensive maintenance, repair or enhancements. In particular, 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. The weaknesses of this system are described in more detail in the Flood section.

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

The City's sanitary sewer system includes sections of over-sized pipelines that provide temporary storage of excess flows when the East Bay Municipal Utilities District (EBMUD) transport system cannot accept flows. The amount of time provided by the storage depends on the inflow volume and the ability of downhill segments to flow. Liquefaction will damage the sewer lines and compromise their ability to flow freely. Failure of the pressurized EBMUD transport line to flow, due to damage to either the pipeline or nearby pumps, could backup the Berkeley system beyond its storage capacity. When the system is overloaded, effluent will flow through utility covers, onto the City's streets and into the storm water drain system and creeks that flow to the Bay.

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.

The Hayward fault cuts through Berkeley in a northwest-southeast direction at the base of the hills. Figures 3-1 and 3-2 indicate the location. Fault rupture, if it occurs, would damage important east-west streets making travel between the hills and flatland areas difficult where displacements are large. It would also critically damage the storm drainage system and creeks. The liquefaction hazard is more acute on the west side of the city and liquefaction caused earth movements will affect underground infrastructure (drainage and sewer systems and creeks) and above ground infrastructure (streets, curbs, sidewalks, and electric systems).

Table 3-4 lists the lengths of key elements of city-owned infrastructure in high hazard zones of liquefaction, seismically induced landslides and fault rupture. Infrastructure elements in these zones are highly prone to damage in earthquakes.

Critical Facilities and Infrastructure Not Owned by the City

Critical Facilities

Hospitals and schools are critical facilities that are not operated or owned by city government. Figure 3-6 shows the locations of these facilities.

Hospitals

There is one acute care hospital in Berkeley, Alta Bates, owned and operated by the Sutter Health Corporation. The hospital has two campuses, Ashby and Herrick. The corporation is planning renovations for the Alta Bates Hospital to comply with the State Hospital Seismic Safety Act. The Ashby campus includes eight buildings, five of which were built to pre-1973 seismic standards[29]. Alta Bates states that these buildings will not jeopardize lives, but may not be functional after an earthquake. Many pre-1973 buildings do pose life safety hazards, and it is not known whether detailed structural analyses of these buildings were conducted to assess their safety. By California state law, these buildings must all be retrofitted or replaced by 2030. Three additional buildings at Ashby and one at Herrick could experience damage in an earthquake[30]. One building at the Herrick campus is categorized as structurally capable of providing hospital services after a major earthquake. $200 to $250 million has been earmarked to increase the emergency capacity and seismic resistance of these facilities[31].

The Berkeley Unified School District

The Berkeley Unified School District is independent from the City government and manages primary and secondary education and education facilities, including all public schools in the city. The City government has no authority over these structures, but does provide police and fire services to the District.

In 1989, shortly after the Loma Prieta earthquake, a group of parents approached the Berkeley Unified School District with concerns about the preparedness efforts of the

schools and the structural safety of the buildings. Their concern prompted a review of all school structures that found significant problems: seven of the district's sixteen schools were found to pose life-safety risks. Further, the engineering consultants recommended the immediate closure of one particularly dangerous school and plans to close four others in the near future. 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.

With the help of the Governor's Office of Emergency Services and the Association of Bay Area Governments, the Berkeley Unified School District undertook an aggressive campaign to provide disaster supplies and safety equipment for all sixteen Berkeley schools. Safety experts helped to develop emergency response plans for each school site, and with the District's administrative staff, to strengthen the capacity for effective disaster response.

In June 1992, local voters approved a bond measure to raise taxes, one of the single largest measures ever proposed for a school district in California, with an overwhelming 71 percent approval rate. This measure provided $158 million to renovate and modernize the city's schools. In the nine years since voters approved the original tax measure, many of the schools are now seismically resistant and others are well along in the renovation process. In November 2000, voters approved another supplemental bond measure for the safety program totaling an additional $114 million. The additional bond measure funded cost increases, added renovations for existing schools and brought an additional school into the safety program.

While school buildings are a primary concern, and have an important role during and after disasters as mass care facilities, other buildings used by the District also have structural problems. The District has office space in Old City Hall, a potential collapse hazard building, and houses all of its maintenance supplies in an unreinforced masonry building at its corporate yard.

Lifeline Utilities and Transportation Systems

A large amount of infrastructure that is key to the functioning of the city is not owned by the city. The city does not have direct control over the vulnerability of these structures, but will be heavily impacted, including the City's emergency response efforts, if they fail. A list of some of these facilities appears below:

- Potable and fire water supply system consisting of mains, storage tanks and reservoirs owned by the East Bay Municipal Utilities District (EBMUD)

- Sanitary sewer transport main located east of and adjacent to Highway 80 owned by the EBMUD

- The electric distribution system, including substations, mains, laterals and meters, owned by the Pacific Gas and Electric Company (PG&E).

- Natural gas distribution system, including mains, laterals and meters, owned by PG&E

- 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), owned by the state Department of Transportation

- The BART system, consisting of four miles of underground rails and three stations, at Adeline/Ashby, Center Street, and North Berkeley, owned by the Bay Area Rapid Transit District.

- The Amtrak train tracks and University Avenue passenger stop

- Land line telephone distribution system owned by SBC that share poles with the PG&E in some locations and are located underground in other locations

- Cable systems that share poles with PG&E in some locations and are located underground in other locations

- Cellular telephone antennae owned by Verizon, Sprint PCS, Nextel, and other companies distributed throughout the city

- Aviation fuel and multi-product pipelines owned and operated by the Kinder Morgan Corporation, buried under the right-of-way of the Southern Pacific railroad tracks.

The vulnerability, and in some cases locations, of non-city-owned infrastructure is not known to the City. Figure 3-7 shows locations of infrastructure that are known to the City. Table 3-5 presents a summary of the known vulnerabilities and upgrade programs of key lifelines that serve Berkeley.

The electricity, telephone and cable communications systems are almost entirely above ground in Berkeley. 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 get damaged, as can equipment at substations and transmission lines, possibly leading to system wide loss of these utilities.

Underground systems are particularly prone to damage from ground failure in earthquakes and landslides. Underground damage is harder to detect and repair and the length of service losses may be greater than for above ground systems. Berkeley's underground utilities are water, sewer, communications conduits and natural gas lines. 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 will also severely impact these systems. Liquefied

areas may move laterally breaking underground natural gas, water, sanitary sewer and storm pipelines and cables, and damaging buildings, and infrastructure including road, curbs and sidewalks, power and communication lines. Liquefaction could compromise the function of the EBMUD's sewer trunk line adjacent to Interstate 80, and the highway roadbed. In the aftermath of a local earthquake on the Hayward fault, water for fighting fires and emergency access may be compromised and evacuation impeded.

Underground gas lines run throughout the city. Pipelines carrying aviation fuel run along the railroad right-of-way in the western part of the city through liquefaction susceptible soils. Rupture of these fuel lines could spark and feed a dangerous fire in the city that could coincide with a non-functional water system.

High-Potential Loss Facilities

There are two reservoirs with dams in or near the city, but neither poses a significant threat in the event of collapse. The Berryman reservoir, located in Berkeley along the Hayward fault, has been a known problem for many years and should be drained and decommissioned by the end of 2004. Should a major earthquake occur before this is drained, it could inundate a large swath of the city, bounded by Hopkins and Eunice streets to the north, and Cedar and Delaware streets to the south. The flow could extend clear to the Bay and inundate the low-lying areas near Aquatic Park. This reservoir holds about 11 million gallons of water, which represents about three-quarters of its actual capacity due to restrictions by regulators.

The 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. This is a major reservoir, holding 37 million gallons. In the unlikely event of collapse, this reservoir could inundate properties in Berkeley, but would more seriously impact neighboring communities, namely Albany, El Cerrito and Kensington.

Hazardous Materials

The City carefully tracks and regulates hazardous materials in both public and private structures through its Toxics Management Division. There are 302 sites in the city with hazardous materials[32]. The Fire Department, in charge of responding to toxics problems, knows all of these locations. Three of these sites contain large amounts of toxic gases, and the City requires significant structural measures to minimize the risk of release during an earthquake. One site is currently in compliance with City regulations and the other two are actively working to upgrade their storage arrangements. UC Berkeley and Lawrence Berkeley National Laboratory, which both rely on the Berkeley Fire Department, provide lists of their hazardous materials to the City but the City has no authority to regulate how these materials are stored.

Privately Owned and Other Structures

Housing

Berkeley has about 46,900 housing units, serving the city's population of 103,000. Nearly half of these units were built before 1940, and only 5 percent were built after 1980[33]. This means 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.

There are four general categories of housing in Berkeley that are particularly vulnerable to earthquake shaking. The first category is older, wood framed single-family houses and small multi-unit buildings constructed like houses with a crawl space under the first floor. The second category is houses located on steep, hillside lots. The third, and extremely vulnerable, category is multi-unit apartments with an open or "soft" first story. Fourth, 19 unreinforced masonry (URM) buildings serve as multi-family dwellings, with a total of 220 housing units (this type of structure is discussed more fully below). In addition, houses of any style can have brick chimneys that are very vulnerable to collapse and can cause fatalities.

Houses constructed with a crawl space below the first floor can have several weaknesses. 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. Through a variety of city incentive programs more than 60 percent of single-family homes have been strengthened to various degrees. Some of these upgrades, however, are nonstructural. Figure 3-8 shows the locations of these upgraded homes, which are distributed over all residential neighborhoods.

About 10 percent (4,950 units) of Berkeley's housing units, occupied by more than 10,000 people, are located in soft-story apartment buildings or open front stores[34]. Soft-story buildings are often multi-family structures with openings for parking at the ground floor. These openings result in a far less sturdy wall in the ground story level than in the stories above and, 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 low-income housing units are located in this type of structure. An Association of Bay Area Governments study in 1996 estimated that nearly 60 percent of affected multifamily residences would be uninhabitable after a large earthquake on the Hayward fault, whereas less than 2 percent of single-family homes would be similarly damaged. 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[35]. City officials believe that very few of these soft-story buildings

have been structurally strengthened. Figure 3-9 shows the locations of soft-story structures.

Commercial and Industrial Structures

In 1994, Berkeley identified about 700 URM structures, used for both commercial and residential purposes. This is another type of structure that is very vulnerable to earthquake forces and can collapse. In response to a state law, the City instituted an Unreinforced Masonry Safety program consisting of identifying such buildings and mandatory retrofit deadlines based on a building's designated risk category. Since the program's original inception in 1991, owners have improved seismic resistance in over 600 of the 700 identified buildings (89 buildings remain on the list of buildings requiring upgrades at the time of writing). Although this program has brought substantial increases in safety, even upgraded URM buildings are still vulnerable to extensive damage in earthquakes. Figure 3-9 shows the locations of both retrofit and yet-to-be retrofit URM structures.

Another type of building called "tilt-up" concrete construction, used primarily for industrial and commercial buildings, is vulnerable to collapse in earthquakes. This type of building has connections between its roof and exterior walls that can fail in earthquake shaking. When the connections fail, the roof is left unsupported and can collapse. 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. Figure 3-9 shows the locations of tilt-up concrete buildings.

UC Berkeley Campus

UC Berkeley is a major institution separate from the City but located at its core. 32,000 students, 2,500 faculty and over 11,000 staff work or study on campus[36]. Beginning in the early-1970's, the university began earthquake vulnerability studies and retrofit projects, championed by senior university officials. More recently, 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 over 27 percent of the building space could perform poorly in a major local or regional earthquake[37]. These findings led to SAFER effectively becoming a physical renewal plan for UC Berkeley's built environment. Currently, the campus is implementing a $1.2 billion reconstruction program. All told, some seventeen UC Berkeley buildings will be in some stage of retrofit within the next three years. But the program is even more than its capital projects: planners and executive staff devoted attention to a wide-range of disaster preparedness efforts, as well, which range from emergency preparedness to facilities and lifeline planning, along with a robust financing strategy[38].

The City and the University have independent disaster planning programs. However, their risks are inextricably intertwined. Sixty-one (61%) percent of UC Berkeley students,

and 25 percent of its faculty and staff live in the city[39]. All of them rely on the city's private industries, housing and infrastructure. The condition of the city after a disaster directly impacts the ability of the University students, faculty and staff to continue their work. Likewise, the City thrives 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 City maintaining its 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 needed capacity of the City's emergency responders. It is in the mutual interest of both the City and the University to coordinate disaster planning and preparedness efforts.

Lawrence Berkeley National Laboratory

The Ernest Orlando Lawrence Berkeley National Laboratory (LBNL), is a Department of Energy National Laboratory operated through contract by the University of California. Although associated with the UC Berkeley campus through staff and students, is a separate institution in terms of facilities management. The Lab campus is located in both Berkeley and Oakland. Minor amounts of hazardous and radioactive materials are in used in Lab research activities.

The Lab is proactive about disaster risk mitigation. Each year, LBNL prepares an integrated report on its environmental programs to satisfy the requirements of United States Department of Energy Order 231.1. The Site Environmental Report for 2002 summarizes Berkeley Lab's compliance with environmental standards and requirements, characterizes environmental management efforts through surveillance and monitoring activities, and highlights significant programs and efforts for calendar year 2002[40].

LBNL has an in-house, on-going program to review the seismic performance of its buildings. Several buildings have been strengthened in the last decade due to the findings of these studies. Non-structural mitigation safety measures are part of the Lab's policies and procedures manual, and are inspected annually. In addition, LBNL maintains backups to offsite utility services with generators and reserve water tanks.

Alameda County Fire Department, Station 19, is located on the LBNL site. There is an automatic aid agreement between LBNL and the City of Berkeley. Both agencies are signatory to the Alameda County Fire Mutual Aid agreement. The LBNL fire department is a key part of the City's hazardous materials response team. LBNL has an active drill and exercise program, and conducted three major exercises in the past year.

As of October 2003 there were about 4000 people assigned to the Lab, a combination of career employees and guests. Of those, 1,707 live in the City of Berkeley, and 495 are students (graduate research or student assistants). One of the projects the Lab is preparing is a business continuity plan, expected to be completed in 2004, with the goal of resuming functionality of the Lab and its employees as soon as possible after a major disaster[41].

Vista Community College of the Peralta District

Vista Community College in downtown Berkeley is constructing a new building on Center Street to serve as its permanent home. For nearly thirty years, the community college has used classrooms and offices in various Berkeley locations. The new building, funded by two local bond measures, will be a state-of-the-art facility meeting the latest seismic and fire safety codes. The building will have an emergency operations center in the library and will be connected to the Alameda County Sheriff and the Peralta Community College district headquarters through short-wave radio. Completion is expected in 2005.

Large Corporations

Table 3-3 lists the ten largest employers in the City of Berkeley.

The Bayer Corporation's headquarters for biotechnology is located in Berkeley and employs about 1500 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[42]. Two older buildings used by the company have been structurally strengthened, and there are plans to demolish and replace two others. New buildings have been designed to exceed code requirements. In particular, one building that houses a large ammonia refrigerator unit has been designed to standards exceeding current codes and has been studied to ensure that ammonia would not leak during a major earthquake. Bayer has also trained its own emergency response team, which conducts frequent drills with the Berkeley Fire Department.

The disaster preparedness and emergency response programs of other major companies in the city are not known.

Risk and Loss Estimates

No one knows what the characteristics of the next damaging quake to strike Berkeley will be. It could happen on any of the regional faults, be deep or shallow underground, and shake for a few seconds or up to nearly a minute. The amount of shaking and consequent damages will vary greatly depending on these characteristics.

However, it is possible to estimate the consequences of earthquakes that could strike the city using the Hazards US (HAZUS) software developed for FEMA for this purpose. One approach using HAZUS, often called a scenario, is to assume an earthquake of a selected magnitude, with an epicenter location, rupture mechanism and time of day and use this hypothetical earthquake to estimate losses. These losses, while sure to differ from the actual damage in the next earthquake to strike the City, provide reasonable numbers to help the City plan its mitigation and emergency preparedness activities. For this Plan, an M 6.9 scenario earthquake on the Hayward Fault underneath Berkeley was simulated using HAZUS[43]. The shaking that would be produced by a similar scenario earthquake is shown in figure 3-10.

In this scenario, 620 buildings will be completely destroyed. 21,000 more have slight to moderate damage, primarily residential structures. Much of the damage to residential structures will occur in low-income and student housing. These populations disproportionately live in soft-story multi-unit apartment buildings, older buildings with weak foundations, and other vulnerable types of structures.

From 3,000 to 12,000 households will be displaced from their homes after the quake. This represents up to a quarter of households in the city. 1,000 to 4,000 of those households will seek temporary shelter provided by the City and the Red Cross. The remainder might stay with friends, relatives or in hotels.

One hundred people in Berkeley could be killed by this earthquake. Fifty more will be in critical condition requiring urgent medical care. 300 additional people will need hospitalization and 1,000 people will require first aid.

Fires could ignite in about five different locations around the city. About 200 more families will be forced to leave their homes due to fire damage. Emergency personnel will be stretched thin fighting these fires and may need to use a temporary, above-ground water supply system to pump water from the bay. Fire could burn for hours or, in a worse case situation, up to a few days.

Over $1.5 billion of buildings could be heavily damaged. Additional losses to income will likely occur due to business closures, estimated at $215 million. Post-earthquake fires may add about $20 million of damage to structures. These figures represent losses only within the City of Berkeley.

Following the earthquake, the City will need to remove and dispose of up to 570 tons of debris. This process can take months and finding landfill space and available equipment can be difficult.

By combining the HAZUS loss estimates with damage scenarios prepared by other groups, a broader picture of the impact to Berkeley emerges. Immediately following the earthquake, 29,000 homes, more than 60% of Berkeley households, will be without electricity. Power and telephone services, including mobile phone and internet, could be down from days to a week. 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. Water outages could last up to 50 days, with residents needing to purchase bottled water or collect water from tanker trucks at central locations.

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 apartments and low-income housing may choose to build condominiums or other higher profit housing to replace the damaged structures. Many residents will be dismayed when they discover they are underinsured for earthquake and fire damage.

In the longer term, the way of life in Berkeley could be profoundly affected by an earthquake. Rebuilt homes, meeting modern codes and style considerations, will change the look of the city. There is likely to be a major demographic change in the city with the

probable destruction of many low-income residences. Berkeley could become a wealthier, more elite, and less diverse city.

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 major calamity, such as significant loss of life in an older dormitory or classroom building, declines in enrollment will be severe. Remaining students, now about 30% of the city 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.

BART could be damaged in neighboring cities on all sides, shutting off this method of transportation to San Francisco, Oakland and other destinations. Roadways and bridges may be functional, with damage in select locations. However, the Bay Bridge is vulnerable to damage until the retrofit and reconstruction activities currently underway are completed, now estimated for 2007[44]. Additional ferries and bus lines will probably be established within a week to provide substitutes for BART.

BART connections to east bay locations are likely to be out of service for more than a month. The BART Transbay Tube could be closed for over two years, cutting a key commuting link. This will cause inconvenience to many Berkeley residents and may change employment patterns. Temporary transport options, such as buses, ferries 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 a minimum of a couple years following the earthquake.

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.

Figure 3-1. Regional faults and their location with respect to Berkeley.

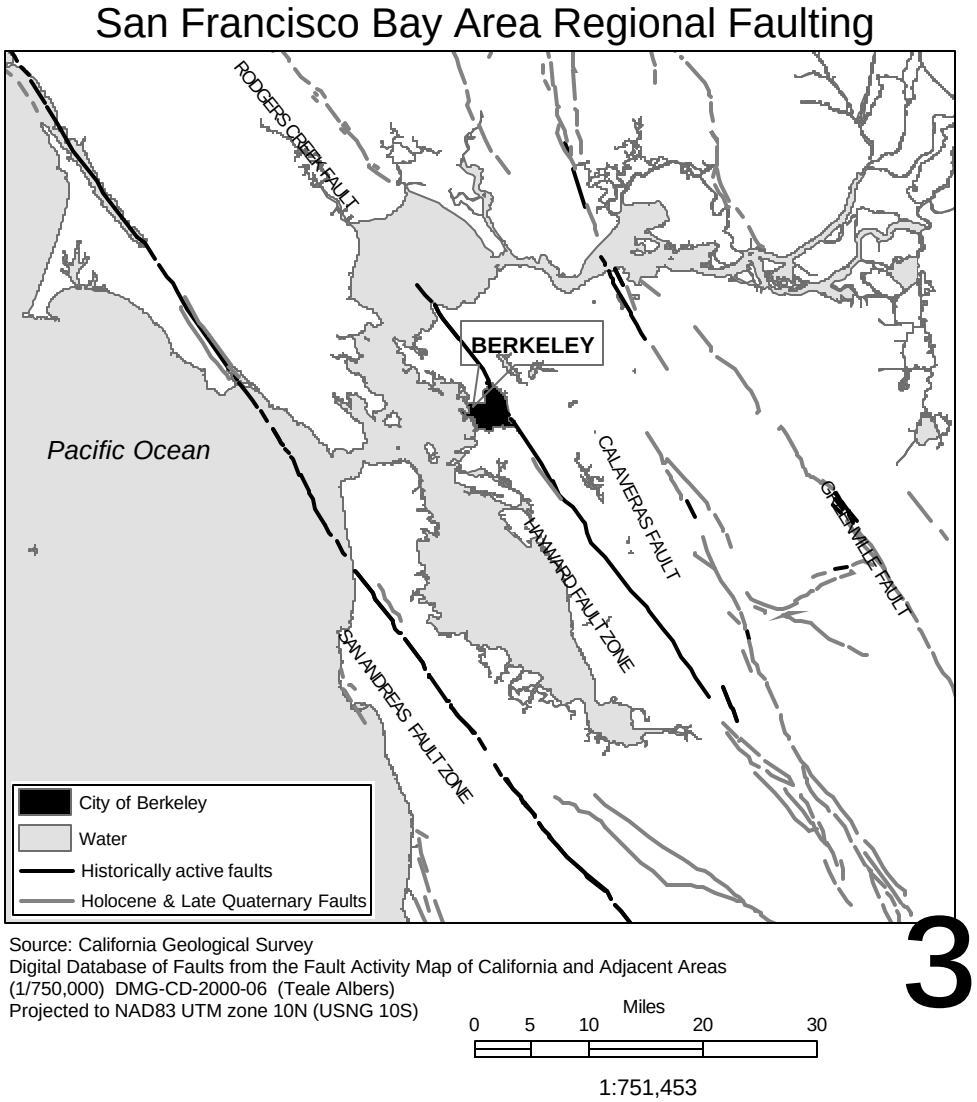
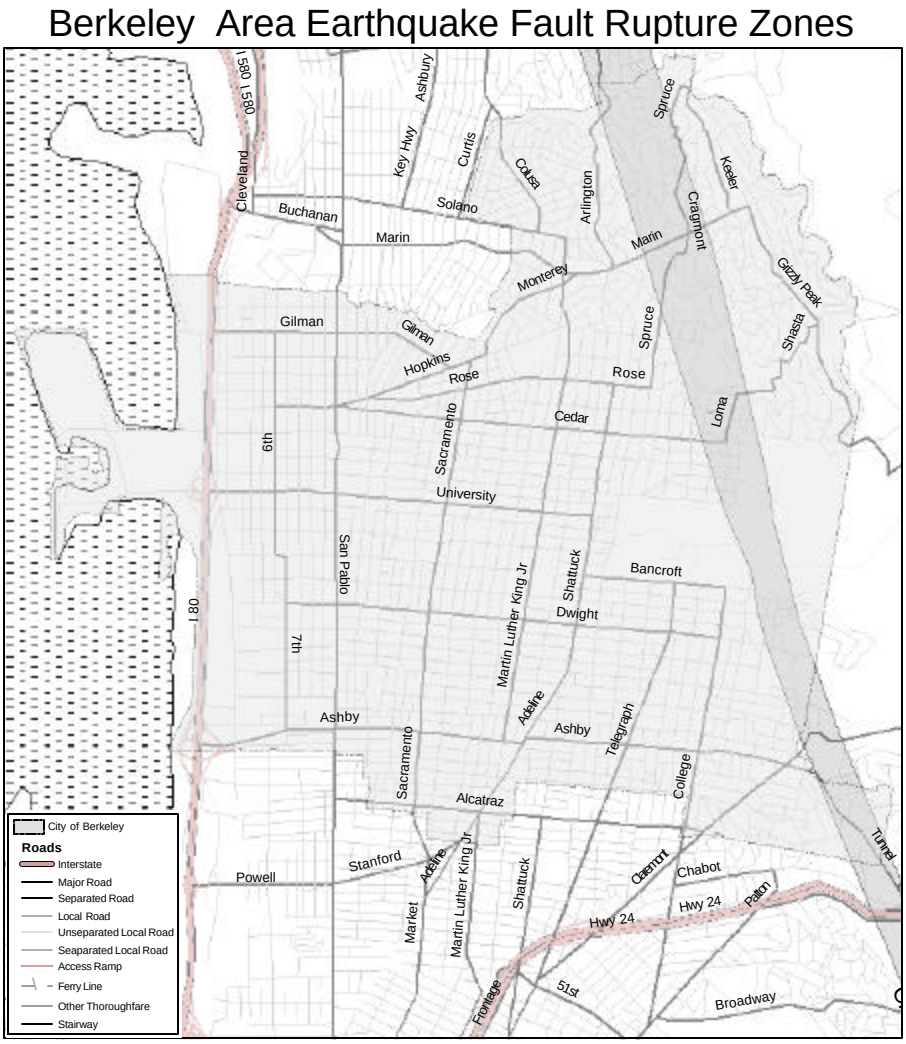


Figure 3-2 Fault rupture zones in Berkeley.



Source: California Geological Survey Seismic Hazard Zone digital map files (1/24,000) http://gmw.consrv.ca.gov/shmp/
Projected to NAD83 UTM zone 10N (USNG 10SEG)

3

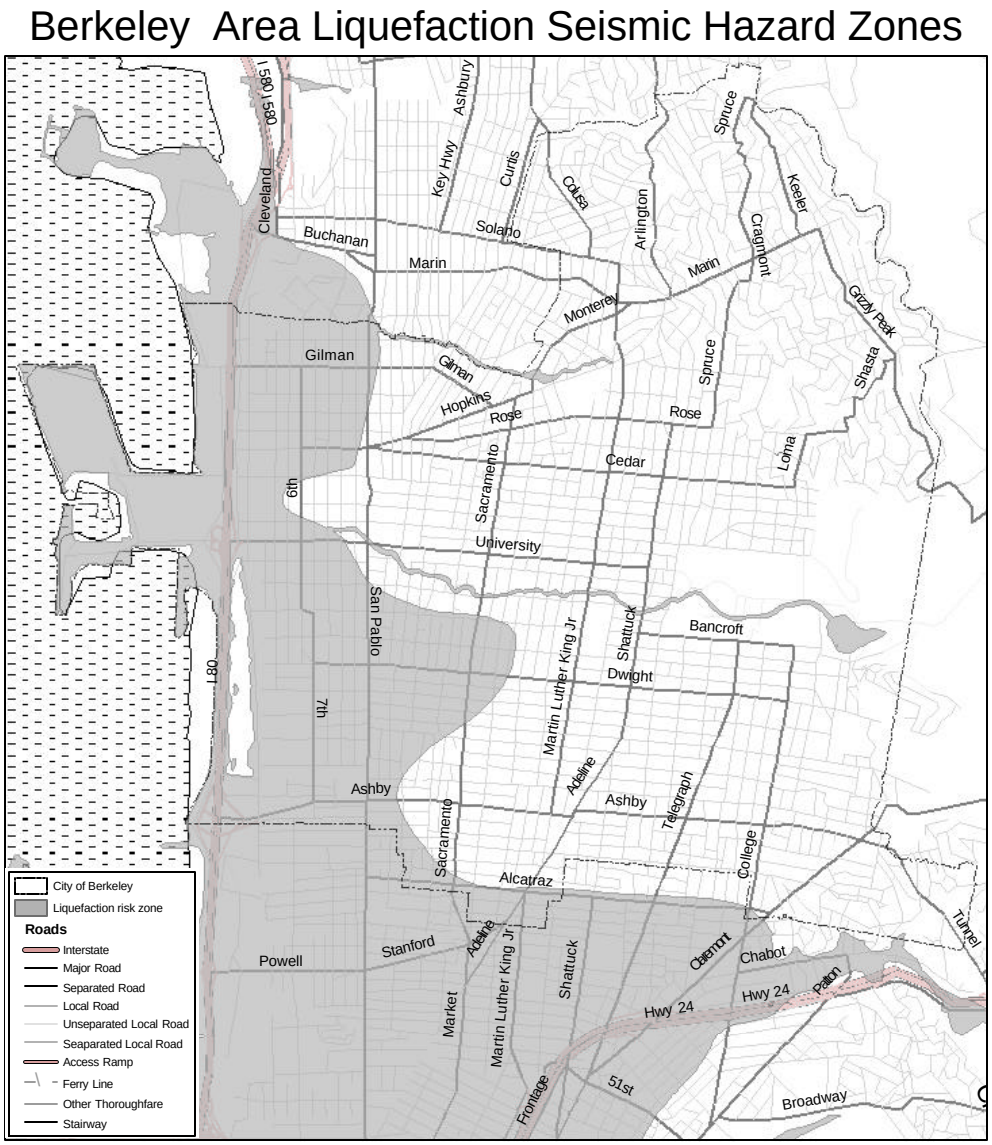
0 0.5 1 Miles

1:40,000

1 inch equals 0.63 miles

02_berkeley_EFZ.mxd of 20040128 bbq@ci.berkeley.ca.us

Figure 3-3. Liquefaction zones in Berkeley.



Source: California Geological Survey Seismic Hazard Zone digital map files (1/24,000) http://gmw.consrv.ca.gov/shmp/
Projected to NAD83 UTM zone 10N (USNG 10SEG)

3

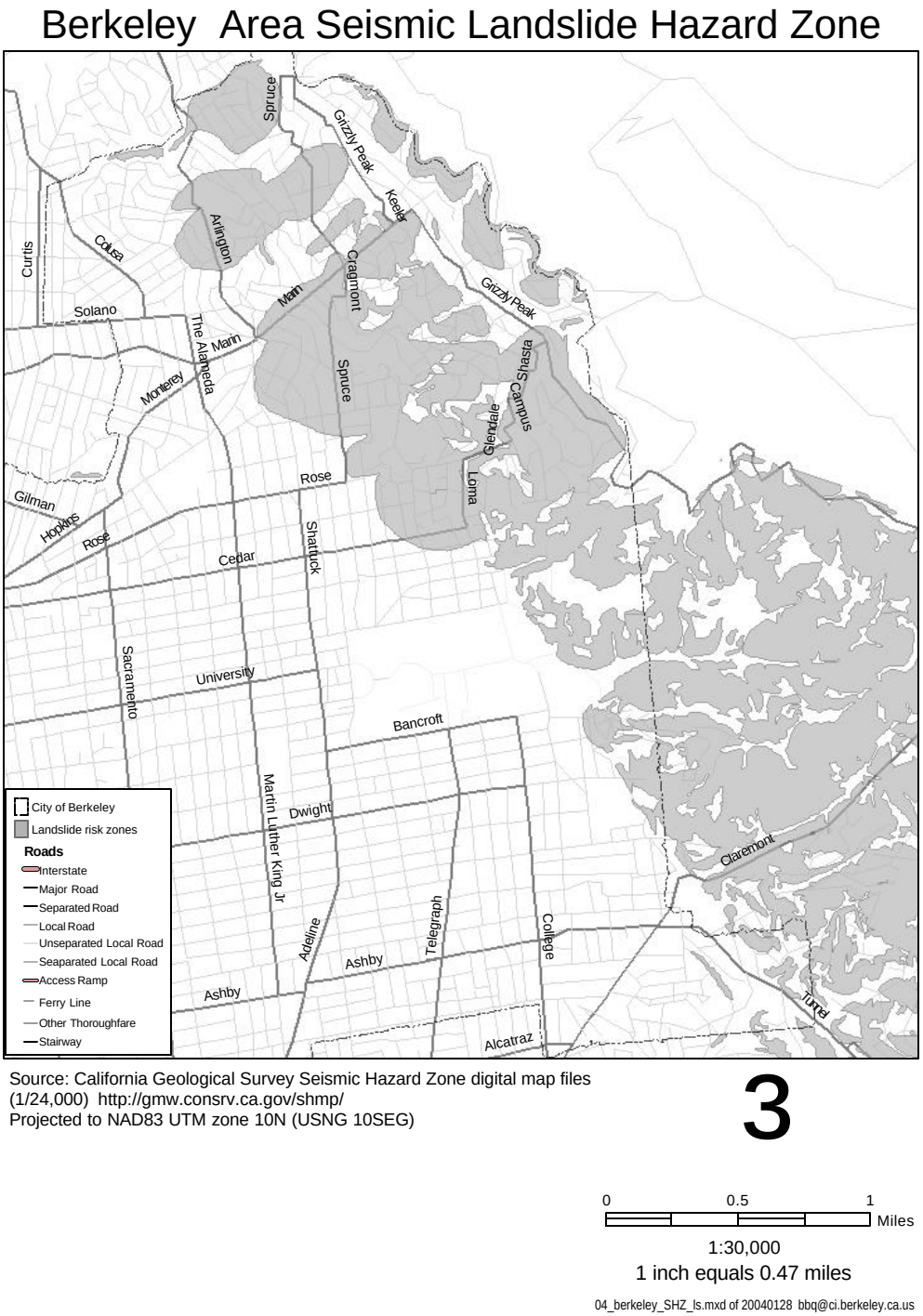
0 0.5 1 Miles

1:40,000

1 inch equals 0.63 miles

03_berkeley_SHZ_lq.mxd of 20040128 bbq@ci.berkeley.ca.us

Figure 3-4. Seismically induced landslide zones in Berkeley.



Source: California Geological Survey Seismic Hazard Zone digital map files (1/24,000) http://gmw.consrv.ca.gov/shmp/
Projected to NAD83 UTM zone 10N (USNG 10SEG)

3

Figure 3-5. Critical facilities and City owned buildings used for emergency response.

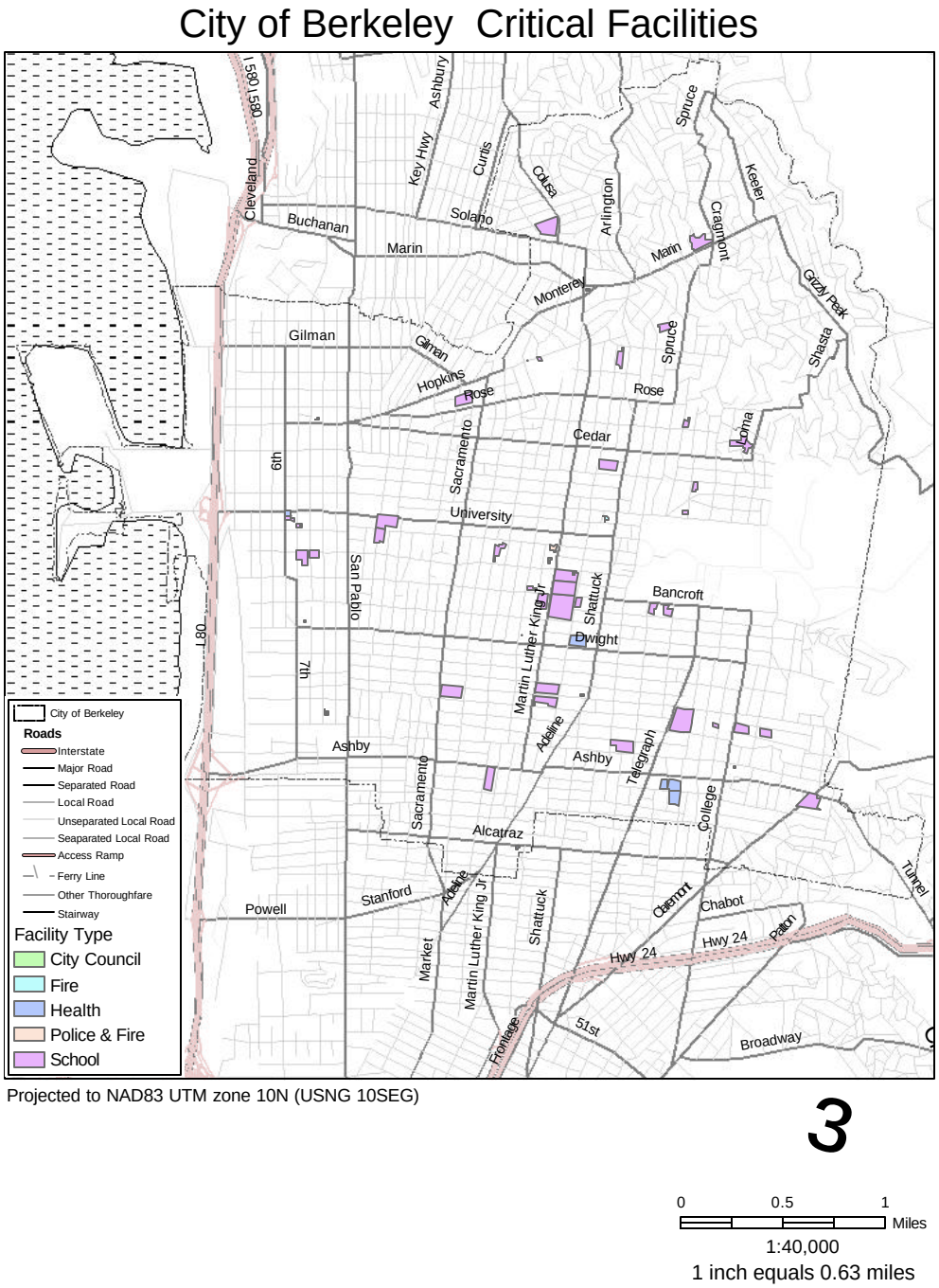


Figure 3-6. Locations of schools and hospitals.

Projected to NAD83 UTM zone 10N (USNG 10SEG)

3

0 0.5 1 Miles

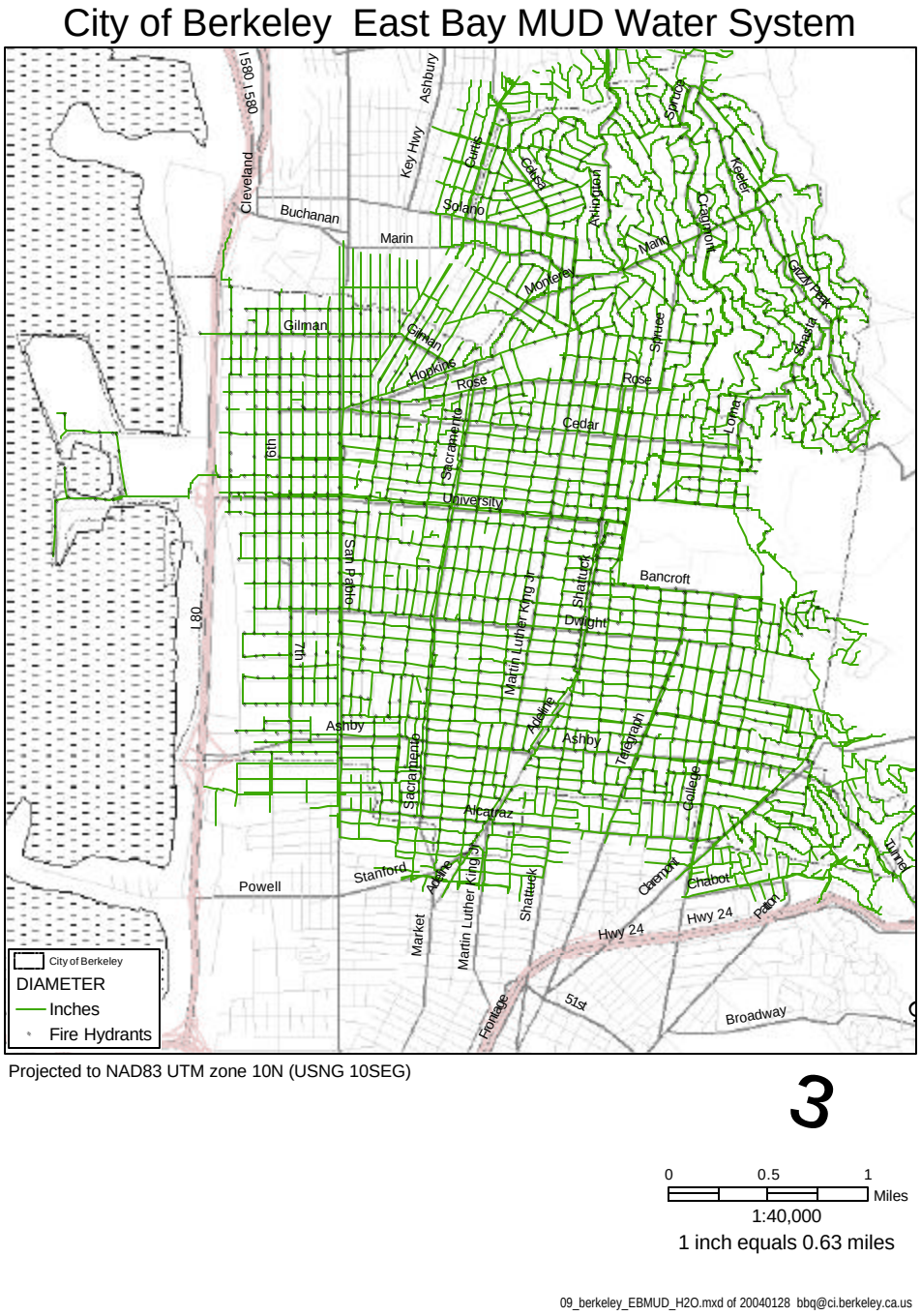
1:40,000

1 inch equals 0.63 miles

08_berkeley_Schools_Hosp.mxd of 20040128 bbq@ci.berkeley.ca.us

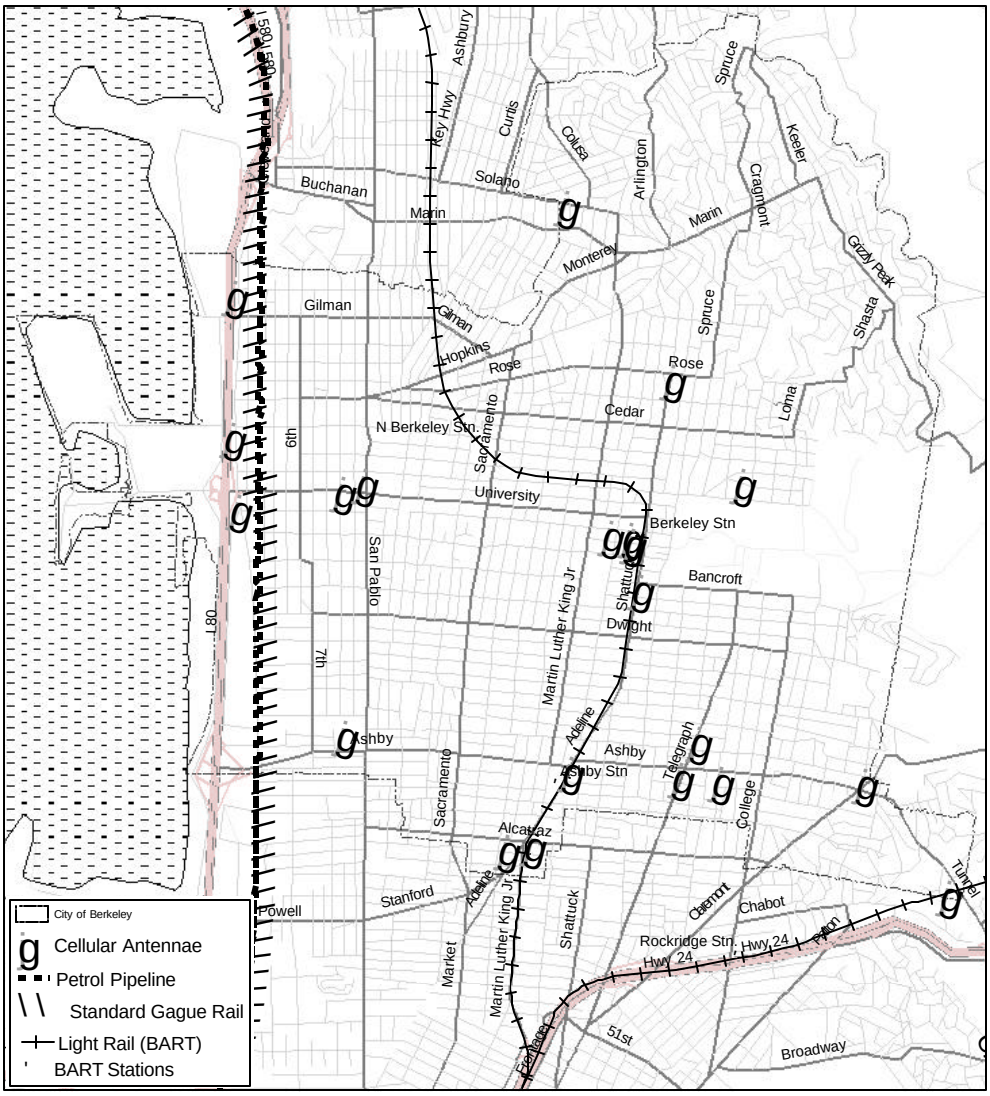
Figure 3-7 a and b. Known locations of utility and transportation systems not owned by the City.

a. Locations of EBMUD infrastructure.



b. Known locations of other utilities and transportation systems not owned by the City.

City of Berkeley Area Infrastructure



Projected to NAD83 UTM zone 10N (USNG 10SEG)

3

0 0.5 1 Miles

1:40,000

1 inch equals 0.63 miles

10_berkeley_Infrastruct.mxd of 20040128 bbq@ci.berkeley.ca.us

Figure 3-8. Seismically strengthened single-family homes

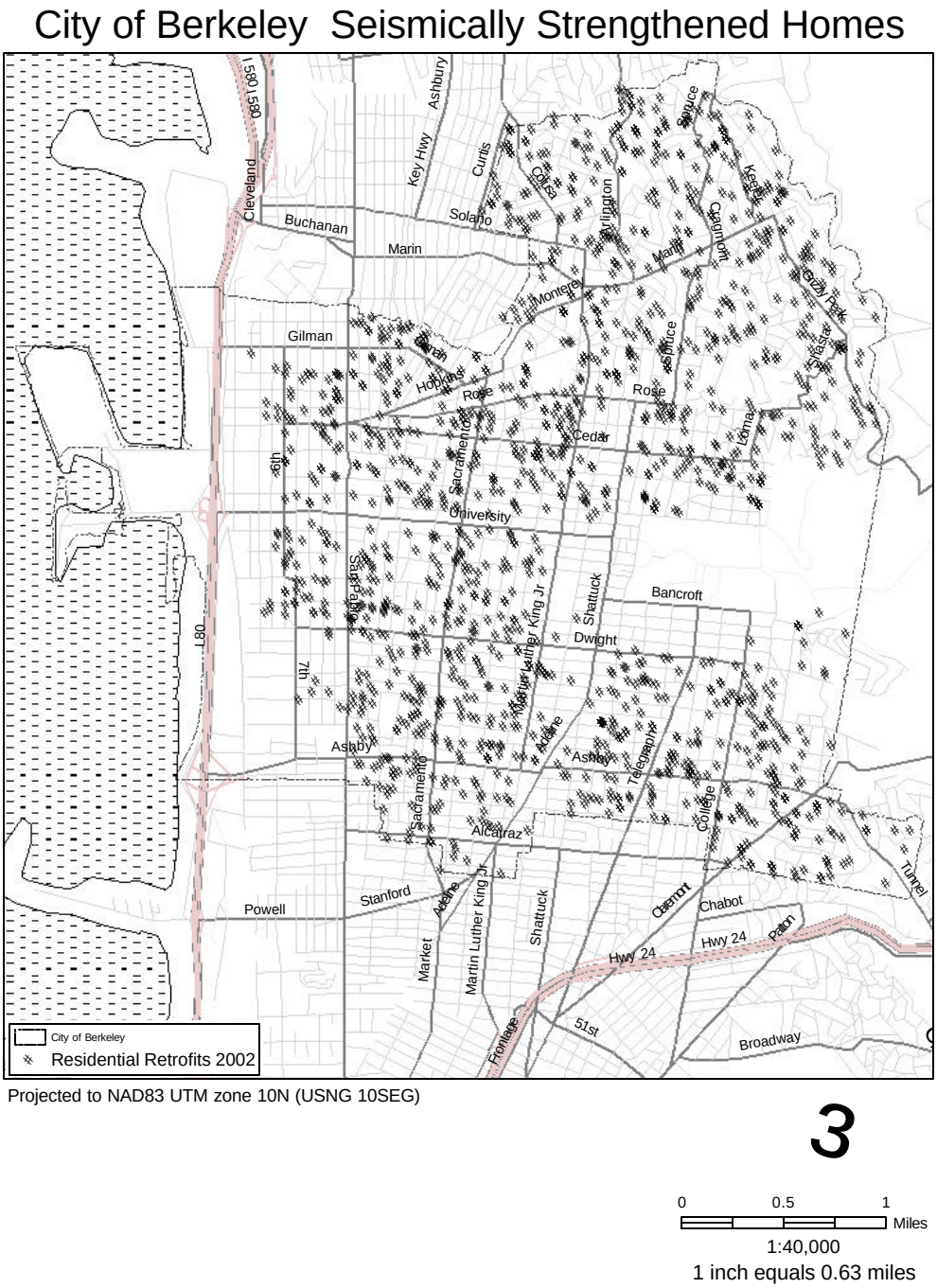
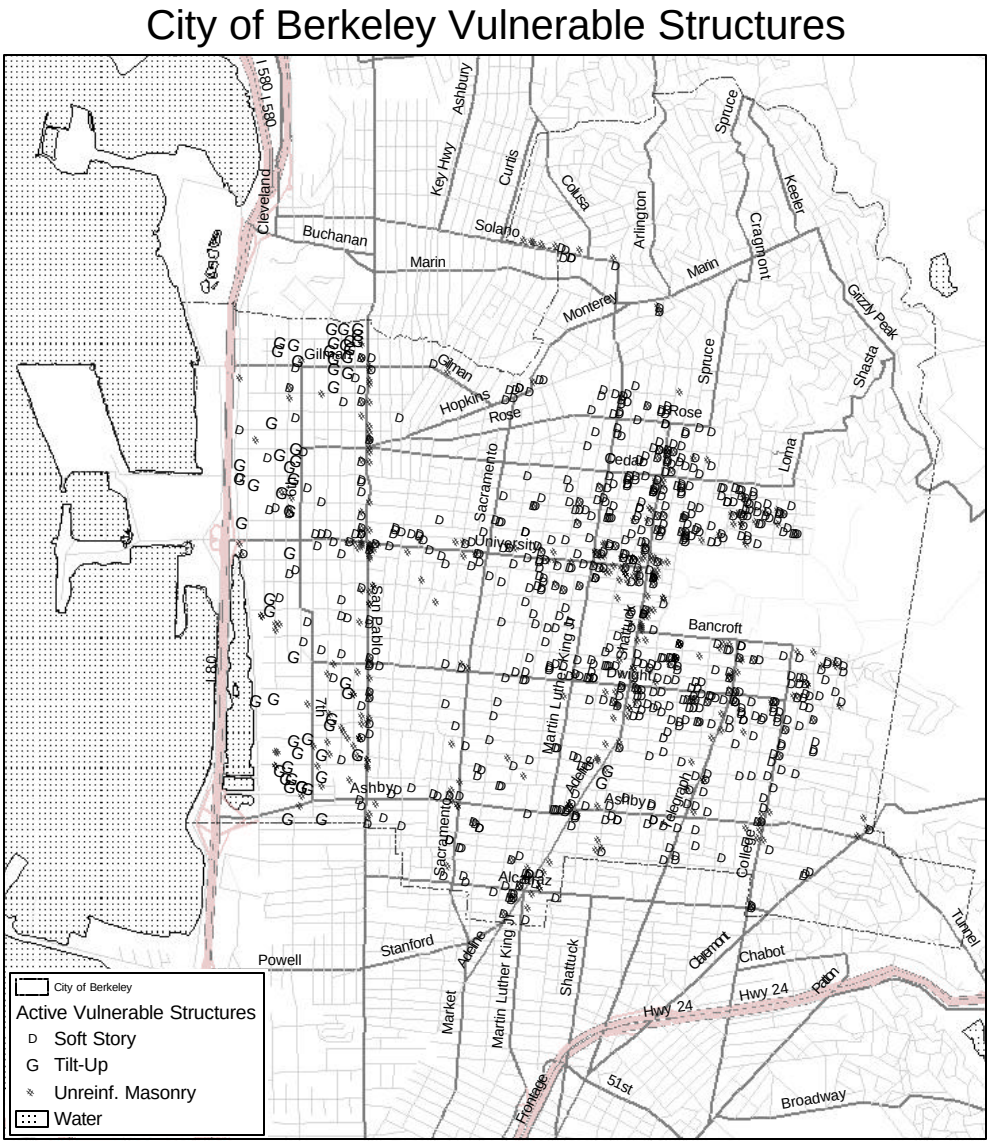


Figure 3-9. Soft-story structures, strengthened and unstrengthened URM buildings, and tilt-up buildings.



Projected to NAD83 UTM zone 10N (USNG 10SEG)

3

0 0.5 1 Miles

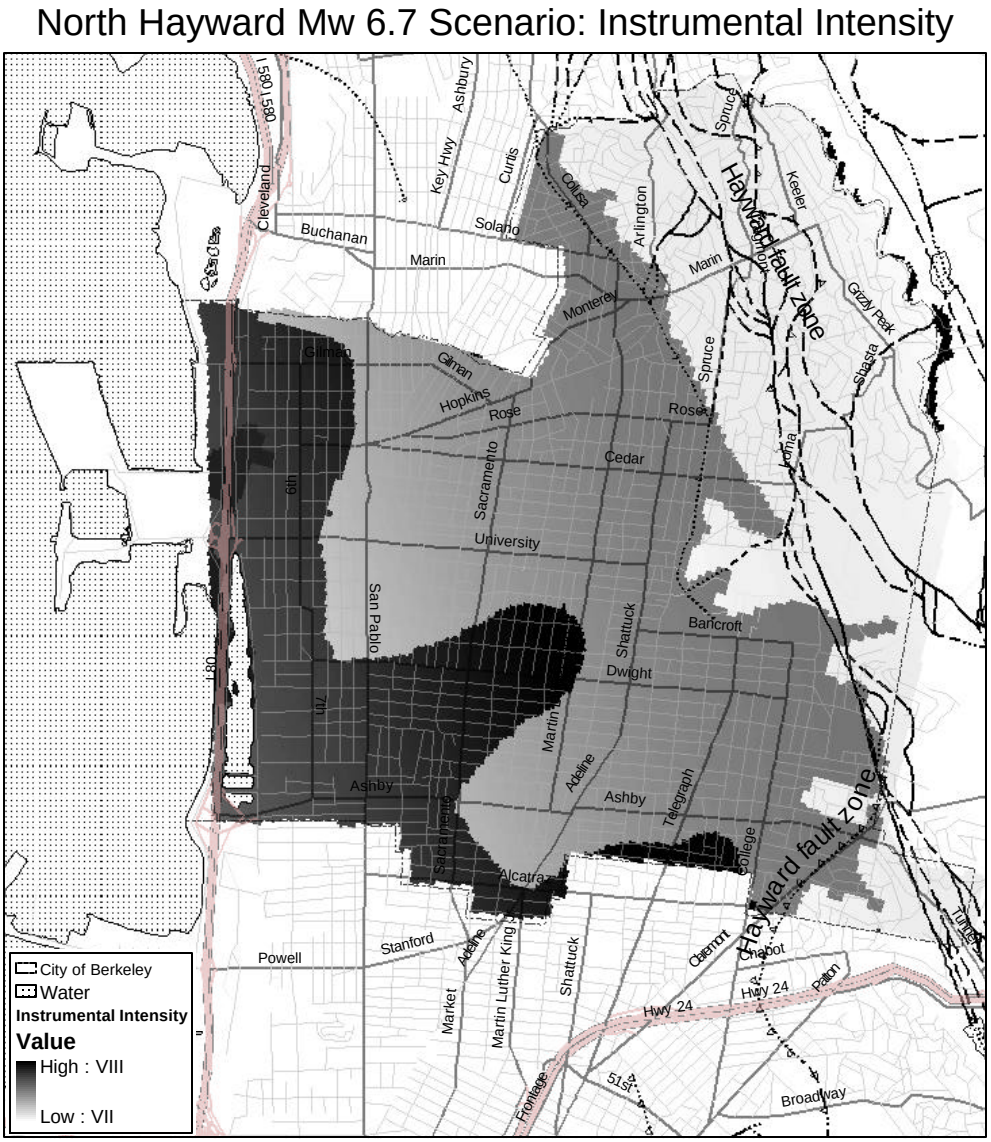
1:40,034

1 inch equals 0.63 miles

12_berkeley_ActiveVulnStruct.mxd of 20040304 bbq@ci.berkeley.ca.us

Figure 3-10 Modified Mercalli Intensity for M 6.7 Scenario Earthquake on the Hayward Fault.

Note: MMI VIII represents shaking that makes it difficult to stand, collapses poorly built structures and damages ordinary structures. MMI VII represents shaking that significantly damages poorly built structures.



Instrumental Mercalli Index for north Hayward Fault Mw 6.7 scenario Peak Ground Acceleration
HAZUS99 SR2 controlled with Vs30 and liquefaction susceptibility data from USGS
Open File Report OFR 02-296 Vs30 categories correlated to Pleistocene features
Seismic landslide hazard input from USGS MF-2378
Ground Motion estimated on 20-meter grid interval
Projected to NAD83 UTM zone 10N (USNG 10SEG)

3

0 0.5 1 Miles

1:40,000

1 inch equals 0.63 miles

21g2_berkeley_scenario_IMI.mxd of 20040302 bbq@ci.berkeley.ca.us

Table 3-2. City buildings that should be given priority for seismic evaluation

Building Name	***Address***	***Use***	**Emergency Response Importance**	**Recovery Importance**
Key Civic Buildings				
Newly Acquired City Office Building	1947 Center St.	Cap.Projects/Pb.Wrk.Eng.	High	High
Public Health Buildings				
Health Clinic	830 University Ave.	Health Clinic		
Mental Health Offices	2636-40 MLK Way	Mental Health Offices		
Health and Human Services Office	2344 6th St.	HHS Offices		
Fire Stations				
Fire Station #7	2931 Shasta Road		High	
Senior Citizen Centers				
North Berkeley Senor Citizens Center	1901 Hearst St.	Public assembly	High – Possible Shelter	
South Berkeley Senior Citizens Center	2939 Ellis St.	Public assembly	High – Possible Shelter	
West Berkeley Senior Citizens Center	1900 6th Street (1904?)	Public assembly	High – Possible Shelter	
Recreation and Parks				
Francis Albrier Center	2800 Park St.	Recreation and Assembly	High – Possible Shelter	
James Kenney Community Center	1720 8th St.	Recreation/Assembly	High – Possible Shelter	
Grove Recreation Center	1730 Oregon St.	Recreation/Assembly	High – Possible Shelter	
Ala Costa Center	1300 Rose St.	Recreation/Assembly/Child Care	High – Possible Shelter	
Cedar Rose Park Building		Center for disabled children		
Marina (other than leased locations)				
Administration Building	201 University Ave.	Offices		
Buildings Leased To Others (LESSOR)				
Black Repertory Theater	3201 Adeline St.	Assembly		
Locations leased by the City (LESSEE)				
Police substation. BPD traffic control	3140 MLK Jr. Way	Offices		

Table 3-3. Largest ten employers in Berkeley

Employer	**Number of Employees**
University of California, Berkeley	14,135
Lawrence Berkeley National Labs	4,300
Alta Bates Medical Center	2,242
City of Berkeley	1,620
Bayer Corporation	1,554
Kaiser Permanente Medical Group	1292
Berkeley Unified School District	1,200
YMCA	501
California Department of Health Services	500
Pacific Steel Casting Company	347

Table 3-4. City owned infrastructure in hazard zones.

Infrastructure Element	Total Length	Length in Hazard Areas				
		High Landslide risk	Fault Zone	Liquefaction High	Liquefaction Medium	Liquefaction low
Curbs	570 km	54 km	67 km	14 km	69 km	492 km
Streets	401 km	73 km	44 km	32 km	65 km	332 km
Storm Drains	135 km	17 km	11 km	13 km	18 km	107 km
Water Lines (EBMUD)	504 km	74 km	60 km	10 km	47 km	380 km
Hydrants	1645	226	143	44	184	1401

Liquefaction Zones identified in USGS maps
Landslide Zones identified in USGS Miscellaneous File Report 2378 (Keefer and Miles)
Fault zone delineated in the Alquist-Priolo Earthquake Fault Zone

Table 3-5. Vulnerabilities and Upgrade Programs of Key Lifelines Serving Berkeley.

East Bay Municipal Utilities District (EBMUD)[45]
The East Bay Municipal Utilities District (EBMUD) provides water to approximately 1.3 million people and sewer services to 640,000 in the east bay. After an earthquake, EMBUD is concerned not only about providing water and sewer services to customers, but also needs to provide water for post-earthquake fire suppression efforts. EBMUD has been operating since 1923, and the age and extent of its system makes it particularly vulnerable to damage in earthquakes. Much of the water for the East Bay comes through the Claremont tunnel, which transports about 150 million gallons of water per day. This water is stored in two Berkeley reservoirs – Berryman and Summit – and various tanks, and is distributed to customers through underground pipelines. EBMUD has studied the impacts of earthquake shaking, liquefaction, landslides and fault rupture on most of its infrastructure. The Claremont tunnel crosses the Hayward fault 130 feet below Tunnel Road in Berkeley and it could experience severe displacement and blockage in a magnitude 7 earthquake on the Hayward fault[46]. The major reservoirs in Berkeley could empty within twelve hours. Seventy percent of customers could experience water loss, with downtown Berkeley particularly vulnerable due to weak underground pipelines. Restoration of basic services to most customers could take 20 to 50 days, depending on the severity of the earthquake. EBMUD crews should be working to repair the system within twelve hours of an event. Full service may not be restored for over six months. Recognizing their vulnerability, EBMUD has taken aggressive steps to strengthen their system and reduce their dependence on the Claremont tunnel. In 1994, EBMUD allocated nearly $200 million for seismic upgrades. The Claremont Tunnel is being strengthened. In addition, an effort to construct a bypass tunnel where the Claremont Tunnel intersects the fault is now underway. Steps to reduce dependence of the Claremont tunnel also include drilling ground wells, purchasing flexible joints and hoses to temporarily reroute water flows, anchoring local water storage reservoirs, and upgrading pumping plants. EBMUD has worked with PG&E to strengthen portions of the electricity grid critical to the water supply. It has also partnered with the Berkeley Fire Department to estimate water flows required to fight post-earthquake fires and develop alternate water sources for firefighting should main supplied be unavailable. No comprehensive programs have addressed risks to underground pipelines. Measure H, an additional source of funding for upgrading EBMUD's system, has made no progress in seismic safety due to disputes with residents.
Pacific Gas and Electric Company (PG&E)[47]
Pacific Gas and Electric (PG&E) provides electricity and natural gas to 13 million people in northern and central California. They have a staff of 18,000 prepared to respond to return electrical service after disasters, primarily storms. They also have a well-established priority system for resuming power to emergency services before less essential 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 support fire if ignited until the fuel supply is exhausted. The repair of damaged underground lines takes time. Following the Loma Prieta earthquake it took about 30 days to repair damaged lines in the San Francisco Marina.

Bay Area Rapid Transit District (BART)[48]

The Bay Area Rapid Transit District (BART) provides a well-used public transportation link between Berkeley, San Francisco, and other Bay Area locations to 300,000 riders daily. In the 1960's, 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 at low risk by BART engineers. BART is concerned about aerial structures in other cities and the Transbay Tube, the tunnel from San Francisco to Oakland. The Transbay Tube could experience significant liquefaction problems and gaps could open in the tube joints. Aerial structures could experience foundation damage. Lines from Richmond to Fremont could be out of service for one month. The Transbay tube would be unusable for two years. Damaged aerial structures would require 18 months to repair. The tunnel between Oakland and Orinda could have limited service for nine months. Many parking structures will be unusable.

BART spent one and a half years studying its earthquake vulnerability, analyzing multiple earthquakes, predicting damage, and assessing cost-effectiveness of retrofits. A bond measure to address these concerns was presented to and defeated by voters in 2002 because it failed to receive the supermajority needed in all counties served by BART. BART plans to begin the critical upgrades on the Transbay Tube in 2004 with borrowed money from Caltrans[49]. Another bond measure will be placed before voters in 2004. No retrofit work has been done on the system so far, but BART is equipped with alarms that trigger all trains to stop at 0.1g ground shaking.

CalTrans[50]

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, and 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 structure abutting the University Ave. overpass to the same high standards. CalTrans emergency response teams are trained to inspect their facilities and manage some elements of traffic flow after a major earthquake.

SBC Communications[51]

SBC Communications provides and maintains telephone service to Berkeley residents, along with internet access, mobile telephone service (it is the major owner of Cingular Wireless), 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 SBC 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. SBC 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 replicate its functions. SBC is prepared to set up additional phone lines open to the public at a central location if major service losses occur.
Kinder Morgan Corporation[52]
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 1960's, although a few segments were installed in the 1950's. The company has not conducted a study of the impacts of an earthquake on the Hayward Fault, or any other earthquake, nor have they studied risks to the pipeline from liquefaction. This type of pipeline, however, is known to have performed well, due to its ductile nature, in earthquake elsewhere in the world. Kinder Morgan has focused on developing good procedures to respond immediately after a disaster to shut down the pipeline. The pipeline has remote control valves and other manual valves and, after a decision has been made, the flow can be shut down within a couple of minutes. After 1989 Loma Prieta earthquake, these pipelines were shutdown and carefully monitored for leaks, breaks and changes in pressure. No damage was found.

3.2. Wildfire

Historical Wildfires

Berkeley has significant wildfire history, most recently in 1991. The October 20, 1991 East Bay "Tunnel Fire" in the Oakland/Berkeley hills was declared the most destructive urban/wildland fire in United States history. The fire, which had started the day before as a grass fire in the drought-dried hills east of Oakland, was re-ignited and whipped into conflagration 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 homes were destroyed in Berkeley. Ten thousand people were evacuated from the hills areas. Of the 25 people killed in the blaze, most were trying to evacuate when they were killed. 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[53].

The day of the fire, the Bay Area experienced high temperatures, 80-90 degrees, and unusual hot, dry winds blowing from the east, rather than the normal, moisture-laden western winds from the ocean. This type of wind, referred as Foehn or Diablo winds, occurs only eight to ten days per year, primarily but not exclusively in August, September and October. The resulting high temperature, low humidity, gusting northeast wind and built-up dry fuel load created "critical fire weather". The fire fighters were helped when on the second day, the winds shifted to the west and cooler temperatures and fog rolled in.

Major fires had occurred in the past in the urban-wildland interface under virtually the same critical fire conditions. The Berkeley fire of 1923 began in the open lands of Wildcat Canyon to the northeast and, swept by a hot September Foehn wind, penetrated residential north Berkeley and destroyed nearly 600 structures, including homes, apartments, fraternities and sororities, a church, a fire station and a library. Shingle roofs are cited as a large contributing factor in the spread of that 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. After this devastating fire, officials stated that the only reason that the fire stopped spreading was the fact 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[54].

Wildfire Hazard

The City of Berkeley faces an ongoing threat from wild land fire along its hillsides where the wild lands and residential areas interface. Wild land fires can be sparked by both human activity and natural causes. Once ignited, these fires can be difficult to contain.

A wild fire can move with breathtaking speed, expanding to one square mile in one hour, and consuming hundreds of residences in a day.

The California Department of Forestry creates maps ranking the flammability of locations. This ranking is based on vegetation, slope and other factors[55]. Figure 3-11 shows how Berkeley's hills and surrounding areas rate on this scale.

Lawrence Berkeley National Lab has worked with the City Fire Department to model fire spread in the wildland-urban interface zone bordering Berkeley using the FARSIGHT model. Both LBNL and the City of Berkeley are charter members of the Hills Emergency Forum, a consortium of nine agencies working on fire mitigation measures for the East Bay Hills. The Berkeley Fire Department has coordinated extensively with LBNL on computer modeling of wildfires, although all of the main simulations were conducted outside the city borders, in wildland areas adjacent to the city. This modeling highlighted the risk of spot fires (fires up to one mile from the main fire edge sparked by wind-blown burning debris) in the Panoramic Way neighborhood.

LBNL places strong emphasis on studying and mitigation its own fire risk, because of its proximity to the 1991 Tunnel Fire. Its computer-aided plans for vegetation management and control have been modeled at other DOE facilities.

Wildfires start during hot, dry, windy weather. Their 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 in some border areas of 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 homes and also threaten infrastructure. The intense heat associated with a conflagration can cause concrete and asphalt pavements, curbs, sidewalks, and drainage structures to deteriorate. Above ground wiring for electricity, telephone and cable, poles for lights, and street signals burn. The 1991 firestorm caused $3 million damage to infrastructure. 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 fire fighting units, fire prevention measures by homeowners, and broken water service connections in burned homes. Loss of power early in the fire caused by burning power lines and melting underground services, 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 of the conflagration. 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.

Fire season in the Bay Area – late summer to fall – is followed by the winter rainy season. Areas burned by large fires lose all vegetation and the ground surface is significantly altered, leading to increased risk of rainfall-induced erosion and landslides in hilly areas, and increased run-off. This is a secondary hazard that must be mitigated immediately after a fire.

Fire spread is reduced by fire fighting efforts. Many wildfires are prevented by early suppression efforts, before they grow out of control. Since the 1991 fire, the Berkeley Fire Department has been working to strengthen its wildfire fighting skills and to prevent conflagrations. Strong cooperation has been built with neighboring fire departments to put out grass fires before they grow into multi-jurisdictional problems. This cooperation has been assisted through formal efforts, such as the Inter-jurisdictional Hills Emergency Forum, started after the 1991 fire. A new fire station is soon to be under construction on Summit Road, just north of the UC Berkeley campus in the hills. This station, in addition to being in the urban-wildland interface, is the only City fire station east of the Hayward fault.

The City is also acquiring 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 20,000 gallons of water per minute for a distance of one mile and elevation gain of 100 feet, and it will 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.

Exposure and Vulnerability

Structures located in the urban-wildland interface have the most acute vulnerability to wildfires. After the 1980 fire, the Berkeley Planning Department designated two hazardous hill area zones, representing the area at greatest risk of fires. These zones were expanded after the 1991 fire and now include about 8,000 properties. These zones, shown in Figure 3-12, have the strictest fire prevention standards in the city for issues like new structure building materials. In addition, the Berkeley Fire Department established a zone in which vegetation management measures are enforced, also shown in Figure 3-12.

The neighborhood of most concern is the Panoramic Way area, designated as Fire Zone Three by the Planning Department. It is an urban-wildland interface area located on a hill above Memorial Stadium, in between Strawberry Canyon on the north and Claremont Canyon Nature Preserve on the south. The ample vegetation in both canyons adds to the neighborhood's risk. Panoramic Way is the only road in and out of this neighborhood. It is a narrow, windy road, barely accessible to fire engines. Water supply in this area is limited to one undersized line. Many of the Berkeley homes in this area have wood shake and shingle roofs and are surrounded by brush type vegetation.

Jurisdictionally, the neighborhood lies in both Berkeley and Oakland and is surrounded by LBNL, the University of California (Clark Kerr campus) and the East Bay Regional Parks, areas not regulated by City fire ordinances. The City's Fire Department has been actively coordinating with all of these groups to manage vegetation and plan for fire fighting. Vegetation management programs have been guided by the fire spread models produced by LBNL with the FARSIGHT program.

An earthquake could spark a fire in this neighborhood that could be fueled by damaged gas lines. This neighborhood does have landslide risk and one slide could block access to the entire area. The one water line serving the area, if damaged by the earthquake or

landslides, could limit the ability of residents and professionals to suppress the fire. This sequence of events could devastate the neighborhood and grow into an out-of-control conflagration threatening other parts of the city and neighboring jurisdictions.

Residents of the hill neighborhood are well organized and concerned. For example, one group named Berkeley Pathwanderers has taken the responsibility to clear and maintain city paths in the hills. In addition to producing a community recreation asset, these pathways can assist evacuation from and fire fighting in the hills. In the city's many steep neighborhoods with windy roads, these paths take the shortest, most direct routes, mimicking city block grids that do not exist.

UC Berkeley dorms located at the eastern edge of campus face high fire risk due to their location near the wildland interface and depend on the City for fire services while not falling under city fire preparedness ordinances.

While much of the concern for fire is placed on the hills, the flat lands are at risk as well. The flatlands are at risk of multiple ignitions following an earthquake that could be fueled by broken gas lines. Firefighters worry about conflagration that would burn across the entire city given sufficient heat and wind. The flatlands are densely covered with old, wood buildings with narrow side yards and dense vegetation. They house vulnerable populations, including the elderly, persons with disabilities, and students. Most of these houses are old, not built with modern, fire-resistant materials, and are at high risk of damage in an earthquake that could spark fires, for example, by damaging gas lines.

The City enforces several programs to reduce fire risk, especially in the hills, that should reduce future conflagrations. These include strict building code provisions for new and renovated construction, vegetation control inspections in high-risk properties, and a popular yard waste collection service. This service, known as the Fuel Chipper/Debris Bin program, serves 6,200 properties in the hills from June to September each year. In 2003, over 200 tons of vegetation was collected and recycled.

Risk and Loss Estimates

The science of estimating potential losses from wildfires is in its infancy. Some sophisticated computer models exist that can model wildfire spread, such as the FARSIGHT model used by LBNL. Such models, however, are expensive and impractical for use by the City. This Plan, instead, relies on less advanced yet still valuable methods to estimate potential losses that could occur to the city. The losses are calculated that would occur if the worst wildfire to impact Berkeley in recent history were to recur today, namely the great 1923 fire. A repeat of this fire would cause significantly more damage in Berkeley than the recent 1991 fire disaster.

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. Figure 3-13 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, 3,272 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 would exceed $1.0 billion, nearly one-eighth of the total value of structures in Berkeley. Destruction of contents in all of the homes and businesses burned could increase the losses by another $500 million to $1.0 billion. The costs of fighting this fire could easily run into hundreds of millions of dollars for the City, and huge tracts of infrastructure would be destroyed. The losses of electricity poles and lines to PG&E, for example, would 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 would be devastating. Thousands of families would be homeless following such an event, losing all of their possessions. Many more would need short-term shelter while the fire was burning. Residents and firefighters could be killed, especially in difficult to access areas. Local, independent businesses would disappear forever. A large portion of the city would need to be entirely rebuilt. In short, the entire face of northeast Berkeley would be completely changed.

Figure 3-11. California Department of Forestry fire fuel ranking for Berkeley hills and surrounding wildlands.

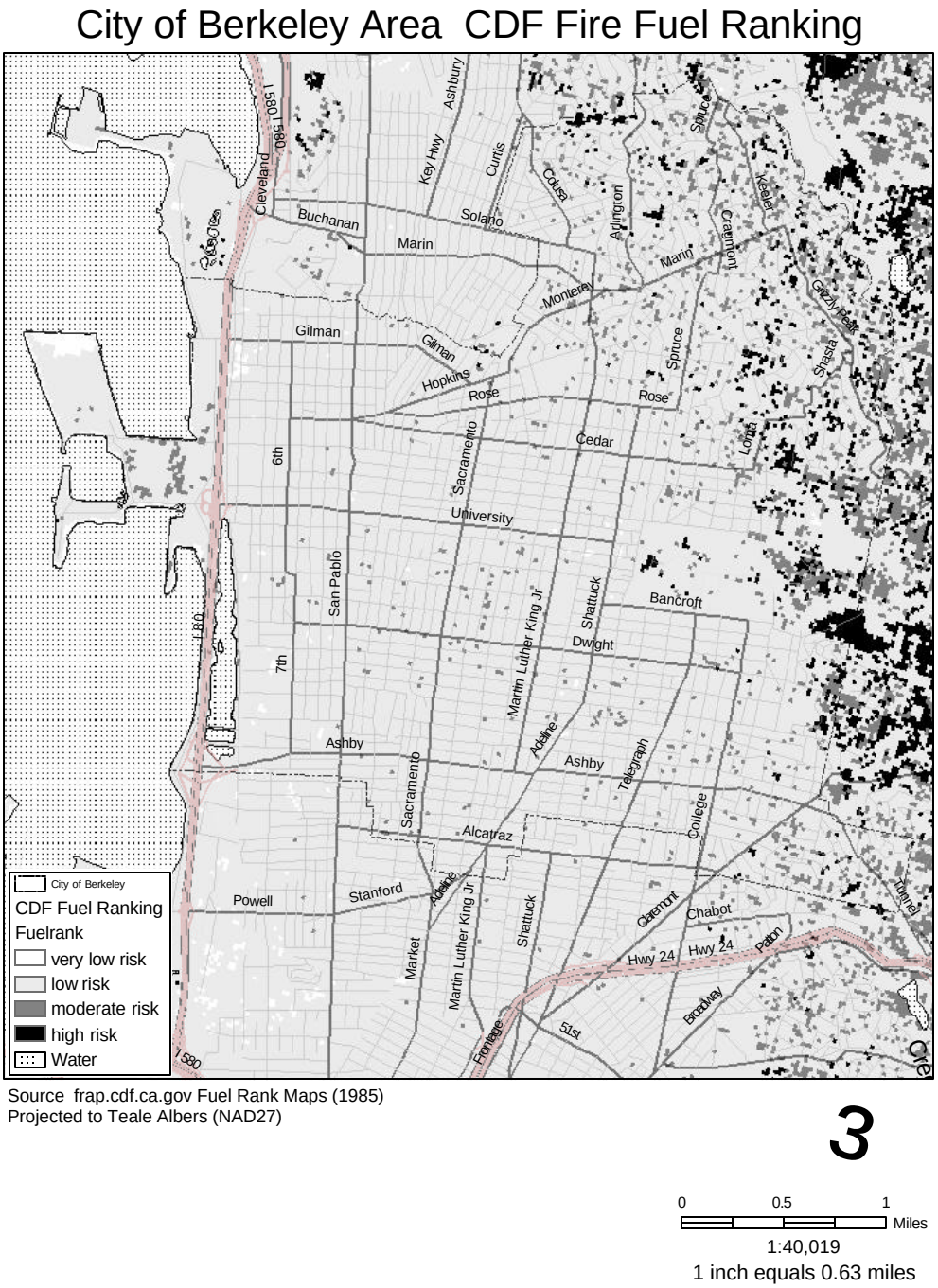
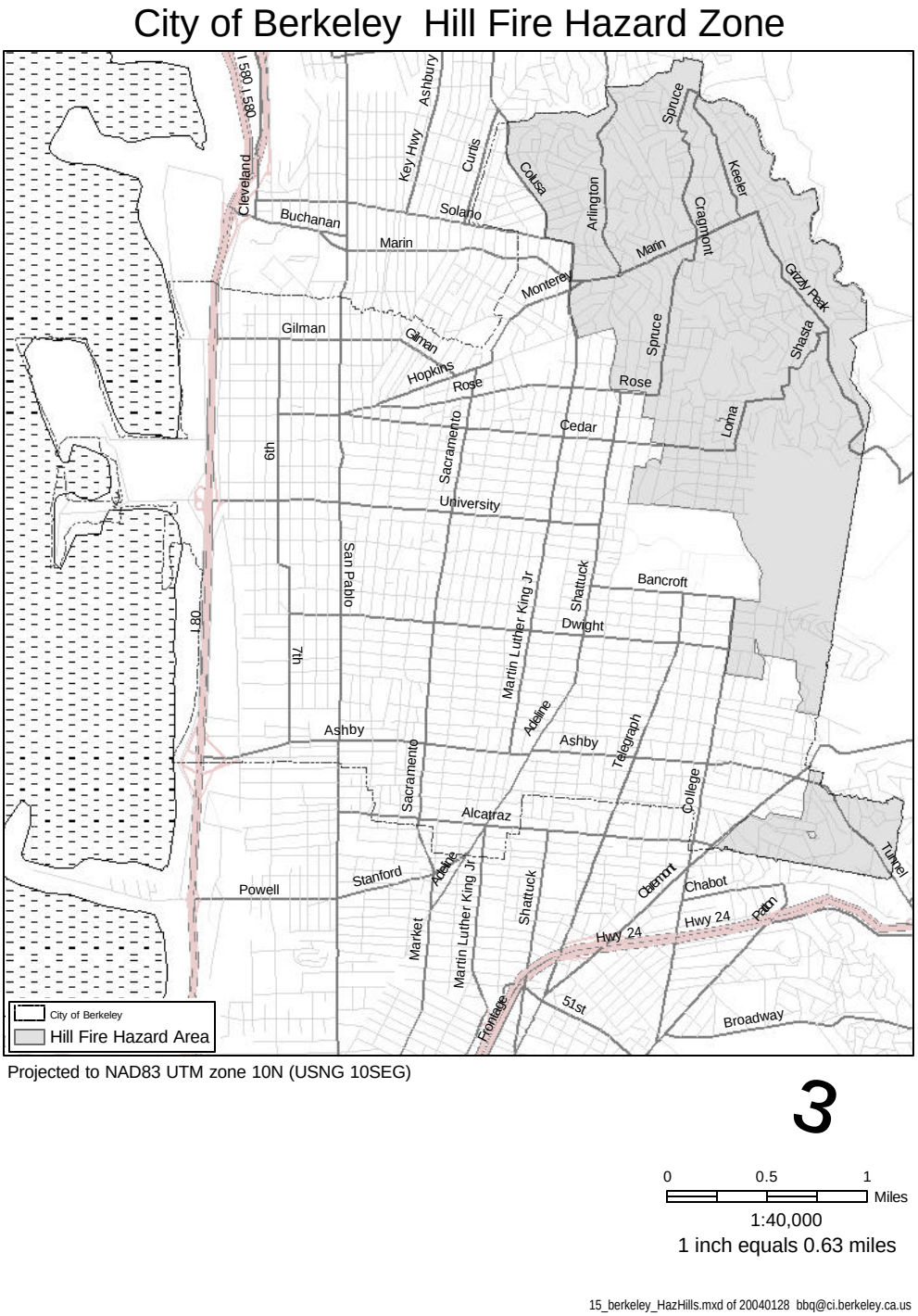


Figure 3-12. City-designated hazardous hill zone areas.



Projected to NAD83 UTM zone 10N (USNG 10SEG)

3

0 0.5 1 Miles

1:40,000

1 inch equals 0.63 miles

15_berkeley_HazHills.mxd of 20040128 bbq@ci.berkeley.ca.us

Figure 3-13. Area burned by 1923 Berkeley Fire

Burned area interpreted from insurance map and historical accounts
Projected to NAD83 UTM zone 10N (USNG 10SEG)

3

0 0.5 1 Miles

1:40,000

1 inch equals 0.63 miles

19_berkeley_Fire1923.mxd of 20040128 bbq@ci.berkeley.ca.us

3.3 Landslides

Historical Landslides

Berkeley's most significant, recent landslide experience happened during the 1997-98 heavy rains brought by the El Nino weather system. In February 1998, one home in north Berkeley was significantly damaged by a landslide 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.

There are about five deep-seated landslides that continuously move, with the rate of movement affected by rainfall and groundwater conditions. These slides are shown in Figure 3-15.

Landslide Hazard

In Berkeley, the potential for landslide from seismic activity or heavy rain is high in the hill areas and along stream banks in some parks and neighborhoods. Both the US Geological Survey and the California Geological Survey have mapped landslide risk in the city of Berkeley. Both maps show that significant portions of the hilly areas of the city are at risk of sliding. Figure 3-14 shows the USGS map that indicates the relative risk of various areas in the hills of sliding due to rainfall, earthquake and all other causes.

Landslides are natural geologic phenomenons that range from slow moving slumps in shallow hillsides to rapid rockfalls in steep hillsides. 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, or increasing water content.

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

Landslide hazard can be reduced through grading, soil strengthening, structural engineering components, drainage, control of run-off and landscape methods. In new city development, all of these activities are regulated and inspected by the City. Most of the Berkeley hillside development, however, pre-dates current best practices and codes and therefore remains vulnerable to the threat of landslides. The City built and maintains many major retaining structures in the hills that help to control landslide risk in key areas.

Exposure and Vulnerability

Existing active slides and earthquake shaking could activate other sites. Strong earthquake shaking coincident with wet, saturated hills presents a worst case for landslides. Movement could range from a few inches to 20 feet. Applicants for permits

in areas of high landslide potential are required to have site-specific geotechnical investigations and use engineering measures to mitigate the hazard.

Areas of the community that are vulnerable to landslide hazards include hundreds of homes, roads, sidewalks, underground utilities (water, sewer lines, storm drains, natural gas, conduits) and aboveground utilities (electricity, telecommunications, cable) that are situated on historic landslide areas. Several collector streets that are critical for emergency access and evacuation are located in areas historically susceptible to landslides.

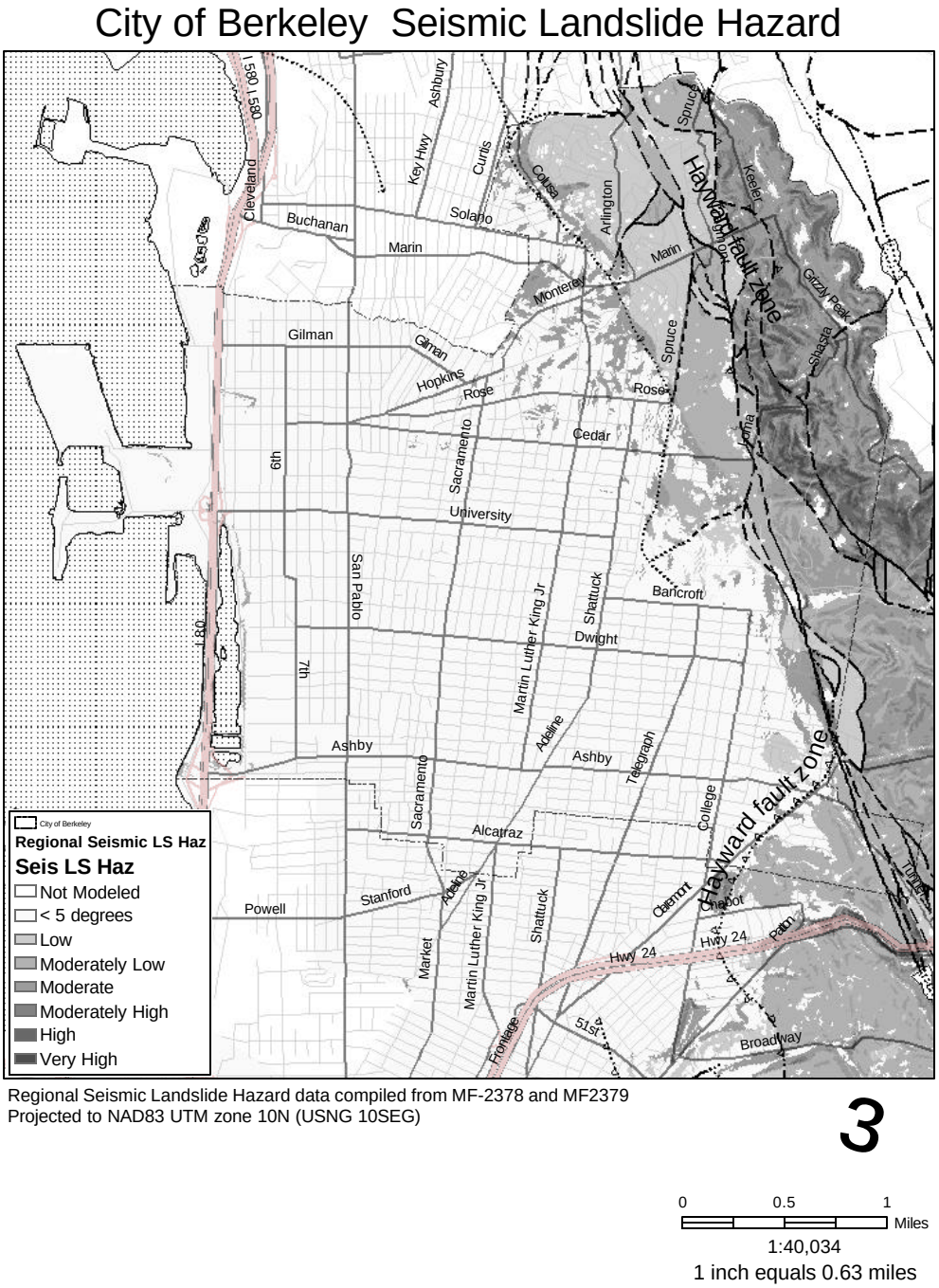
Risk and Loss Estimates

Many of Berkeley's hillside homes are located in areas that could slide under the right circumstances. In fact, according to a USGS report[56], approximately 6,000 structures are located in areas at moderate to high risk of landslides. While rainy weather or earthquakes could cause small landslide events that would impact a few homes, the juxtaposition of a significant earthquake during or following wet weather could cause the worst-case landslide event the city should reasonably plan for.

There are few generally accepted methods to estimate damage from landslides caused by rain or by earthquakes. 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 would be about $75 million. A single landslide impacting this many structures is unlikely, but possible. Smaller slides affecting a handful of structures are more probable.

Damage to these homes could vary considerably, depending on their location, and the quality of their foundations and important retaining walls. Some houses could be entirely destroyed or washed down the hill, while others may see minimal, repairable damage. Earthquake induced slides may occur at the time of a major earthquake, or in subsequent aftershocks or rainstorms. Many roads in the city's hillside neighborhoods will be blocked and inaccessible. Residents may have some warning that slides are imminent, helping to reduce damage and casualties.

Figure 3-14. Landslide risk ranking assessed by USGS.



Regional Seismic Landslide Hazard data compiled from MF-2378 and MF2379
Projected to NAD83 UTM zone 10N (USNG 10SEG)

3

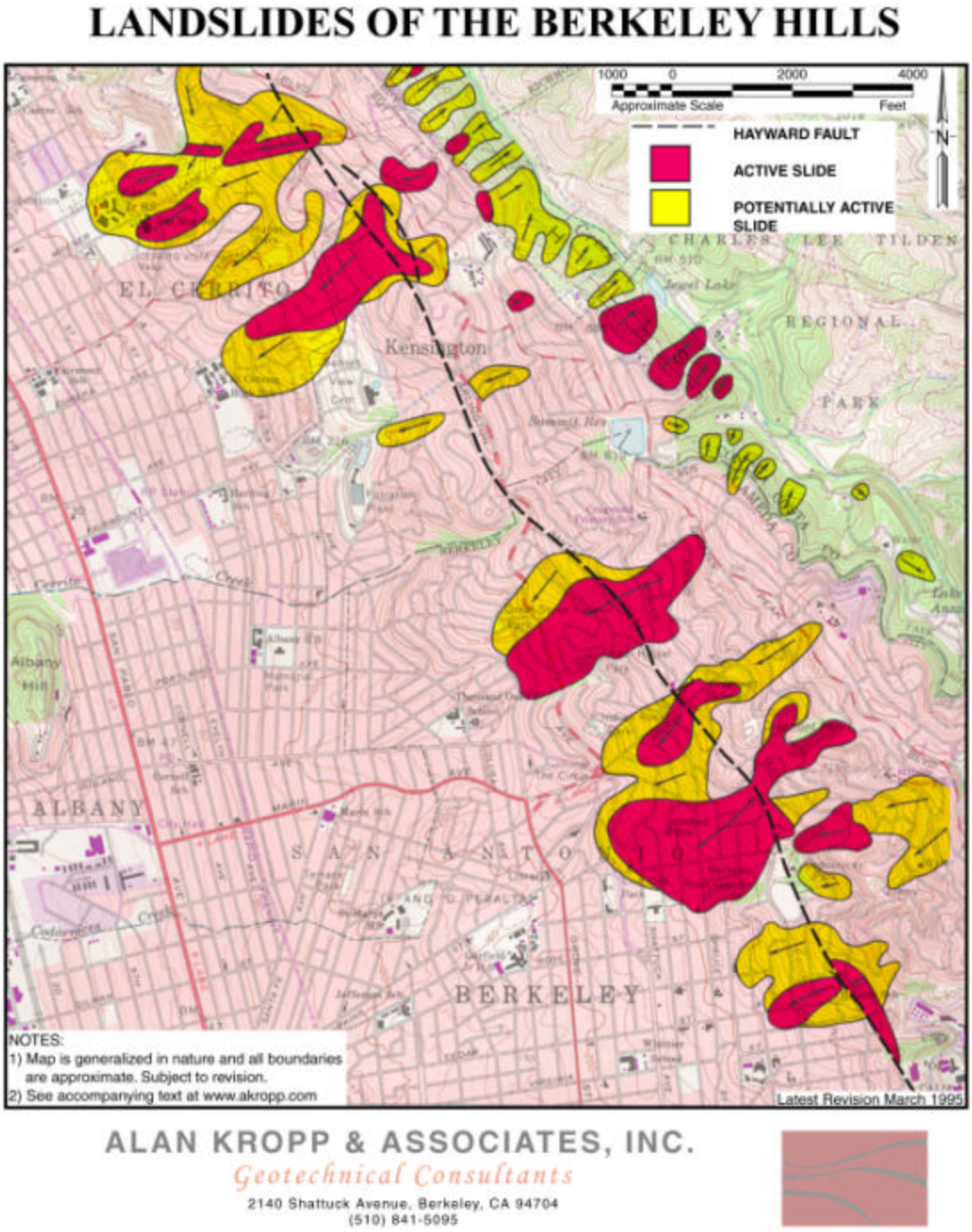
0 0.5 1 Miles

1:40,034

1 inch equals 0.63 miles

17g_berkeley_SeisLSHaz.mxd of 20040304 bbq@ci.berkeley.ca.us

Figure 3-15. Active landslides in Berkeley hills (developed by Alan Kropp Associates)



3.4 Floods

Historical Floods

The most recent flooding occurred during the 1997-98 El Nino season. The problems caused by the El Nino winters in the 1990s totaled millions of dollars in emergency response and recovery efforts. Other flooding occurred in the early 1960s when Strawberry and Codornices creeks overflowed. Sheet flooding in streets and intersections was a nuisance. A few buildings, including some on the University of California campus, were flooded. Since then, a number of streams were redirected into underground culverts.

Flood Hazard

Berkeley faces a moderate flood hazard. There are thirteen major creeks flowing through Berkeley that have flooded in recent years. The city creeks are shown in Figure 3-16. High bay levels could flood waterfront areas. Flooding events may occur as flash floods, local storm drain blockages, or tidally or tsunami influenced events[57]. The watersheds feeding the major streams are small and steep, and flooding conditions require intense local rainfall and depend on the condition of storm drain grates and capacity of the storm drain system. Flow capacity of the drain system, in terms of storm recurrence intervals, is not known.

Flowing from the hills through the University campus, Strawberry Creek poses a flood hazard for downtown Berkeley immediately west of Oxford Street, as well as to parts of the campus. The North Fork of Strawberry Creek in particular, which captures a significant amount of urban runoff, is subject to flash flood conditions in periods of intense rainfall.

The tidal basin areas south of Third Street, between Codornices Creek and Gilman Street, and between University Ave. and Ashby Ave. (Aquatic Park) are potentially vulnerable to flooding. Many of the city's streams drain into this low-lying area. This area is also the most industrialized part of Berkeley.

Figure 3-17 depicts flood zones mapped for the National Flood Insurance Program during the 1970s, with locations of hazardous materials in the floodplain indicated. Full-scale maps depicting these zones relative to parcels are posted in the Planning Department. Maps of flood zones are considered outdated by City officials and there are plans to update them.

Exposure and Vulnerability

Floods could inundate the lower portions of a small number of houses in the city and a significant area of the western industrial portion. This type of flooding is unlikely to damage structures but could significantly damage basement and first-floor finishes, contents and appliances in these buildings. The maximum flood depth associated with a 100-year flood expected for any given building in the city is three feet. The limited capacity of the City's storm drains mean that other portions of the city, away from

streams mapped in flood insurance studies, could also experience minor, nuisance flooding.

The north fork of Strawberry Creek runs through UC Berkeley campus. The watershed for the creek is highly urbanized – 77 percent of the Berkeley campus is paved – leading to possible flash flood conditions[58]. Strawberry Creek leaves campus and enters a city culvert at Oxford Street. The grate on this culvert collects trash and, during intense rainfall, could cause significant backup of water in the city's downtown areas.

Many 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 flooding damage in many structures because of the failure of these pumps.

The City's storm drainage system was installed before World War II, prior to much of the development of the watershed. Some segments of the storm sewer system are in danger of collapse and may jeopardize nearby structures. The unreinforced concrete pipes have eroded over the years and, in some locations, sand and soil is being sucked into the pipelines causing washouts. Weak elements under normal conditions become potential failure locations during storms with high runoff and during earthquakes. These segments are likely to be a high priority for improvements in the City's ongoing renovation planning. The drainage system consists of open and covered streams, street culverts and a system of storm water drains that connect with the stream channels that flow into San Francisco Bay. The Department of Public Works is completing a geographic database and acquiring software that will allow hydraulic analysis of the system to better identify choke point segments, and to predict areas of flooding. This geographic database will facilitate identification of the segments in need of maintenance or replacement and setting priorities.

Many of the structures in or near the flood zone have hazardous materials on their properties. The hazardous materials at the sites include many polluting and health-hazard chemicals. The City has no regulations requiring hazardous materials to 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. There are 14 hazardous sites in the 100-year floodplain and 59 in the 500-year floodplain. One City facility with a potential pollutant – the Refuse Transfer refueling station for City vehicles on Allston Way at Strawberry Creek – is located in the 100-year floodplain.

Public Works staff will take advantage of FEMA training and will cooperate in the federal program to update and improve flood risk maps. The vector data being collected on the size and condition of storm drains, and new software, will allow better analysis and identification of flood conditions for 25, 50 and 100-year storm conditions. Completion of this work will provide a better understanding of the flood hazard and allow the City to assess points where improvements, such as added flow capacity, will have the greatest effect.

Thanks to the foresight of the storm water system planners in the 1920s, and also 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. Berkeley also requires one foot of freeboard on all development at risk from bay floodwater.

Risk and Loss Estimates

Estimating flood losses is an established process. If the "100-year" flood occurred in Berkeley, meaning the flood that has a 1% chance of occurring in any given year, it would impact about 675 structures to various degrees. This was determined by intersecting the city's database of structures with the FEMA developed maps of the 100-year floodplain. The majority of these structures would be inundated by one foot or less of water. Approximately 200 structures, however, could flood with up to three feet of water.

Berkeley structures in the floodplain vary in construction in size, ranging from single-family homes to large, industrial workspaces. Basements are uncommon, and few structures in these areas are multistory. For this analysis it is assumed that all structures are one story with no basement, which may over estimate 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 get flooded before any other portion of a structure.

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 floodwaters 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.

The estimated losses to properties in Berkeley from a 100-year flood total $120 million[59]. Approximately $50 million is damage to the building structures, including walls, finishes, etc. $70 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 adequate warning time to property owners and adequate manpower.

Floodwaters in Berkeley, due to the small watersheds and paved, urban environment, are likely to both rise and recede quickly. This means residents and business owners may have a short warning period about impending floodwaters, but they should be able to begin the clean-up and repair process quickly. Buildings should be cleaned up within a handful of days and repairing and replacing furniture and equipment will take weeks to months.

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

Because much of the city's industrial area is located in the floodplain, there could be spills of some hazardous materials 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 clean-up efforts.

In addition to the neighborhoods mapped by FEMA, other areas could experience localized flooding due to damaged or inadequately sized storm drains. Until the storm drain system is fully analyzed, it is difficult to estimate where these backups are most likely to occur.

Figure 3-16. Berkeley Area Historic and Existing Creeks.

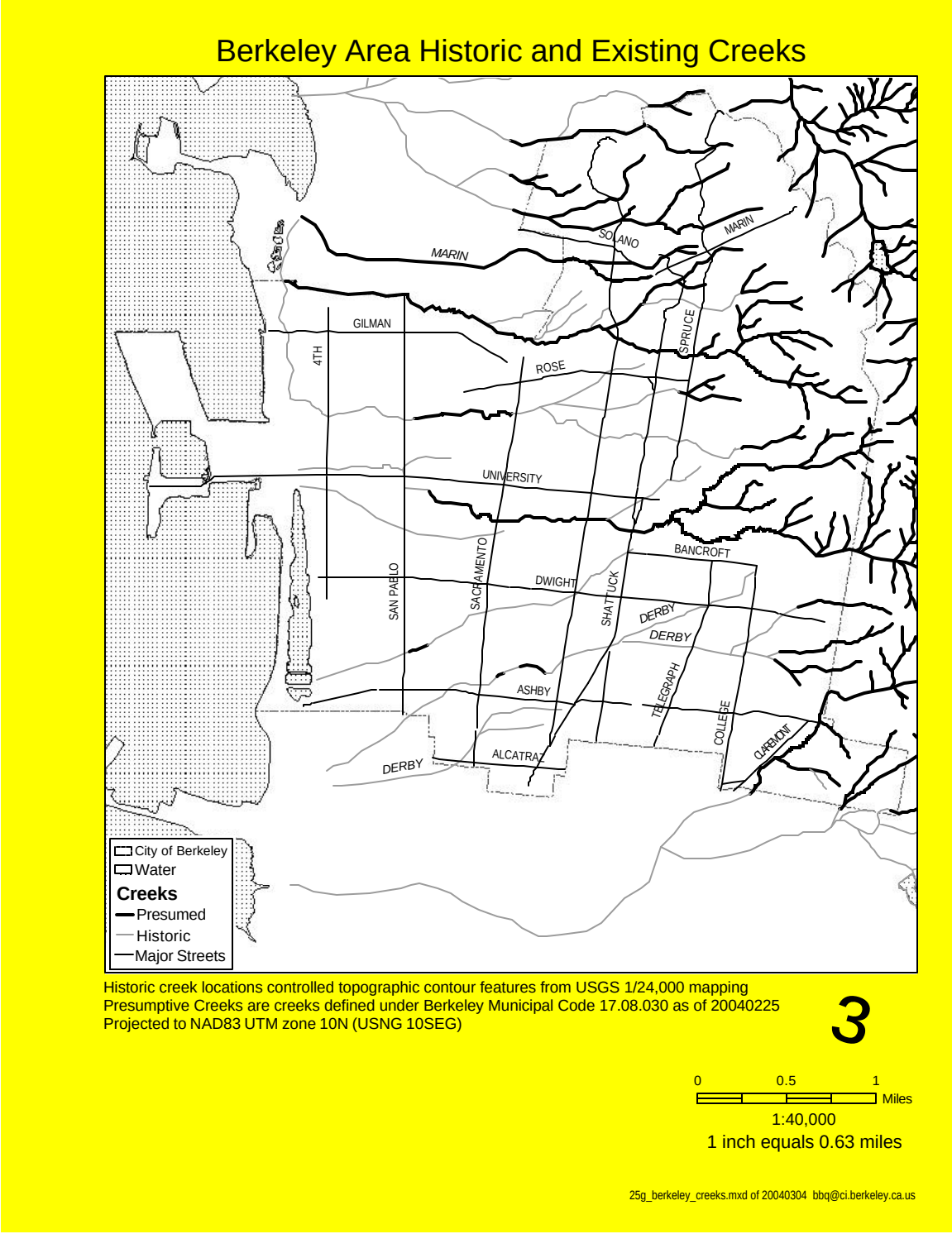
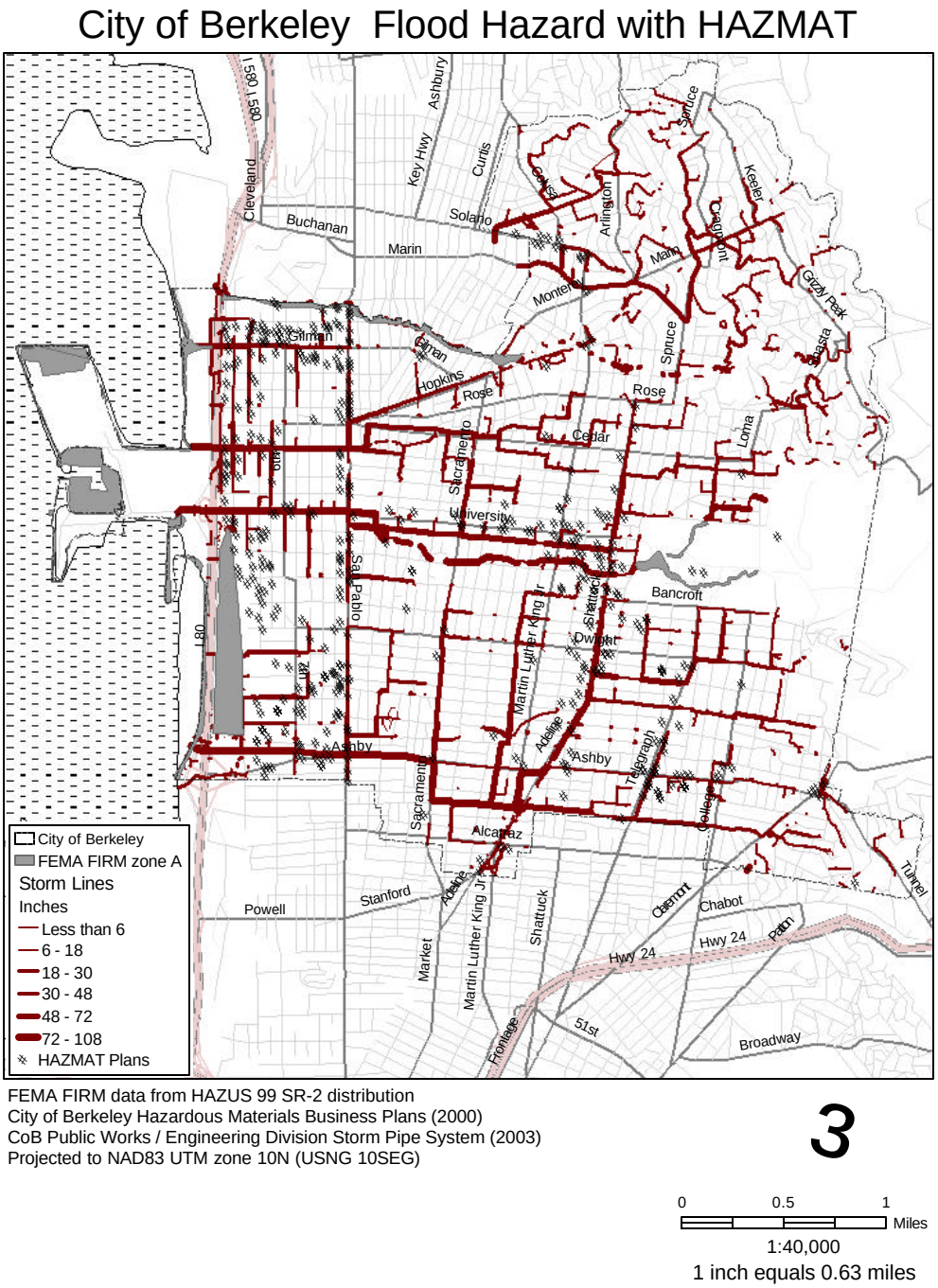


Figure 3-17. NFIP mapped floodplains with hazardous materials sites in the floodplain.



FEMA FIRM data from HAZUS 99 SR-2 distribution
City of Berkeley Hazardous Materials Business Plans (2000)
CoB Public Works / Engineering Division Storm Pipe System (2003)
Projected to NAD83 UTM zone 10N (USNG 10SEG)

3.5 Hazardous Materials Accidents

Historical Hazardous Materials Accidents

Hazardous material accidents take many forms. This plan is concerned with industrial accidents that cause immediate emergencies, such as the accidental release of an acutely toxic chemical plume or an explosion of a highly flammable hazardous substance.

Berkeley has experienced industrial accidents over the years. Highway 80, in the city's west, has had truck accidents with potentially harmful materials involved. Industrial sites have occasionally released small amounts of dangerous substances, such as a recent release of anhydrous ammonia from an ice rink in the city. Luckily, none of these events have caused significant impacts on the community, but they are a reminder of this hazard.

Hazardous Materials Accidents Hazard

Accidents could potentially harm city residents by exposing people and buildings to gases that are poisonous, suffocating, irritating or cause burns. The impacts of such an accident depend on the amount and rate of substance spilled, the location, and its dispersion. Wind rates and directions can greatly impact dispersion. Typically, the wind blows from the west to the east, meaning that hazardous spills on the City's major transportation routes or from the industrial area could form a plume that would blow over the City's residential areas in the east. The flat lands are more susceptible to these plumes than hilly neighborhoods because for many substances, topography can break their spread. Accidents could also take the form of explosions that damage buildings, harm occupants and start fires.

Exposure and Vulnerability

Berkeley tracks harmful chemicals and other substances on industrial sites rigorously. At this time, 302 locations within the city are known to have some sort of hazardous materials on their sites, with the large majority of these being materials that could damage the environment but would not pose significant life safety hazards to Berkeley residents if they became released[60].

There are three industrial sites in Berkeley with large quantities of toxic gases. The Toxics Management Division works directly with each of these sites to make sure they meet stringent safety requirements. Currently, one company complies with all city rules, and the other two sites are in the process of complying. In addition, there are numerous sites that store highly flammable materials, smaller amounts of toxic gases, and small amounts of radioactive materials. Storage of materials at these sites is regulated by the Fire and Building Departments through design requirements in the Fire and Building Codes. Natural gas lines run throughout the city, and potential releases leading to fire or explosions could happen in most areas. Neighboring cities contain petrochemical refineries that, although outside Berkeley's borders, could cause hazardous materials incidents impacting Berkeley residents.

Hazardous materials also travel through the city by truck and rail. Major rail and highway transportation routes, specifically Highway 80 and the Southern Pacific railroad tracks, cross Berkeley. These routes are known to carry hazardous chemicals.

Transportation accidents have occurred with trucks carrying dangerous materials in the past, and will in the future[61]. A release on the freeway or rail line would most immediately impact the western industrial area of the city. Winds typically blow to the east, meaning that any gaseous releases could easily spread to residential areas.

There are many hazardous substances located on the UC Berkeley campus. The university does not make a list of the substances used in research on campus publicly available, but this information is provided to the Berkeley Fire Department. The university is presumably addressing many issues relating to the safety of such materials in its own disaster mitigation plans. However, hazardous materials are widely dispersed throughout many laboratories on campus and it is unknown whether there are comprehensive programs to make sure they are secured during and after disasters. Because the campus relies on the city for fire and search and rescue services, good coordination on this topic is important.

LBNL is another site in the City that contains hazardous substances. Minor amounts of hazardous and radioactive materials are in used in Lab research activities. City residents have expressed particular concerns about radioactive materials used at the labs. LBNL has studied the potential release of radioactive substances due to accidents and natural disasters and assures residents that, from all causes, the worst-case scenario releases would produce public radiation doses that would not cause significant local impacts[62]. The Lab's strict non-structural safety program should reduce risk of hazardous materials spills in earthquakes.

Risk and Loss Estimates

The City has conducted some preliminary scenarios for training purposes of industrial accidents using a computer simulation program CATS (Consequences Assessment Tool Set). The CATS program models chemical and hazardous material releases using real weather data to predict spread. Because of the uncertain nature of industrial accidents, loss estimates are not presented in this plan.

3.6 Terror Attack

Historical Terrorism

Berkeley has experienced several terrorist attacks. Two of the victims of the Unabomber were at UC Berkeley. In 1982, Professor Angelakos was seriously injured by a disguised pipe bomb planted by Theodore Kaczynski, the Unabomber, in Cory Hall on campus. Three years later, a student, John Hauser, was severely injured by a bomb hidden in a stack of binders in a computer lab in the same building[63]. In the 1970's, several bank branches in Berkeley were bombed and Berkeley played a role in the activities of the Symbionese Liberation Army, known for abducting heiress Patty Hearst.

Terrorism Hazard

Intentional attacks are much harder to predict than accidents. Terrorists could attack Berkeley in numerous different ways. These include the following:

- Conventional bomb
- Biological agent
- Chemical agent
- Nuclear bomb
- Radiological agent
- Arson/incendiary attack
- Armed attack
- Cyber-terrorism
- Intentional hazardous materials release

The damage caused by a terror attack is dependent on the method of attack. Large bomb attacks could destroy major infrastructure, kill many people and disrupt city functioning for a significant time. Cyber-terrorism would cause very different types of damage, possibly severely hampering City operations and local business with no direct injuries or loss of lives (indirect loss of life could occur if 911 systems were compromised).

In addition to direct physical damage, terrorist attacks breed fear. Even an unsuccessful attempt to attack the city would seriously impact the comfort level of residents and could affect business and university enrollment.

Terrorism emerges from many different ideologies, on the left and the right of the political spectrum, ranging from highly sophisticated and trained groups to individual, spontaneous acts. For many people, Berkeley, both the University and the City, symbolizes specific sets of political beliefs, which has made the community a terrorist target in the past.

Exposure and Vulnerability

It is not possible to estimate the probability of a terrorist attack. The approach experts use to prioritize mitigation and preparedness efforts is to identify critical sites and assess the vulnerability of these sites to terrorist attack. Critical sites include those that are essential to the functioning of the city, contain critical assets, or 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 the Office of Homeland Security and other State and regional groups to prevent and prepare for terrorist attacks. This effort involves the City's Fire, Police, 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 emergency response teams actively train for bomb scenarios, hostage situations, and other terror-associated incidents. They regularly conduct trainings with neighboring jurisdictions for these types of events.

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. Efforts to retrofit buildings to resist earthquakes often provide cost-effective opportunities to incorporate measures to mitigate against attacks using bombs, chemical and biological agents.

Risk and Loss Estimates

Because of the unpredictable and sensitive nature of terrorism, no specific loss estimates are calculated.

3.7 Multi-hazard Event

All of the hazards that threaten Berkeley could happen in combination with another hazard. In fact, there is a high likelihood that a major earthquake on the Hayward fault will unleash secondary hazards that could be as disastrous to Berkeley as the earthquake itself. An unforgettable reference point for the Bay Area is the devastating fire in 1906 that burned down San Francisco, causing significantly more destruction than the earthquake that sparked it.

Earthquakes have started fires throughout history, including recently after the 1995 Kobe, Japan earthquake. Earthquake shaking can start fires in numerous ways, such as tipping over appliances with pilot lights or damaging electrical equipment leading to sparks. Ruptured gas lines, both underground and where they connect to houses, or spilled flammable chemicals can cause post-earthquake fires to spread quickly. Efforts to fight fires after an earthquake are often severely hampered by non-functional water systems, damaged electrical systems that are needed to provide energy to pump water, or roads blocked by debris or landslides. These problems coincide with fire personnel being required for search and rescue activities and other disaster response activities. HAZUS, FEMA's earthquake loss estimation software described earlier, includes the ability to estimate the number of fire ignitions and fire spread following an earthquake.

Berkeley expects to experience landslides during the next earthquake, particularly if the earthquake occurs during the rainy winter months. Small aftershocks could continue to cause slides for weeks after a quake, blocking roads and damaging homes. In addition, the next earthquake is expected to cause significant damage to the city's antiquated storm drain system, and possibly to the stream culverts. 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. Wildfires also increase the risk of landslide and flood. When all supporting vegetation is burned away, hillsides become destabilized and prone to erosion. The charred surface of the earth becomes hard and absorbs less water during rainfall, leading to increased runoff.

Many of Berkeley's industrial sites with hazardous materials are located in areas with liquefaction susceptibility. While property owners are required to secure and isolate hazardous chemicals, there could be dangerous spills that fuel fires or cause health hazards after an earthquake. A major fire could also release toxic chemicals. Near the hill wildfire risk area, there are two major sources of dangerous chemicals and radioactive material: UC Berkeley and the Lawrence Berkeley National Laboratory. While both sites have active disaster preparedness programs, wildfires are notoriously difficult to fight and hazardous materials could be released in a major disaster. Flooding could also cause problems with hazardous materials, particularly because many industrial sites are located in potential flood zones. The City has no requirements that hazardous materials be elevated, although some must be surrounded by berms to contain any spills. Floods might occur with adequate warning time to protect any areas of particular concern with sandbags.

People have speculated that a terrorist attack could follow a major natural disaster, striking a community at its weakest and most vulnerable time. Historically, however,

crime has been low following natural disasters in the US as communities unite to respond. Terror attacks could also trigger other hazards, such as chemical release (particularly if the target was a source of dangerous chemicals) or major fire.

Many mitigation activities reduce risk from more than one hazard. However, there are some mitigation activities that reduce risk from one possible threat while increasing it from another. One example is placing utility lines underground. Underground utilities are less damaged by a major fire than those aboveground. In an earthquake, underground utilities in areas prone to landslides or liquefaction are susceptible to damage and are more costly and time-consuming to repair than aboveground utilities. Another example of a mitigation activity with positive and negative impacts is vegetation removal for wildfire risk reduction. Trees and other established plants play a key role in securing hillsides and reducing landslide risk. They also reduce erosion and slow rain runoff time, which reduces flood peaks. It is important to remember all of the implications of any risk reduction steps when planning mitigation activities.

4. Current Mitigation Programs and Resources

This section identifies and describes the Berkeley community's ability to evaluate and address the crucial questions related to hazards. Managing risk requires support and persistence from the community and government at all levels to identify and evaluate risks, and implement and maintain policies, practices and projects. Leadership must recognize the importance of social, cultural, economic, political, and institutional factors. The City of Berkeley has shown leadership in all of these areas. This section describes the public and private practices regarding the risk from hazards – whether self-motivated, mandated or a result of incentive – that have allowed decision makers to effectively manage the City's risk from hazards.

First, in section 4.1, the ongoing and past efforts of the city to manage its risks are discussed. This includes a discussion of the legal and policy framework of risk management, such as municipal ordinances, plans and programs. Section 4.2 discusses the City's resources to manage risks. This includes financial resources, human capital and institutional knowledge. The City has Council members, staff, and residents knowledgeable about and deeply committed to reducing risks. Following this, in section 4.3, State and Federal laws that affect the City's risk management are presented.

4.1. City Programs and Plans

Legal and Policy Framework

The City of Berkeley exercises its responsibility for the health, safety and welfare of those in the community. Its legal authority is derived from the state and the City Charter. The City has been an innovative leader in developing risk management programs and ordinances. Some of the most important programs are described below:

City Buildings

- 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, including six of the City's seven fire stations (with the seventh currently in the planning phases), all public school buildings, a new emergency operations center, the Civic Center (which houses many key government functions), and the Main Library.

City Infrastructure

- Emergency Water Supply for Fire Fighting. The City's Fire Department is currently purchasing an innovative, aboveground temporary water system that can be used to fight fire when the underground system is not functioning. This system will connect with any water source, including the San Francisco Bay. It should be functional in 2004.

- Integrated Alert System. The City is working to build an integrated alert system that would reach a maximum number of Berkeley residents and occupants through a radio station (1610 am), sirens, public address systems, and telephones. This system will

rely on web-based databases to target alerts to the ideal locations and formats. The City is currently writing the specifications for equipment to purchase and expects an enhanced mass notification system to be in place by 2005.

Codes, Inspections and Upgrades

- Building Codes. The City enforces disaster-resistant development through the application of the state-mandated California Building Code and more stringent local amendments. The Code must be applied to all new construction and to substantial renovations. The code requires the most up-to-date earthquake resistant design and fire resistant design and materials exceeding current state standards. Homes in the hill areas are required to apply stringent landslide and fire prevention features. The Codes are updated regularly, for example, after the 1991 Tunnel Fire, the City's standards for roofing, siding, eaves, chimneys, and utilities were upgraded. Nearly half of the properties in the area now comply with the fire resistant roofing standards[64]. Numerous inspections and reinspections are conducted each year by city building inspectors under the Building Official, staff of the Division of Fire Prevention and Investigation, and private firms contracted to do this work.

- Home Repair and Loan Programs. The city operates a home repair program through a local non-profit organization that provides free repairs for homes owned by low-income seniors (62 years of age or older) or people who are permanently disabled. The non-profit group provides all seismic retrofit design plans and obtains permits necessary for the work. The work generally consists of anchoring floor systems to the foundation and bracing cripple walls to resist lateral forces. Loan programs are also available for qualified senior and disabled homeowners, and the City Council established a rental rehabilitation program to help owners seismically strengthen properties occupied by low-income tenants.

- 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, owners have improved seismic resistance in over 600 of 700 buildings initially designated as URMs in Berkeley.

- Study of At-Risk Private Buildings. The City, in February of 2001, obtained a FEMA grant to assess multi-unit soft story residential buildings and develop a program to reduce their vulnerability, building on an earlier effort in 1996. Under the direction of the City's Seismic Technical Advisory Group, a team of staff, outside experts and University of California students assessed soft story residential buildings with five or more residential units. They found that nearly half (over 200 structures) are expected to be red-tagged, uninhabitable and likely to require extensive repair or total replacement. Further, over 95 percent of soft story units may not be livable immediately following a large Hayward earthquake[65]. Commercial tilt-up buildings were also identified and mapped.

- Hazardous Fire Area Zones. Following the 1991 fire, the Council designated a special assessment district in the Berkeley hills area that instituted an additional $50 per parcel annual tax on each parcel in the district. This tax collected upwards of $1.2

million on an annual basis to apply to fire safety programs including additional inspections and aggressive vegetation management. The district was decertified following enactment of state proposition 218 that required a 2/3 supermajority for the creation of this type of district. However, popular programs such as free collection of vegetation waste during fire hazard months were continued by a surcharge added to waste collection bills.

- Fire Inspections. The Berkeley Fire Department annually inspects designated high fire risk zones for hazards such as excess vegetation. There are about 8,000 properties in the Berkeley Hills. Today, the Fire Department is able to inspect about 1,000 of them between June and August and respond to specific complaints. Residents must clear combustible brush and vegetation adjacent to buildings 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 urban/wildland interface zone on their property.

- Debris Collection Program. The Fuel Chipper/Debris Bin program, a popular yard waste collection service, serves 6,200 properties in the hills from June to September each year. In 2003, over 200 tons of vegetation was collected and recycled. The program is funded by a surcharge on garbage collection bills of all residents.

Financial Incentives for Homeowners

- City Transfer Tax Rebate Program. By ordinance, the City of Berkeley 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 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. Repair standards for "seismic retrofit" are defined in City ordinance 752.060. This program, in concert with the City's other retrofit incentives, has led to nearly 60 percent of the private residences in Berkeley being made more seismically resistant.

Community Involvement and Preparedness

- CERT Training and Neighborhood Caches. CERT classes – Community Emergency Response Training – are offered through the Fire Department to all Berkeley residents and those who work in Berkeley. Trained volunteers can help douse small fires, assist in deploying the soon to be purchased above ground emergency water supply system, and help firefighters. Neighborhood caches of emergency supplies are being established in many neighborhoods. The locations of neighborhood caches are shown in Figure 4-1.

- Project Impact and Disaster Resistant Berkeley. Through funding from FEMA's Project Impact, the City ramped up public awareness and training of emergency preparedness and mitigation activities. Numerous well attended Community Forums and Meetings were held, along with disaster drills in each neighborhood. Public

awareness materials are posted to the City's website and circulated through other information conduits[66].

- Citizens' Overview. Two citizen advisory commissions, the Disaster Council and the Fire Safety Commission, closely monitor the City's preparedness and mitigation efforts. They are comprised of safety advocates appointed by the mayor and City Council. The Disaster Council was established in 1989, just a few months before the Loma Prieta Earthquake.

A timeline of the key benchmarks for Berkeley's mitigation programs appears in Table 4-1.

Plans

The City has other plans published to prevent, prepare for, respond to and rebound after hazard events. This mitigation plan builds on and refers to all of these existing plans.

- General Plan. The City's General Plan lays out major City goals. The Disaster Preparedness and Safety Element of the City's General Plan proposes specific policies and actions to meet the City's goal to become a disaster-resistant community. Many other sections of the Plan incorporate disaster management issues, such as the Environmental Management Element, which addresses hazardous materials.

- Terrorism Response Plan. City officials are currently working with the Office of Homeland Security and other State and regional groups to prevent and prepare for terrorist attacks. This effort involves the City's Fire, Police, 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.

- Emergency Operations Plan. The City created a comprehensive emergency operations plan two years ago using the Standardized Emergency Management System (SEMS). This plan covers all city departments. Every one to two months, personnel responsible for management, operations, finance and logistics of this plan meet to coordinate their activities. Each year, one to two major exercises are conducted, such as a table-top exercise or a full-scale drill. The plan is updated and improved following each exercise by city staff.

- Disaster Recovery Plan. The City is currently developing a recovery plan to guide rebuilding and returning to operability after the next major disaster impacts the city. This plan is expected to be complete in 2004.

- Toxics HazMat Response Plan. The City has a dedicated plan for responding to hazardous materials releases. This plan is exercised with key institutions and companies holding significant amounts of toxic materials in the city.

- Sheltering Plan. A comprehensive plan to manage post-disaster shelter requirements within the city is currently being developed.

Table 4-1. Timeline of Berkeley Mitigation Activities and Key Events

Date	Event	Results
1868	UC Berkeley campus established	
1868	Hayward earthquake	Impacts on Berkeley are not known
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 not known
1906	San Francisco razed by major earthquake	Damage in Berkeley was significantly smaller than damage in San Francisco
1911	Damaging earthquake near San José	Impacts in Berkeley are not known
1923	Major wild fire	Large area of homes burned
1927	City of Berkeley Adopts Uniform Building Code (UBC)	Community conforms to building regulations and safety codes
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
1959	UBC updated	Calculation methods improve to better represent different types of structures
1962	Flood	Damages led to legislative change
1970	Enacted floodplain ordinance	Flood Insurance Rate Maps were developed for the community.
1973-76	UBC updated	Ductile elements introduced into reinforced concrete buildings to prevent catastrophic failure and improvements to wood frame design
1980	Grass fire in hills consumed several Berkeley houses	City developed hazardous hills zones and regulated building materials in hills

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	
December 1989	URM inventory established, risks identified and owners notified	
August 1990	Board of Education convenes to review school engineering analysis	Life safety hazards found in 7 of 16 district schools
July 1991	Transfer tax rebate ordinance adopted	Allows for rebate of 1/3 of the real estate transfer tax up to $1500 for seismic safety improvements to dwellings. Retroactive to 10/17/89
Mid- 1991	Fee waiver program established	Waives permit fees on residential seismic safety projects
October 1991	East Bay Hills Fire	
	Special Assessment District created for Berkeley Hills	Assessed $50/parcel/year for fire safety programs
	Strengthened requirements for hazards hill fire zones	Stricter standards for roofing and other building materials.
December 1991	Established mandatory URM retrofit program	To date nearly 600 out of 700 URM's 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
March 1995	Seismic Technical Advisory Group convened	Assures City has appropriate technical information to make informed seismic safety policy decisions.
July 1996	Soft-story and tilt-up building inventories developed	A ballot measure was defeated in 2002 aiming to raise funds to reduce risk in soft-story structures.
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

	SAFER Program established	University's $1.2 billion reconstruction program
1997	UBC updated	Requirements increased for buildings close to active faults
December 1999	Designated FEMA Community of the Year for mitigation work	
November 2000	Measures AA and Q approved	$116.5 million for school safety program; Tax measure for safety efforts
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.
1991 to present	Completion of various retrofits and replacement projects	Retrofits were conducted for the Martin Luther King, Jr. Civic Center Building (City Hall), the Main Library, six out of seven fire stations (the seventh is in the process of being replaced), all public schools with life safety risks, and numerous private homes and businesses. New facilities, such as the Tsukamoto Public Safety Building, were constructed to replace vulnerable buildings.

Figure 4-1. Neighborhood Cache Locations

Disaster Resistant Berkeley program Neighborhood Cache Locations from Berkeley Fire Dept.
Projected to NAD83 UTM zone 10N (USNG 10SEG)

3

0 0.5 1 Miles

1:40,034

1 inch equals 0.63 miles

26_berkeley_caches.mxd of 20040303 bbq@ci.berkeley.ca.us

4.2. City Resources

Programs and policies are only meaningful if they are supported, enacted and enforced by motivated people with the time and interest to make them work. The City of Berkeley has many staff people who have hazard mitigation as an important part of their job description. Table 4-2 lists the key staff members in the City of Berkeley who focus on disaster mitigation issues.

The City staff has worked with federal and state grants through Project Impact, the Hazard Mitigation Grant Program and other efforts. As a result, the City has the appropriate budget and fiscal controls in place to manage future grants appropriately, pass audits, and contract out for specialists.

But the City's programs depend on more than just City staff. There are many advocates for safety in the larger community and represented on the City Council and numerous boards. The City Council recently gained a lot of experience in disaster mitigation through the revision of the General Plan and the Disaster Preparedness and Safety Element. Citizen boards and commissions, such as the Disaster Council, Housing Advisory Council, Landmarks Board and Planning Commission, also participated in this effort. The City Council has given strong support to many mitigation programs. For example, a City Council member conceived one of Berkeley's most successful and innovative programs, the transfer tax rebate for seismic safety upgrades.

Berkeley's residents are also very knowledgeable about and active in disaster management. Thousands of citizens have been trained in Community Emergency Response Teams (CERT) classes. Community members themselves initiated many of the innovative programs in the City, such as the seismic retrofit of schools.

Local residents have made significant investments in the community infrastructure via special taxes. Over the last nine years, five special ballot measures have been approved by a two-thirds majority of local voters to fund school safety programs and seismic retrofit of public buildings.

Berkeley garnered $6 million, more than any other city, from state funds associated with Proposition 122 in 1990. This proposition allocated money for local government safety projects, and the funds were used to construct the new Tsukamoto Public Safety Building, which houses the Emergency Operations Center, 9 -1-1 call center, Berkeley Fire and Police Departments.

The community-driven process to strengthen Berkeley's schools led to a discovery that state funds allocated for public safety projects could not be used in school districts. Berkeley was instrumental in enacting state legislation in 1991 and 1992 that allowed urban school districts eligibility for these funds. Berkeley also spearheaded the effort that changed funding regulations for state school bond funds to allow seismic safety projects to be funded. Since 1991, the City and Berkeley Unified School District have invested over $40 million dollars in state and federal funds in seismic safety projects.

Table 4-2. Key City Staff Who Work on Mitigation Issues

Department	Position and Name	Duties
City Manager's Office	Assistant City Manager; Arrietta Chakos	Coordinates City's mitigation and policy
Fire Department	Fire Chief Reg Garcia and Disaster Resistant Berkeley Coordinator; Carol Lopes	Coordinates preparedness activities
Fire Department	Emergency Services Manager; Bill Greulich	Manages OES for city
Fire Department	CERT trainers	Trains residents in citizen emergency response techniques.
Fire Department	Fire department inspectors	Prevention inspection
Health and Human Services	Director Health and Human Services Department; Fred Medrano	Manages health and safety preparedness efforts
Housing	Housing staff Janet Kennedy	Manages post-disaster housing effort
Human Resources	Deputy Director; David Hodgkins	Risk manager for building insurance
Planning and Development	Building Official; Joan MacQuarrie	Enforces building codes and oversees retrofit programs
Planning and Development	Three plan checkers and seven building inspectors	Reviews plans and inspects construction for code compliance
Planning and Development	Senior Analyst; Dan Lambert	Oversees URM and Soft Story building programs
Planning and Development	Zoning Official; Mark Rhoades	Manages current planning efforts
Public Works	City Engineer; Jeff Egeberg and staff engineers	Monitoring storm drains, culverted streams; City engineering work
Public Works	Senior Civil Engineer; Lorin Jensen	Floodplain manager

4.3. State and Federal Programs

Many of the 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 4-3 gives an overview of important State laws related to hazards and comments on how Berkeley complies with these laws.

Table 4-3. State Mitigation Requirement and Berkeley Implementation

Statewide Requirements	Berkeley Implementation
Mandatory Building Code. The State requires all communities to enforce a 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 the years. 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 making them vulnerable to unacceptable levels of life threatening collapse in earthquakes as intense as those that threaten Berkeley.	Berkeley enforces the state building code with additional local seismic and fire safety provisions. Berkeley staff and seismic advisors are currently working on a thorough risk analysis of the community. Updated local requirements for increased seismic codes were implemented in February 2003, exceeding 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 standard safety standard than other buildings. The standards include back-up utilities and design and construction checks by inspectors following state guidelines.	The Public Safety Building, the MLK Civic Center, six of seven fire stations and the EOC all have been built or retrofitted to meet essential services requirements. Construction of a new fire station to replace the one not retrofitted is scheduled. All public schools have been upgraded to Field Act standards.

Statewide Requirements	Berkeley Implementation
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 has just completed updating the General Plan, including the Safety Element. One of the Plan's key goals is to make a disaster-resistant community. The Safety Element has a mitigation approach and significant policy and action recommendations. This mitigation plan builds directly from the General Plan.
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 all state requirements.
Fault Zones. The 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 that zone maps be available for review by the public.	The State's Division of Mines and Geology created maps that delineate a 1/4 mile wide fault zone through the east side of the city where the Hayward fault is located. 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.	The City enforces state requirements by requiring site-specific investigations and feasible mitigation measures.

Statewide Requirements	Berkeley Implementation
Bay front 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 are subject to a permit from BCDC. The BCDC's Engineering Criteria Review Board before construction subjected the restaurants, harbormaster building and piers to rigorous independent review. Full consideration was given to the effects of deep-saturated, Bay mud soils and fill material. All development in this zone must be built with one foot of freeboard over flood levels.
Hospital Seismic Safety Act. The Office of Statewide Health Planning and Development (OSHPD) regulates hospital construction and renovation. The state required hospital owners to evaluate existing buildings. By 2008, all hospital buildings considered collapse hazards are to be removed from service and by 2030 all acute hospital facilities are expected to meet rigorous safety standards.	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, more than 610 have been retrofit. The City is retrofitting or abandoning the few URMs it uses.
Disclosure of Earthquake Risk. Four state laws work in tandem with state real estate requirements mandating 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.	Local compliance on this state law is carefully observed.

Statewide Requirements	Berkeley Implementation
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.	Berkeley has maps on file in the Planning Department and the newly updated General Plan. The Berryman reservoir is soon to be decommissioned, and the Summit Reservoir would not inundate areas of Berkeley.
Emergency Response Plans. In the wake of the 1991 East Bay Hills (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 and has supplemented many of its published plans for better local use.

5. Community Profile and Trends

Changing Demographics

The people and structures of Berkeley are continually changing. The number of people living in Berkeley has remained constant for the last decade at about 103,000. Households are, however, getting richer: in 1990, 8% of the population earned more than $100,000 per year; by 2000, more than 20% earned that much. The number of households earning less than $25,000 per year has declined from 43% to 32%[67]. The social implications of the income shift are varied. From a disaster perspective, typically wealthy populations rebound faster than poor ones after devastating events. However, emergency response personnel such as firefighters, police and city staff, may be less able to live in the city as real estate prices rise, possibly complicating post-earthquake response. Whether this economic shift is permanent or is a temporary impact of the financial boom in the late 1990's remains to be seen.

Although the population of Berkeley has remained constant, the number of jobs in the city has increased dramatically from about 50,000 in 1970 to nearly 80,000 today. This means that commuters into the city have increased significantly[68].

The number of people who speak a foreign language at home grew by 30% in the last decade. 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.

Berkeley has a mobile population, with just 46% of its current residents living in the city in 1995. This means that any community disaster awareness activities need to be ongoing to penetrate the population.

A lot of Berkeley's mobility is due to its large college student population, which ranges from about 25% to 30% of the city's residents. These students represent a significant portion of the rental market in the city 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 for some time. Similarly, the University of California at Berkeley faces significant earthquake risks[69], and a closure of this campus for any length of time would greatly impact the city.

Upgrading Building Stock

Berkeley is a densely populated city with well-established land use patterns. Nonetheless, a significant amount of development activity is ongoing in the city. In recent years, nearly 500 rental or condo housing units have been built or substantially renovated in the downtown area. Typically, this development represents densification of the downtown area, but not development of new sites. Similarly in private homes, many homes have been expanded or torn down and rebuilt, but few new lots have been developed due to Berkeley's already built-up state. The city's downtown commercial zone has been slowly upgrading, replacing older, vulnerable buildings with modern structures.

New construction adheres to modern design codes. These include regulations for structural resistance to earthquakes, landslide mitigation efforts, fire-resistant materials, and elevation above flood levels. From a natural disasters perspective, replacing or significantly renovating older structures increases the city's safety significantly.

City Policies and Goals

Many city policies are in place that are shaping the way the city is growing. In addition to disaster resiliency, the city's goals include protecting the environment, providing low-income housing, preserving historic structures, and maintaining City infrastructure.

Many areas of the city are subject to "down zoning". This means that future developments in these areas are required to be less dense than existing development. This designation was given in the 1970's following the construction of dense, multi-family structures in neighborhoods without community support. Many of these multi-family structures are particularly vulnerable to earthquakes. If they are destroyed in an earthquake and must be replaced with single-family homes or less dense occupancies, the City may lose much of its low-income housing. This threatens one of the key goals of the General Plan.

The Environmental Management section of the General Plan lists encouraging the restoration of natural waterways as one if its goals. Many of the city's streams were culverted in the 1960's as a flood control measure. Any change in the status of these culverts, already in a weakened state, would alter the city's flood risk.

The City has a strong value for preserving historic character. Any hazard, but particularly earthquakes or fires, could eliminate significant numbers of historic structures, which tend to be more vulnerable than modern construction to these hazards.

The University of California at Berkeley has expressed plans to expand their facilities. Any expansions could indirectly impact the city by bringing more people into the City. This could lead to more development in commercial areas that support the university and greater stress on the city's transportation routes. It could also complicate emergency response efforts and shelter needs.

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[70].

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Appendix A. Plan Development Process

Berkeley has a long tradition of an involved and active public. Disaster mitigation planning in the city is no exception: all of Berkeley's mitigation programs have involved extensive community involvement and, often, were initiated by the community itself rather than city government.

The Disaster Mitigation Plan for the City of Berkeley was developed through a process that built on years of disaster mitigation activities. Its development involved many departments in the City government; a host of councils and commissions at the City level; institutions, agencies, lifelines and companies in or serving the Berkeley community; and the general public. A wide range of voices contributed to this plan through many community meetings, a Mitigation Summit, and hours of public commission and council meetings on the broader issue of mitigation planning. This process is explained in more detail below.

Multi-year Development of Plan

Berkeley has been focusing on disaster mitigation for well over a decade. This Plan directly flows from two key initiatives: the recent city General Plan update and the Project Impact and Disaster Resistant Berkeley programs.

The City General Plan Update.

The recent revision of Berkeley's General Plan provided clear focus for the goals and objectives of the Disaster Mitigation Plan. In addition, the detailed research into hazards conducted as part of the Safety Element of the General Plan provided an excellent starting point for the hazards and risks analyses in this Plan. The General Plan was built with extensive public participation.

The General Plan is the result of an intensive two-and-a-half-year effort by the Berkeley Planning Commission with help from the Berkeley community and City staff. City staff prepared the first draft of the General Plan in May 1999. After a series of five community workshops, staff prepared a second draft in October 1999 for Planning Commission consideration. Over the next 12 months, the Planning Commission held seven public workshops, which included over 20 hours of "roundtable" discussions. Hundreds of Berkeley citizens participated in the workshops or submitted written suggestions for the Planning Commission Draft General Plan. After an additional series of Planning Commission meetings, the Planning Commission published a Planning Commission Draft General Plan in October 2000. Following publication of the Planning Commission Draft Plan, the Commission initiated a series of public hearings on the Draft Plan. During the spring of 2001, the Planning Commission dedicated another ten Planning Commission meetings to the consideration of additional public testimony and proposed amendments to the Planning Commission Draft Plan and held three public

hearings for the public to comment on the draft Plan. The goals, objectives, policies, and actions included in the General Plan are the result of four drafts, approximately 100 hours of public workshops, meetings, and hearings, close to 1,000 pages of policy suggestions submitted by Berkeley citizens, and the hard work and dedication of the Berkeley community and Berkeley Planning Commission. On July 11, 2001 the Planning Commission concluded its work on the update of the Berkeley General Plan and forwarded its recommended General Plan to the City Council for consideration and adoption.

This Mitigation Plan has, as an appendix, a matrix that cross-tabulated the General Plan and Safety Element actions that are directly incorporated into this plan. The Mitigation Plan arises from Berkeley's on-going and consistent mitigation dialogue. Unlike other jurisdictions to which the "mitigation" concept may be new, it has long been familiar territory in Berkeley's public arenas.

Project Impact and Disaster Resistant Berkeley

Berkeley was designated a Project Impact Community in 1999. Prior to 1999, Berkeley conducted numerous disaster mitigation and preparedness activities. Berkeley's incremental mitigation programs were generally initiated, promoted and advocated for by community members. A prime example of this is the 1990 program to assess and upgrade Berkeley's school buildings: this was initiated by a group of concerned parents who worked to identify the problem and craft a solution with local, state and federal government resources. All of Berkeley's early mitigation and preparedness programs involved extensive community input and participation, as this is a core element of how things get done in the city.

Project Impact was used to coordinate the many ongoing disaster mitigation and preparedness efforts in the city. Numerous community outreach programs were launched, providing significant opportunities for community input on mitigation programs. This includes over 150 community presentations, meetings, forums and neighborhood drills. Some of the many activities that Berkeley conducted under Project Impact are listed in detail in Appendix B.

In addition to public outreach, the City changed the way departments within the city work together on disaster related issues. Representatives from all of the key departments involved in disaster mitigation, preparedness and emergency response activities were brought together in a formal process to review disaster related activities on a monthly basis. This ongoing effort has improved communication on disaster issues among city departments as well as bringing varied expertise to the many ongoing projects.

All of the activities conducted under Project Impact are now referred to as the Disaster Resistant Berkeley program.

Organizations and People Involved

Many people and institutions participated in different roles in the development of the Berkeley Mitigation Plan. The key groups are listed below with the roles they played.

City Manager's Office

The City Manager's Office coordinated all aspects of preparing the Disaster Mitigation Plan.

Core City Plan Development Team

Many city departments participated actively in the development of the Mitigation Plan. The Planning Department, Public Works Department, Fire Department and Information Technology Department participated in bimonthly meetings developing the Plan. Other city departments participated in selected meetings and provided detailed reviews of the draft plans.

All department heads in the City were given an opportunity to review and contribute to the Plan.

Disaster Resistant Berkeley Standing Committee

This committee provided oversight for the plan development process. This group has met for over three years and provided baseline information and programs and facilities, gave regular guidance on the Plan as it progressed, and contributed advice on priorities for objectives and actions. This group also gave feedback on feasibility of actions in the plan and implementation details.

The Disaster Council

Berkeley established a Disaster Council of experts and concerned citizens in 1989 to monitor disaster mitigation and preparedness activities in the city. This council meets in public monthly. It is an advisory council that provides the City Council with advice and information relating to disasters. Its members are appointed by the City Council, per the guidance of a local ordinance. This group has provided oversight to implementation of state mandated programs, such as the URM upgrade program. It has also monitored disaster related bond spending, such as the bond funding spent on upgrading municipal buildings. This group publicly reviewed the Safety Element and the Mitigation Plan and played an instrumental role in crafting these documents.

Other Commissions, Councils and Boards

The Safety Element and the Disaster Mitigation Plan were reviewed by the Housing Advisory Commission, the Planning Commission, the Police Review Commission, the Public Works Commission, the Landmarks Preservation Commission, the Commission on Disability, and the Community Environmental Advisory Commission. All of these commissions are appointed by the City Council and hold monthly meetings in public.

Some of these commissions provided detailed review of certain elements key to the mitigation plan. For example, the Housing Advisory Commission provided detailed review for the inventory and risk analysis of soft-story structures.

In addition, the Mitigation Plan was sent to all of the over forty commissions, councils and boards in the city for their review and comment.

Seismic Technical Advisory Group

This group of technical specialists meets monthly and reviewed technical information related to the Plan regularly during its development process. This group also held a working meeting with utility representatives to discuss joint mitigation priorities and programs.

The Mitigation Summit

A Mitigation Summit was held on December 5, 2003. This event was the culmination of two years' worth of work to discuss mitigation with the City's most involved communities in order to develop a mitigation plan that reflected their concerns. The City of Berkeley and the University of California at Berkeley cosponsored the event. More than 120 invited leaders representing the following groups attended it:

City of Berkeley Government, Councils, Commissions and Boards

- Mayor's Office
- City Manager's Office
- Finance Department
- Department of Information Technology
- Neighborhood Services
- Planning and Development Department
- Public Works Department
- Transportation Department
- Fire Department
- Health and Human Services Department
- Office of Emergency Services
- Berkeley Unified School District
- Board of Education
- City Council
- Public Works Commission
- Rent Stabilization Board
- Parks and Recreation Commission
- Transportation Commission
- Commission on Disability
- Housing Advisory Commission
- Landmarks Preservation Commission
- Disaster Council
- Fire Safety Commission
- Seismic Technical Advisory Group

U.C. Berkeley

- Chancellor's Office
- Office of Facilities Services
- Office of Emergency Planning
- Office of Business and Administrative Services
- Office of Business Resumption
- Office of Economic Development
- Office of Budget Finance

- Office of the Registrar
- Office of Information Systems Technology
- Office of Vice Chancellor for Research
- Office of Community Relations
- Department of Architecture
- Disaster Resistant University Initiative
- Residential and Student Services Program
- Office of Government Affairs
- Physical Plant Campus Services
- Office of Parking and Transportation
- Communication and Network Services
- Berkeley Seismology Lab
- University Health Services
- Office of Environment, Health and Safety
- Office of the Vice Provost
- Physical and Environmental Planning

Other Government Agencies

- Federal Emergency Management Agency
- California Office of Emergency Services
- University of California: Office of the President
- Alameda County
- Alameda County Board of Supervisors
- Association of Bay Area Governments (ABAG)
- California Public Utilities Commission
- United States Geological Survey (USGS)
- Lawrence Berkeley National Laboratory
- State Department of Health Services
- City of Oakland Office of Emergency Services

Lifelines and Utilities

- The Bay Area Rapid Transit District (BART)
- Pacific Gas and Electric Company (PG&E)
- East Bay Municipal Utilities District (EBMUD)
- SBC

Private Companies, Nonprofits, and Community Groups

- Bayer Corporation
- Alta Bates Hospital
- The Berkeley Alliance
- Property Owners Association
- Black Property Owners Association
- Collaborating Agencies Responding to Disasters (CARD)
- Downtown Berkeley Business Association
- St. Paul AME Church
- The Salvation Army
- Associated Students of the University of California
- Parent Teachers Association

- Neighborhood representatives

The Forum discussed appropriate mitigation approaches to numerous important topics for the Berkeley community, such as preserving the rental market and protecting community infrastructure. Forum participants were given a draft of the Mitigation Plan's objectives and act

The Planning Committee for the Disaster Forum brought together key representatives of the City, including the City Manager's Office, Fire, Planning, and Building Departments with representatives of numerous departments within UC Berkeley. This group, in the process of planning the community event, addressed numerous disaster mitigation topics and explored how the City and the University can work together fruitfully on future disaster mitigation activities.

Regional Lifelines and Utilities

Representatives from key regional lifelines and utilities participated in the plan development process by providing detailed information about their hazard and risk assessments and risk mitigation plans. These organizations include East Bay Municipal Utilities District, Pacific Gas and Electric Company, Bay Area Rapid Transit District, CalTrans, SBC Communications and the Kinder Morgan Pipeline Corporation. Many representatives of these agencies attended the Disaster Forum held in December 2003.

Key Institutions in City

Representatives from key institutions in the City participated in the Plan development process by providing detailed information about their hazards, risk assessments and future mitigation plans. These institutions included UC Berkeley, Lawrence Berkeley National Lab, Vista Community College, and large corporations in Berkeley such as Bayer Corporation.

Community Groups

Community groups participated in the disaster preparedness programs of the city and were given many chances to air their opinions about disaster mitigation activities. In 2003, during the plan development process, the City convened 20 neighborhood presentations and five community town hall meetings on disaster topics. Many representatives of community groups attended the December 5, 2003 Disaster Forum.

Consultant Team

A team of four consultants provided assistance with document review, data compilation, technical analyses, preparation and other activities associated with developing the Plan. This team had meetings with the City Manager's Office staff bi-monthly, and met with other City departments as needed.

Public Input to the Plan

Public input is a way of life in Berkeley's city governance. Public input to this Plan occurred in numerous ways.

Residents of Berkeley were directly given the opportunity to review the Mitigation Plan in draft form. The Plan was posted to the City website for comments for thirty days. Copies of the draft Plan were also posted at all City libraries for thirty days for review and comment by citizens.

The city has nearly 40 commissions, councils and boards made up of concerned citizens that address a wide range of issues important to the community. All of these commissions meet in public. Nine key commissions, councils and boards reviewed the Plan in detail and discussed it at a public meeting. All of the commissions were given the opportunity to review the Mitigation Plan.

Members of key institutions, non-profits, businesses, business organizations and neighborhood groups attended a Mitigation Summit in December 2003 where priorities for mitigation were discussed during a full-day program. The draft Mitigation Plan objectives and actions were distributed to all attendees for comments.

The Seismic Safety Element of the City's General Plan was updated shortly before preparation of the Mitigation Plan. The Safety Element describes many of the hazards issues presented in the Mitigation Plan, as well as outlining goals and policy objectives that guided the objectives and actions in the Disaster Mitigation Plan. The Safety Element was crafted through a public review process and community meeting process.

Berkeley's ongoing mitigation and preparedness activities include significant public outreach, including dozens of community meetings, forums and neighborhood drills. Berkeley inhabitants have clearly expressed their opinions and concerns about disaster issues through these forums.

Appendix B. Overview of Recent Disaster Management Efforts

The City of Berkeley is a model for disaster preparedness and hazard mitigation in California. By taking a multi-hazard approach to preparedness and damage prevention, the City has significantly improved the community's resources for recovery and resilience.

Protecting Public Facilities

Since 1991, Berkeley voters have approved over $362 million in local bonds to seismically upgrade and improve fire resistance at public facilities.

- Sixteen (16) public schools
- Seven fire stations
- Civic Center Administrative Building
- Main Library
- Emergency Operations Center and Public Safety Administrative Building

Innovations

- The City has a 1.5 percent tax levied on property transfer transactions. Up to one-third of this amount can be rebated for home seismic upgrades during the sale of property

- The City waives permit fees for seismic retrofits on non-strengthened residences and unreinforced masonry structures

- Up to 60 percent of Berkeley homes made safer through these programs

- The City grants and loans up to $35,000 to low-income homeowners and seniors to seismically strengthen their homes their homes

- Fire Assessment District formed to support vegetation reduction programs

- Improved Water Distribution System and mobile pumping units for fire suppression

- Over 500 of 600 Unreinforced buildings have been addressed since the City enacted the Unreinforced Masonry Compliance Program in 2000

Community Participation

- Community members prepare for disaster by participating in City-sponsored training programs in fire suppression, disaster first aid, and light search and rescue

- Neighborhood Emergency Cache Program: Placement of professional emergency supplies in selected, highly prepared neighborhoods within each of eight City

Council districts to back up emergency responders and at each of Berkeley's 16 public schools

Awards

- Disaster Pre-disaster Mitigation Grant Program and Designated Model Community from California Office of Emergency Services: Year 2003

- Disaster Resistant California (DRC) - Demonstrated significant commitment to pre-disaster hazard mitigation: Year 2002

- Disaster Resistant California (DRC) Partnership Appreciation - Commitment to Project Impact Initiative and Devotion to the Community: Year 2001

- Department of Insurance Earthquake Retrofit Program: Year 2000

- Model Community of the Year for Federal Emergency Management Agency's Project Impact Program: Year 1999/2000

Disaster Resistant Berkeley Accomplishments in 2002-2003

A close-up look at the detailed activities of the Disaster Resistant Berkeley program for 2002-2003 provides insight into the many ongoing disaster management related activities of the Berkeley community. This is a partial snap-shot of disaster related activities in Berkeley as it represent only the work of one City program during two calendar years.

Presentations

- 50 Neighborhood, Greek Housing and business presentations - 2002

- 20 Neighborhood Presentations – 2003

Forums

- 6 Community Town hall meetings held on preparedness – 2002

- 5 Community Town hall meetings held on preparedness – 2003

- 1 Community Emergency Supply Exposition - 2003

- 8 Stakeholder Meetings and Task Forces developed to promote DRB initiatives, Volunteerism, Care and Shelter, School Emergency Supplies Program, and more

Neighborhood Disaster Drills in 2003

- 6 Fire Department-led advanced disaster drills in highly trained neighborhoods

City Disaster Drills

- City participates in five-agency Berkeley Alert disaster drill June 6, 2002

- City conducts first emergency operations center (EOC) disaster drill in new EOC

- City plans for Berkeley Alert 2004 multi-agency disaster drill

Emergency Supply Cache Program 2003

- Professional Emergency Supply Cache designated to highest ranking prepared neighborhood within each Council District

- 20 - 10 to 20 foot containers and emergency supplies placed at all public schools

Community Emergency Response Team Classes Offered

- CERT class enrollment doubled in 2003 due to emergency supply cache program

- Three new CERT classes added to CERT curriculum since 2000:

    - Home Retrofit
    - Shelter Operations
    - Anti-Terrorism Preparedness Workshop

Outreach

- 1000 Berkeley businesses hand delivered business preparedness brochure 2002

- 350 Neighborhoods offered competition to host free emergency supply cache for each Council District - 2003

- 18 Neighborhood site interviews and assessments held with cache applicants

- 2 Disaster Resistant Berkeley information booths at Disaster Resistant California

Facilities Surveyed for Shelter Capacity 2002

- 17 Public Schools Surveyed for Shelter Capacity

- 10 Faith based organizations surveyed

- 5 Community based organizations surveyed in preparation for City Care and Shelter Plan

- City Wide Care and Shelter Plan underway 2003

Public Education Materials Developed

- Brochures designed and distributed:

    - Seniors, Persons with Disabilities
    - Homeowners
    - Renters and Building Owners
    - Businesses

    - Contractor Hiring Tips
    - Home Strengthening Incentive Programs
    - Disaster Resistant Berkeley Program

- Neighborhood Preparedness Presentation developed

- Business presentation for created

- Disaster preparedness guideline for businesses created

- Berkeley Cable Television Educational Series created 2002

Incentives and Contributions Requested and Received

- 24 Emergency Kits from Truitt and White

- 2 Emergency NOAA Radios

- 20 Emergency Kits from Ashby Lumber

- 4 Emergency Radios

- City offers one (8 total) professional emergency supply cache for highest ranking prepared neighborhoods in each Council District causing CERT enrollment to double - Year 2003

- City offers purchasing opportunities for professional emergency supplies to Berkeley residents – Year 2003

Database Development

- 390 Contact numbers added into the City of Berkeley's database

- 417 Neighborhood Associations added into City of Berkeley's database

Insights into Making Mitigation Work in Berkeley

The Natural Hazards Review published a paper analyzing mitigation programs in Berkeley and investigating the community support and personal leadership that led to successes. This paper, "Making it Work in Berkeley: Investing in Community Sustainability," written by Arrietta Chakos, Paula Schulz, and L. Thomas Tobin was published in Vol. 3, No. 2, May 1, 2002 of the journal and provides a deeper discussion of Berkeley programs.

Appendix C. List of City Owned and Leased Buildings

City of Berkeley Buildings

Note: This table may have errors or omissions

Retrofitted Buildings

No.	Building Name	Address	Use	Emergency Response Importance	Comments on Condition & Construction	Square Feet	Building Replacement Value ($)	Historic Landmark
Key Civic Buildings								
1	Martin Luther King, Jr. Civic Center	2180 Milvia St.	Offices, Historic	High	Concrete Frame, 6 story, Retrofit in 2001, Base Isolated	77,145	16,562,000	Yes
2	Public Safety Building	2100 MLK Jr. Way	Police, Fire, and 9-1-1 Headquarters	High	2 story, Built in 2000 to essential services standards. Base Isolated	60,108	11,465,300	
3	PSB Garage		Garage/Storage		1 story, Built 2000	2,738	296,400	
4	Emergency Operations Center	997 Cedar St.	Emergency Oper.Ctr.	High	New building to essential services standards +/- 5 years old	3,774	773,000	
5	Sather Gate Mall and Garage	2438 Durant Ave.	Public Parking and Retail		Retrofitted +/- 10 years ago. Still vulnerable to damage, but not collapse. Concrete Frame, 5 story	224,628	8,868,300	
Libraries								
6	Main Library	2090 Kittredge St. &	Library, public assembly, Historic Building		Complete retrofit to seismic code (?) with new underpinning and additional piles, and remodel completed in 2002. Vulnerable to damage, but repairable.	102,000	16,500,000	Yes
7	Main Library	& 2031 Bancroft	Library, public assembly		Addition constructed in 2002 to regular code.	incl. add.	0	
Fire Stations								
8	Fire Station #1	2442 8th St.		High	Retrofitted to essential services standards. 2 stry.-rebuilt 1999	5,260	675,400	

9	Fire Station #2	2029 Berkeley Way		High	Retrofitted to essential services standards. 2 stry.- rebuilt 1998	12,522	1,608,000	
10	Alarm Headquarters	2029 Berkeley Way		High	1 stry.- rebuilt 1998	840	93,500	
11	Fire Station #3	2710 Russell		High	Retrofitted to essential services standards. 2 stry.- rebuilt 1999	5,100	654,900	
12	Fire Station #4	1900 Marin		High	Retrofitted to essential services standards. 2 stry.- rebuilt 1999	5,341	652,900	
13	Gas Pump House	1900 Marin	Refueling facility	High	1 stry.- rebuilt 1999	101	5,000	
14	Fire Station #5	2680 Shattuck Ave.		High	Retrofitted to essential services standards. 2 stry.- rebuilt 1998	9,302	1,240,400	
15	Fire Station #6	999 Cedar St.		High	Retrofitted to essential services standards. 1 stry.- rebuilt 1999	4,153	607,700	
16	Drill Tower	999 Cedar St.	Training Facility		5 stry.- 1999	1,936	170,700	
Recreation and Parks								
16	Live Oak Community Center	1301 Shattuck Ave.	Recreation and Assembly	High - Shelter	The URM structure was retrofitted using a membrane designed by Pat Crosby. Remains vulnerable.	12,281	1,118,400	

Buildings Known to Require Retrofits

No.	***Building Name***	***Address***	***Use***	**Emergency Response Importance**	***Comments on Condition & Construction***	***Square Feet***	***Building Replacement Value ($)***	**Historic Landmark**
Key Civic Buildings								
17	Veterans Memorial Hall	1931 Center St.	Assembly and Homeless Shelter		Collapse hazard building, study done, needs to be retrofitted	33,254	3,710,100	Yes
18	Center Street Garage and Commuter Store	2025 and 2033 Center St.	City and Public Parking and Offices		Vulnerable to earthquake damage. Too expensive to	175,500	6,408,000	

					retrofit. Will be replaced. Concrete Frame, 5 story,			
Corporation Yard								
19	Ratcliff Building		Park facilities, equipment maintenance, repeaters and storage for emergency communication equipment	High	URM, collapse hazard	16,486	992,200	Yes
Buildings Leased to Others								
20	Old City Hall	2134 MLK, Jr. Way	Offices and Assembly		Collapse hazard building. Preliminary studies done. Needs funding. Continued use by BUSD for offices and the City Council for meetings.		0	

Buildings To Evaluate for their Seismic Safety

No.	*Building Name*	*Address*	*Use*	**Emergency Response Importance**	*Comments on Condition & Construction*	*Square Feet*	*Building Replacement Value ($)*	**Historic Landmark**
Key Civic Buildings								
21	Newly Acquired City Office Building	1947 Center St.	Cap.Projects/Pb.Wrk.Eng.	High	Determined by V. Bertero to meet "substantial life safety" and not be a collapse hazard building. It will house 260 +/- City employees (more than the Civic Center building). Concrete frame structure, 6 stories			
Public Health Buildings								
22	Health Clinic	830 University Ave.	Health Clinic		Single story building, Nothing done to it	6,739	725,100	
23	Mental Health Offices	2636-40 MLK Way	Mental Health Offices		This building has seismic vulnerabilities. A proposed renovation project would cost $1 to 1-1/2 million. HHS wants to replace it with a new building.	11,270	1,039,400	

24	Health and Human Services Office	2344 6th St.	HHS Offices		Building was purchased in 1998, fully renovated, and retrofitted with new shear walls. It is a two-story wood frame building. Building was gutted and fully renovated two story	11,930	1,180,800	
Fire Stations								
25	Fire Station #7	2931 Shasta Road		High	Replacement project underway and should be completed during 2004, Convert to a storage building 1 stry.- not upgr.	2,165	235,300	
Senior Citizen Centers								
26	North Berkeley Senor Citizens Center	1901 Hearst St.	Public assembly	High - Shelter	1979 No seismic work done. Should be evaluated because of post disaster shelter uses.	20,039	2,219,700	
27	South Berkeley Senior Citizens Center	2939 Ellis St.	Public assembly	High - Shelter	1977	17,156	1,824,400	
28	West Berkeley Senior Citizens Center	1900 6th Street (1904?)	Public assembly	High - Shelter	Cl.D - 1982 - C/S fire alarm	9,793	1,084,800	
Recreation and Parks								
29	Francis Albrier Center	2800 Park St.	Recreation and Assembly	High - Shelter	Grant request to replace gymnasium. This should be evaluated.	8,287	710,900	
30	James Kenney Community Center	1720 8th St.	Recreation/Assembly	High - Shelter	A renovation project with some seismic is planned.	tbd	1,666,000	
31	Grove Recreation Center	1730 Oregon St.	Recreation/Assembly	High - Shelter	Should be evaluated.	10,601	939,400	
32	Ala Costa Center	1300 Rose St.	Recreation/Assembly/Child Care	High - Shelter	Should be evaluated.CI.D	5,814	463,700	
33	Cedar Rose Park Building		Center for disabled children		Single story wood frame			
Marina (other than leased locations)								
34	Administration Building	201 University Ave.	Offices		Some dry rot in piles and on liquefiable soils, two sto	2,529	271,100	

Buildings Leased To Others (LESSOR)								
35	Black Repertory Theater	3201 Adeline St.	Assembly		2 story		1,290,000	
Locations leased by the City (LESSEE)								
36	Police substation. BPD traffic control	3140 MLK Jr. Way	Offices				0	
37	Marchant Building (owned by the University of California)	2121 Allston Way	Office surge space building. The building will become a private museum.		Building should be evaluated. It will be used for office surge space pending renovation of 1947 Center St. Ultimately will become a museum.	25,000	0	

Other Buildings

No.	***Building Name***	***Address***	***Use***	**Emergency Response Importance**	***Comments on Condition & Construction***	***Square Feet***	***Building Replacement Value ($)***	**Historic Landmark**
Libraries								
38	North Berkeley Branch Library	1170 The Alameda	Library, public assembly		Frame, See Degenkolb report	5,748	733,800	
39	Claremont Branch Library	2940 Benvenue	Library, public assembly		Frame, See Degenkolb report	10,463	1,025,400	
40	West Berkeley Branch Library	1125 University Ave	Library, public assembly		Frame, See Degenkolb report	5,905	643,300	
41	South Berkeley Branch Library	1901 Russell St.	Library, public assembly		See Degenkolb report	5,250	541,800	
Corporation Yard								
42		1326 Allston Way	Quonset Warehouse		All Steel, 1 stry.	4,100	186,800	
43			Office & Storage			2,939	132,800	
44	Assembly Building		Assembly/Washroom		1 stry.	2,405	231,300	
45	Equipment Maintenance Building		Equipment Main.Bldg		1 stry.	11,277	700,800	
46			Guard Shack		1 stry.	72	4,500	
47			Lumber/Pipe Storage			774	29,800	
48			Small Warehouse		1 stry.	3,000	148,000	
49	Traffic Maintenance		TrafficSign/PaintShop		1 stry.	4,320	334,500	
50			Fuel Island/und.tanks		All Steel, 1 stry.	1,200	180,000	

51			NurseryAssemblyRm			864	51,500	
52			Nursery Storage			864	30,100	
53			NurseryStorage-1975			240	10,100	
Solid Waste Transfer Buildings								
54	Tipping Building/Transfer Station	1199 2nd St.	Waste Transfer		Some maintenance problems. All Steel, 1984	21,000	844,400	
55			Equipment Shelter		Value incl. above	4,000	141,800	
56	Vehicle Maintenance Facility		Maintenance Bldg.		All Steel, 1=2, 1984	6,280	427,900	
57	Scale House		Scale House		All Steel, 1984	360	32,200	
58	Fuel Pumps and Tanks		Fuel Isld./WashRack		All Steel, 1984	2,600	148,100	
59			Underground Scales		All Steel, 1984		311,000	
60	Administration Building	1201 2nd St.	Offices		All Steel, 1984	3,750	352,400	
61		1231 2nd St.	Secondary Office			6,510	220,500	
62			Old Storage Bldg.				200,000	
Animal Shelter								
63	Animal Shelter	2013 2nd St.	Office, Kennels, Laboratory and Storage		Bond passed to build a new shelter, but site selection and design progressing slowly. Property will be sold.	4,780	465,000	
64	Cattlery		Cattlery		1 stry.	800	72,000	
Swim Centers								
65		2100 Browning St.	West Campus Ctr.		incl. 337,000 for pool/ pump/ filter Field Act building on BUSD land. City pays for maintenance and may ultimately have full ownership.	2,567	613,000	
66		On Hopkins St.	M.L.King Jr, Ctr.		Field Act building on BUSD land. City pays for maintenance and may ultimately have full ownership.	3,329	686,600	
67		2771 Telegraph Ave.	Willard Ctr.		Field Act building on BUSD land. City pays for	3,316	599,800	

					maintenance and may ultimately have full ownership.			
68	Berkeley High Warm Water Pool	Berkeley High School						
Redevelopment Agency								
69		1654 5th St.	Dwelling		Frame, 1 unit, hard-wired smoke detectors	1,425	147,800	
70		729-31 Virginia St.	Dwelling		Frame,1unit,2stry.1993	2,221	226,200	
71		1646 5th St.	Dwelling		Frame, 2 unit, hard-wired smoke detectors	1,600	130,400	
Berkeley Housing Authority								
72		1360-70 Dwight Wy	Residential		Frame - 2 units Authority has about 62 dwelling units. These should be evaluated.	2,187	178,100	
73		1371 Dwight Way/ 2450 Valley	Dwelling		Frame - 2 units	2,187	178,100	
74		1500-04 7th St.	Dwelling		Frame - 3 units	3,280	267,100	
75		870-80 Jones St.	Dwelling		Frame - 2 units	2,187	178,100	
76		1402-08 MLK Way	Dwelling		Frame - 4 units	4,433	361,100	
77		1838-40 Rose St.	Dwelling		Frame - 2 units	2,067	168,400	
78		2032-36 Virginia St.	Residential		Frame - 3 units	3,389	276,100	
79		2024-30 Virginia St.	Residential		Frame - 4 units	4,659	379,500	
80		2798A/B Sacramento St.	Dwelling		Frame - 2 units	2,187	178,100	
81		2735-37 Sojourner Ct.	Dwelling		Frame - 2 units	2,067	168,400	
82		2731-33 Sojourner Ct.	Dwelling		Frame - 2 units	2,187	178,100	
83		2725-27-29 Sojourner Ct.	Dwelling		Frame - 3 units	3,279	267,100	

84		1903-09 Ward St.	Dwelling		Frame - 4 units	4,372	356,200	
85		1911-17 Ward St.	Dwelling		Frame - 4 units	4,374	356,300	
86		1921-27 Ward St.	Dwelling		Frame - 4 units	4,374	356,300	
87		1107-15 Francisco	Dwelling		Frame - 5 units	5,466	445,300	
88		1117-23 Francisco	Dwelling		Frame - 4 units	4,374	356,300	
89		1161-65 Francisco	Dwelling		Frame - 3 units	3,279	267,100	
90		1169-75 Francisco	Dwelling		Frame - 4 units	4,374	356,300	
91		2374 West/1323 Channing Way	Residential		Frame - 2 units	2,200	179,200	
92		2800 Sacramento	Dwelling		Frame - 1 unit	820	78,000	
R.H.C.P.								
93		1521 Alcatraz St.	Residential fourplex		Frame - 4 units - 1995	4,539	369,700	
94		1812 Fairview	Residential triplex		Frame - 3 units - 1995	3,280	267,100	
95		2231 8th St.	Dwelling		Frame - 3 units - 1995	2,248	183,100	
96		1605 Stuart St.	Residential triplex		Frame - 3 units - 1995	3,280	267,100	
97		3016 A and B Harper St.	Residential duplex		Frame - 2 units - 1995	2,398	195,300	
Recreation and Parks								
98		777 Harrison St.	Skateboard park bldg		TBD		210,000	
99		1201 Euclid St.	Codornices shed			100	11,700	
100	Rose Garden Restroom and storage		Restroom and storage			671	78,600	
101		El Portal/Glendale	La Loma Park			460	39,000	
102	Live Oak Toilet Shelter	1301 Shattuck Ave.	Restroom			100	11,700	
103	Art & Garden Center	1275 Walnut St.	Assembly	High - Shelter		2,715	277,700	
104	John Hinkel Clubhouse		Recreation/Assembly		This building is closed and fenced.	3,000	254,400	
105		1720 8th St.	Recreation/Assembly	High -		tbd	1,666,000	

				Shelter				
106			Aux. Bldg. East of Center			tbd	278,000	
107		1718 18th Street	Totland Center			1,800	167,100	
108			offices & restrooms			476	48,700	
109			Cragmont Obser.shltr			540	28,100	
110		1901 Yosemite	Stone Face storage			96	4,000	
111		222 Fairlawn St.	Fairlawn Shelter			637	42,100	
112	Lawn Bowling Club House	2270 Acton St.	lawnbowling clubhse.	High - Shelter		2,304	193,900	
113			Storage shed			116	4,000	
114			Cragmont Rest Rms		fire-resistive	1,472	213,500	
Aquatic Park								
115	Boathouse	On Bolivar Drive	Offices and boathouse		Aquatic park facilities are all vacant (?)	6,740	235,200	
116			Storage bldg.			888	50,600	
117			Shop and storage			1,332	76,000	
118	Rod and Gun Club		Assembly			2,400	136,900	
119	Bird Rehabilitation Building					1,000	67,200	
120	Bird Rescue Office		Office			840	58,900	
121			Gardeners Shed			200	6,000	
122			Concession and Restroom			414	40,600	
123			1972 restrooms			440	38,000	
124	Rowing Clubhouse					2,603	113,600	
125			Judges Stand			1,200	59,700	
Marina (other than leased locations)								
126			Maint.bldg/office/stor.		1 story	3,170	213,300	
127	Dock of the Bay	235 University Ave.	Restaurant (vacant)		2 story	12,755	1,266,800	
128	Shorebird Nature Center	160 University Ave.			Good new building (1 story straw bale construction)	960	67,400	
129			Restrm @ Nature Cr			576	90,100	
130			No.Hoist/boathouse		All Steel		45,000	
131			No. Hoist/boathouse		All Steel		45,000	
132			Wst.Restrms.-1974			576	83,100	

133			N/W Restrooms			720	103,900	
134			N/E Restrooms			720	103,900	
135			East Restrooms			720	103,900	
136			South Restrooms			576	83,100	
137			Fish.Pier Restrms.			299	41,200	
Buildings Leased To Others (LESSOR)								
138	Berkeley Yacht Club	1 Seawall Drive	Berkeley Yacht Club			6,507	687,200	
139	Berkeley Adult Health Center	1890 Alcatraz Ave.	Berk. Adult Health Cr.			4,000	424,500	
140	California Conservation Corps	669 Gilman St.	1999 fiber proc.		All Steel	18,000	1,500,000	
141	California Conservation Corps		Restroom C/D			120	29,500	
142	California Conservation Corps		Office			2,300	253,000	
143	California Conservation Corps		Storage			1,350	134,000	
144	Commonarts	2218 Acton St.	Residential			1,600	160,000	
145	Lessee?	2240 9th St.	Group Residence			2,052	222,200	
146	McKinley House for women (B.O.S.S.)	2111 McKinley	Residential shelter		2 story, Two story concrete block building	5,610	406,900	
147	Harrison House for men (B.O.S.S.)	711 Harrison St.	Residential shelter		One story		0	
Locations leased by the City (LESSEE)								
148	City Archives	2065 Kittredge St.	Archival storage of records		Should be evaluated because of archive importance.		0	
149	Library	1222 University Av.	Library book storage		Deleted 3/18/02		0	
150	Library	731 Dwight Way	Library				0	
151	Library	1551 Buena Vista	Alameda - book storage				0	
152	Energy Offices	1013 Pardee	Energy Offices				0	
153	Unknown	1767 Alcatraz	tbd				0	
154	Records Center	6701 San Pablo Av	Records Center				0	

155	Permit Center/Planning Department	2118-20 Milvia St.	Offices for Economic Development, Planning, and Building departments. Contains building plans and records	High	Has had some seismic bracing. Vulnerability unknown.		0	
156								
157	Rent Stabilization Board Office	2125 Milvia St.	Offices		Concrete frame. Should be evaluated. City leases only one floor.		0	
158	BerkeleyWorkSource	1950 Addison Street, #105	Offices		City will move offices to 1947 Center and vacate building.		0	
159	Police Department P.A.L Program	1255 Allston Way	Offices and Assembly				0	
160	Berkeley Housing Authority	1901 Fairview St.	Offices				0	
161		2055-57 Center St.	Print/ Mail				0	
162		2016-20 Center St.	Bus.Lic./Youth Rec.		Open front, masonry walls. City will move offices to 1947 Center and vacate, some retrofit work completed		0	
163	Health and Human Services	2649 MLK Jr.Way	Mental health service				0	
Missing Buildings								
164	Old City Hall Annex	McKinley						
165	Residence	2230 and 2234 Ninth Street	Residential owned by BHA?					
166	Residence	2235 8th Street	Residential owned by BHA?					
167	Women's Refuge	2213 Byron Street						
168	Berkeley High Health Center	2246 Milvia	Portable Building					
169	Woman's Infant Care	1769 Alcatraz Avenue						
170	Library Rental	2200 Shattuck Avenue						
171	Police Review Board and	1900 Addison			Retrofitted			

	Youth Works	Street						
172	Health and Human Services Administrative Offices	2808 Telegraph Avenue						

Appendix D. Cost Benefit Analyses for Actions in Plan

The Berkeley community considered costs and benefits of each action in the Plan during the process of developing and prioritizing them. A detailed cost-benefit calculation was conducted for a portion of action A-1 as part of preparing an application to FEMA for grant funds: seismically strengthening the Ratcliff Building. A narrative and summary of this cost-benefit calculation and analysis follows. Similarly detailed cost-benefit analyses will be conducted for additional actions in the Plan as required to secure funds for and implement each activity.

SUMMARY

Scenario Run ID: 01

Ratcliff Building	1326 Allston Way	Berkeley, CA, 94702	
Project Description: Retrofit existing building to meet Essential Service Building Standards			
Default Building SDF Before Mitigation:	TypicalCalifornia	User-Entered SDF?	YES
Default Building SDF After Mitigation:	SeismicDesign	User-Entered SDF?	YES
Building Type:	UNREINFORCED MASONRY BEARING WALL	Analyst:	James E. Russell

Data Used For This Analysis:

Building Replacement Value ($/sf)			$350.00
Total Floor Area (square feet):			16,700
Total Building Replacement Value:			$5,845,000
Demolition Threshold Damage Percentage:			40%
Total Contents Value			$1,274,000
Total Displacement Costs ($/month):			$92,685
One Time Displacement Costs ($)			$885,950
Cost of Providing Services from this Building ($/day)			$57,795
Post-Disaster Continuity Premium ($/day)			$203,585
Total Value of Lost Services ($/day)			$261,380
Total Monthly Rent from All Tenants ($/month)			$0
Estimated Net Income of Commercial Businesses ($/month)			$0
Total Mitigation Project Costs			$6,785,365
Discount Rate	7.00%	Present Value Coefficient	13.80
Project Useful Life (years)			50
Average Occupancy (24 hours, 7 days per week)			20.33
Value of Avoiding a Minor Injury			$1,250
Value of Avoiding a Serious Injury			$12,500
Statistical Value of Life			$2,200,000

Data That Vary By Seismic Intensity:

PGA (% of g)	Building SDF (%)	Modified SDF (%)	Contents SDF (%)	Displacement Time (days)	Functional Downtime (days)	Building Mit. Eff. (%)	Contents Mit. Eff. (%)	Annual Number of Earthquakes
4-8	1.79	0.10	1.79	0.00	2.50	94.41	N/A	7.20E-02
8-16	12.02	1.27	12.02	46.16	6.00	89.43	99.50	9.48E-02
16-32	40.71	7.40	40.71	365.00	12.00	81.82	97.18	8.37E-02
32-55	72.46	21.31	72.46	365.00	15.00	70.59	96.18	3.16E-02
55-80	89.01	38.09	89.01	365.00	15.00	57.21	92.16	5.89E-03
80-100	95.02	100.00	95.02	365.00	15.00	45.96	84.56	8.01E-04
>100	98.08	100.00	98.08	365.00	15.00	33.73	72.95	8.84E-04

	Before Mitigation			After Mitigation		
PGA (% of g)	Minor Injury Rate (per 1000)	Major Injury Rate (per 1000)	Death Rate (per 1000)	Minor Injury Rate (per 1000)	Major Injury Rate (per 1000)	Death Rate (per 1000)
4-8	9.75E-02	1.30E-02	3.25E-03	9.75E-03	1.30E-04	3.25E-06
8-16	1.56E+00	2.08E-01	5.20E-02	1.56E-01	2.08E-03	5.20E-05
16-32	2.57E+01	3.42E+00	8.56E-01	2.57E+00	3.42E-02	8.56E-04
32-55	2.38E+02	3.18E+01	7.94E+00	2.38E+01	3.18E-01	7.94E-03
55-80	3.45E+02	2.02E+02	9.55E+01	3.45E+01	2.02E+00	9.55E-02
80-100	3.75E+02	3.10E+02	1.53E+02	3.75E+01	3.10E+00	1.53E-01
>100	3.90E+02	3.64E+02	1.81E+02	3.90E+01	3.64E+00	1.81E-01

Soil Type Selected: S3

Seismic Hazard Data

Time Period	% of g
50 year	125
250 year	175

SUMMARY OF BENEFITS AND COSTS WITHOUT CASUALTIES AVOIDED

Project Benefits without Casualties	$22,000,963
Project Costs	$6,785,365
Project Benefits Minus Project Costs	$15,215,599
BENEFIT-COST RATIO WITHOUT CASUALTIES AVOIDED	3.24

SUMMARY OF BENEFITS AND COSTS WITH CASUALTIES AVOIDED

Total Casualties Avoided	$737,747
Project Benefits with Casualties	$22,738,711
Project Benefits Minus Project Costs	$15,953,346
BENEFIT-COST RATIO WITH CASUALTIES AVOIDED	3.35

Narrative Associated with Ratcliff Building Cost-Benefit Calculation

What is the source and type of the problem?

The Ratcliff Building is an "L" shaped unreinforced masonry (URM) bearing wall building constructed in 1916. URM buildings are recognized as perhaps the most hazardous structural type (FEMA 154, 1988) and are well known to be extremely vulnerable to earthquake damage. During past California earthquakes URM buildings have collapsed and led to loss of life. The "L" shaped plan configuration of this building provides an internal (re-entrant) corner where early damage would occur due to independent motions of the two wings.

The building site is located within 3 kilometers of the Hayward Fault, and is within 27 kilometers of both the Rodgers Creek and San Andreas Faults. The combination of the inherent vulnerability of this URM building to damage from earthquake shaking and its close proximity to active faults defines the source and type of hazard that needs to be mitigated.

How frequent is the event?

Previous large magnitude earthquakes (≥ M6.8) have occurred on the San Andreas Fault in 1906 and 1989 and on the Hayward Fault in 1868. While it is not possible to determine with certainty when another large earthquake will occur on either of those faults, the probabilities over the next 30 years have been evaluated and reported by the U.S.Geological Survey-led Working Group on California Earthquake Probabilities. There are multiple faults within the San Francisco Bay Area that the Working Group evaluated, and in their overall analysis reported in May 2003, there is a 62% chance of one of more magnitude 6.7 earthquakes in the greater Bay Area over the next 30 years. This includes an 8.5% chance of a magnitude 6.9 earthquake occurring on the Hayward Fault, a 15.2% probability of a magnitude 7.0 earthquake on the Rodgers Creek Fault, and a 4.7% chance of a magnitude 7.9 earthquake occurring on the San Andreas Fault within the same 30-year period.

How severe is the damage?

Parapets of URM buildings can fall and be a life safety risk when subjected to even minor shaking of Modified Mercalli Intensity (MMI) VI. Stronger shaking can collapse portions of exterior URM walls because they are poorly connected to the roof framing. Partial wall collapse can also lead to collapse of supported portions of a roof or floors. Building contents that are not securely anchored begin to fall and can be damaged even prior to the onset of structural damage. The Ratcliff Building has two very long narrow portions that form an "L" shape. This configuration is a known weakness that will result in greater damage particularly at the point where the two wings connect.

What kinds of property are at risk?

The building itself, a portion of which has official Landmark status within the community, is certainly at great risk because of the inherent earthquake vulnerability of a URM building. A study of the building's earthquake vulnerability conducted by Degenkolb Engineers determined that is quite possible the building could collapse and be a total loss after the

occurrence of a nearby strong earthquake. In addition, a great deal of valuable equipment is located in the building.

Are there better, alternative ways to solve the problem?

The most effective way to mitigate the serious damage that can occur to this URM building and its contents, and to protect the safety of its occupants, is to strengthen the building to resist the forces of earthquakes. Because a portion of the building is a historical resource it cannot simply be replaced with a totally new building but instead needs to be preserved by strengthening it in a manner that will preserve its historic fabric.

Are the mitigation project costs well documented and reasonable?

The project costs are based upon the City of Berkeley's considerable recent experience with seismic rehabilitation of other city owned and operated buildings such as the Martin Luther King Jr, Civic Center Building, the Main Library and six out of seven fire stations. A breakdown of project costs is provided in the Cost Estimate Section of this Sub grant application that includes costs associated with relocation of the building occupants to temporary facilities, design and construction costs, and associated construction management costs.

The cost estimates are realistic because they include a 10 percent contingency that is typical of most capital improvement projects undertaken by the city.

History of Past Damages:

No observable earthquake related damage appears to have occurred because the site has not been subjected to strong ground shaking since its original construction.

Other Comments Section:

The Building Seismic Damage Function (SDF) for the existing pre-mitigation building is predicated on the HAZUS Fragility Curve for a "Pre-Code" URML (low rise) Building Type. This may actually underestimate the actual building's vulnerability and result in a lower than expected benefit cost ratio because the "L" shaped plan configuration will likely increase the damage that occurs.

The Building Seismic Damage Function (SDF) for the post-mitigation building is predicated on a Level 1 "Seismic Design" default value for a steel braced frame and concrete shear wall building, because the design of the seismic strengthening will use that type of structural system to limit building drift.

This may somewhat underestimate the building's post-mitigation vulnerability and the corresponding benefits of the strengthening, because the seismic rehabilitation design will be based on a code importance factor (I) of 1.25 for an essential service building. The 1.25 importance factor will result in a building that is designed to resist seismic forces that are 25% greater than a standard level of seismic resistance required for other buildings. In addition, the current edition of the California Building Code requires an additional 40% increase in design forces based on the 3-kilometer proximity of the Hayward Fault. This increase is known in the code as the Near Source Factor (Na). Therefore, both the pre- and

post-mitigation SDF assumptions of building damage are considered a conservative lower bound.

The Historic Building Controls box contains the word "Partial" to indicate that a portion of the building is a designated historical resource.

The Building Replacement Value of $350 per square foot was derived from city's experience of the actual total costs to build an entirely new replacement building of the same size with the same interior layout and features. That estimate takes into account design costs, inspection costs, construction management costs, materials, labor and contractor overhead and profit costs that are a legitimate part of all new construction. It does not account for any land costs because the assumption is that a replacement building would be built upon the current city owned site. Typically a small single story building will have higher unit costs (per square foot) that a larger multi-story building because of the economies of scale afforded by larger and taller buildings are not available when constructing a small single story building.

The percentage of building damage that would result in demolition is set at 40% rather than the default 50% value. This is because an 87 year old URM building is much more likely to be uneconomical to repair at a small dollar loss threshold, than a more modern building would be.

The contents value of $1,274,000 is predicated on an inventory performed by the city staff that uses the building of equipment, furnishings and other inventory that are present in the existing building, and the estimated cost to replace them with new items of the same quality.

Rental costs of Temporary Building Space are based on current commercial space rental pricing in Berkeley times a factor of 1.5. This 50% premium is applied in recognition of the scarcity and high demand for available (undamaged) rental space in the period immediately after a damaging earthquake, causing a situation that immediately drives local rental prices upwards. The total cost includes $3.75 / square foot /month for 16,700 square feet of floor area and $1.50 / square foot / month for 20,000 square feet of parking area. Parking for the trucks and other motorized equipment that are an essential part of the public services provided by the personnel using the building will be a necessary part of any relocation. Together, these total $92,625 per month. This total was converted to $5.55 / square foot / month by dividing the total dollar amount by the 16,700 square foot floor area of the building.

Other recurring costs such as additional travel costs (fuel and necessary overtime) for the field crews that come and go from the building were not included. These costs were omitted because it is not possible to determine how much additional travel distance and time would be necessary, without knowing a specific address for the space into which the public services would be relocated.

An additional one-time cost of displacement of $885,950 was derived from an analysis of the actions necessary to prepare a rented space and actually move existing inventory furnishings and equipment. These costs are related to making tenant improvements or other modifications to a rental space to provide a work environment consistent with the public

services being provided in the current building. This additional one-time cost was determined as the sum of the following items:

1) $20 / sq. ft for interior improvements in a 16,700 square foot lease space to establish office spaces and provide building code complying separation of shop areas from offices and other occupational safety regulation upgrades for a total of $334,000,

2) Telephone and data modifications for 45 persons, at $2,500 per person, for a total of $112,500,

3) Procuring work stations for 45 persons, at $2,000 per person, for a total of $90,000,

4) Moving costs of $500 per person, for all of the 190 city staff who use the building as a base of operations, for a total of $95,000,

5) Relocating radio transmitters at $50,000, and

6) Other costs like permits, design of the new space layout, etc. at 30% of the other costs for a total of $204,450.

The Building Occupancy data was derived as follows:

There are 45 permanent full time (8 hr/day) personnel in the building on weekdays and an additional 145 field personnel who are in the building approximately 2 hours per day on weekdays (1 hour at the beginning and 1 hour at the end of each day). Taking these 145 occupants at 2 hours per day and dividing by 4 provides the equivalent of 36 occupants during a full 8-hour day. Therefore the total weekday occupancy is listed as 81 (45 + 36). On both weekend days the building is occupied by a full time staff of 11 (8 hr/day). No occupancy of the building occurs during the other 16 hours of the day on either weekdays or weekends except for occasional after normal business hour emergencies.

The Annual Budget of $21,095,305 for the public services provided was determined from the City's latest official budget for the two agencies that occupy the building; Public Works and Parks and Forestry. The budget includes salaries and benefits, equipment and supplies used in the services provided, building maintenance, and communications. Public Works accounts for $14,861,712 of the total, and Parks and Forestry accounts for the remaining $6,233,593.

A Post-disaster Continuity Premium was determined to be 5 times the services provided by Public Works. Based on the Public Works annual budget of $14,861,712, when converted to dollars per day this amounts to $203,585 / day. This continuity premium accounts for the essential service nature of the Public Works operations in the building that provide direct and immediate support of fire and police services and other public safety matters in the event of an earthquake. The Public Works department has the responsibility to inspect city owned transportation infrastructure like tunnels and bridges for safety immediately after an earthquake and to clear debris from streets to open those routes for use by other city emergency responders. They also inspect city buildings to locate and evaluate possible earthquake damage, including as a priority those buildings containing other city essential service functions. These Public Works services are a very high priority to ensure that police and fire services can carry out their responsibilities, however, for this analysis they are being

given a continuity premium that is only one-half of what would be allowed for a fire or police service.

Annual Maintenance Costs of the post-mitigation building are estimated to be $120,000 per year. This is based on 3% of the value of the building and is consistent with maintenance budget estimates used for other newly constructed city buildings. This information is also provided in the section of the Sub grant application titled Maintenance Schedule and Costs.

The estimated Relocation Time Due to Project is estimated to be 21 months. This is based on the phases of work indicated in the section of the Sub grant application titled Work Schedule.

The Rental Cost during Relocation is estimated to be $1.75 / square foot / month. This is based on providing modular buildings in which to house the current operations in the existing building on the same property as the existing building. This includes a monthly rent plus a required installation set up and removal fee from the modular rental company.

Other Relocation Costs are estimated to be $24,550 per month. These are the actual moving costs, management and design of the utility and communications hookups and providing disabled access, management and construction of the utility and communications hookups and accessibility features, permit costs, and inspection costs. These costs total $514,548 and are then divided by 21 months to obtain the monthly cost.

Appendix E. Comparison of Mitigation Plan Actions with General Plan Policies and Actions

Comparison of Mitigation Plan Actions with General Plan Policies and Actions

VERY HIGH PRIORITY ACTIONS		
Ref.	**Mitigation Plan Action**	**Comparison to General Plan Policies/Actions**
A-1	Strengthen or replace important city owned and used buildings that are known to have structural weaknesses.	Derived from General Plan Policy S-20, action H. The action in the Mitigation Plan is very similar to the action in the General Plan, but the action in the Mitigation Plan proposes more detailed steps for implementation.
A-2	Increase efforts to reduce fire risk in existing development by improving vegetation management and appropriate code enforcement.	Derived from General Plan Policy S-23. One subcomponent of the action in the Mitigation Plan listed below does not appear in the General Plan: - Reduce fire risk in existing developed areas by requiring all existing buildings over 75 feet tall to install a sprinkler system.
A-3	Complete the ongoing program to retrofit all remaining non-complying Unreinforced Masonry (URM) buildings.	Derived from General Plan Policy S-20, action A. The action in the Mitigation Plan is very similar to the action in the General Plan.
A-4	Better inform residents about emergency preparedness options.	Derived from General Plan Policy S-3, action B. The action in the Mitigation Plan is very similar to the action in the General Plan.

A-5	Create a program to reduce risks for people and property for all potentially hazardous single-family, soft-story, and hillside residences.	Derived from General Plan Policy S-20, actions B, D, E and F and Policy S-15, action A. One subcomponent of the action in the Mitigation Plan does not appear in the General Plan: - Require engineered plans for single-family homes on hillsides and multi-unit residential structures to qualify for the transfer tax rebate.
B-1	Establish pre-event planning for post-disaster recovery as an integral element of the emergency response planning of the City Council and each of the City departments.	Derived from General Plan Policy S-9. The action in the Mitigation Plan is very similar to the action in the General Plan.
D-1	Encourage mitigation efforts with neighboring cities and counties and key institutions serving Berkeley.	Derived from General Plan Policies S-5, S-7 and S-12. The action in the Mitigation Plan combines elements of all three actions in the General Plan. All components of the action in the Mitigation Plan are very similar to elements of the three actions in the General Plan.

HIGH PRIORITY ACTIONS		
Ref.	**Mitigation Plan Action**	**Comparison to General Plan Policies/Actions**
A-6	Encourage the retrofit of commercial concrete tilt-up, non-ductile frame, and wood frame buildings to improve their ability to resist earthquakes and fires.	Derived from General Plan Policy S-20, actions B, D, and E. The action in the Mitigation Plan is very similar to the action in the General Plan, but focuses on specific types of structures whereas the General Plan action focuses on all potentially hazardous structures.
A-7	Reduce the vulnerability of residential areas located in the Hill Hazardous Fire Area to fires through implementation of the Subdivision Ordinance's merger provisions and through changes to the existing residential zoning laws and building code requirements.	Derived from General Plan Policy S-16 and Policy S-21, parts C, D, and E. The action in the Mitigation Plan is very similar to the actions in the General Plan.
A-8	Perform appropriate seismic and fire safety analysis based on current and future use for all city-owned and leased facilities and structures.	Derived from General Plan Policy S-10, action B and Policy S-20, action G. The action in the Mitigation Plan is very similar to the identified components of actions in the General Plan.
B-2	Review and revise the Disaster Preparedness and Safety Element of the City's General Plan biennially.	This action does not appear in the General Plan.

B-3	Rehabilitate the City's storm drain system to reduce local flooding caused by inadequate storm drainage.	Derived from General Plan Policy S-26, actions B and C. The action in the Mitigation Plan is very similar to the action in the General Plan, but the action in the Mitigation Plan proposes more detailed steps for implementation.
C-1	Encourage and support the long-term protection of historic and architecturally significant structures to preserve neighborhood and community character.	Derived from General Plan Policy S-11. The action in the Mitigation Plan is very similar to the action in the General Plan.
D-2	Work with EBMUD and PG&E to ensure an adequate supply of water and power during emergency periods and during recovery.	Derived from General Plan Policy S-26, action D, Policy S-22, action B and Policy S-12, action C. The action in the Mitigation Plan is very similar to the identified components of actions in the General Plan.

IMPORTANT ACTIONS		
Ref.	**Action**	**Hazard**
B-4	Assess the feasibility and need to incorporate cost-effective terrorism-resistant design features when city owned buildings undergo major renovations.	This action does not appear in the General Plan.
D-3	Update and revise flood maps for the city and consider applying to the Community Rating System (CRS) under the National Flood Insurance Program.	Derived from General Plan Policy S-28. The action in the Mitigation Plan is very similar to the action in the General Plan.

Endnotes

Executive Summary

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

Chapter One: Objectives and Actions

[2] The Environmental Initial Study conducted by the city identified the following mitigation actions to eliminate environmental impacts from this action:

Historic Character:
Action C-1 proposes activities and measures to protect Berkeley's unique character and values from being compromised by hazard events including the following activities:

- Create incentives for owners of historic or architecturally significant structures to undertake mitigation to levels that will minimize the likelihood of damage during or demolition after a disaster.
- Establish preservation-sensitive measures, including requirements for temporary shoring or stabilization where needed; arrangements for consulting with preservationists; expedited permit procedures for suitable repair or rebuilding of historically or architecturally valuable structures; and, where appropriate, provisions for replanting.
- Require alterations to designated and potentially significant landmark structure conform to the Federal Secretary of the Interior's Guidelines for Rehabilitation.

Air Quality During Construction:
Implementation of the following BAAQMD basic control measures would reduce the short-term air quality impacts associated with replacement of the Center Street garage to a less than significant level. The following measures would be taken during all phases of project construction:

- Water all active construction areas at least twice daily;
- Water or cover stockpiles of debris, soil, sand or other materials that can be blown by the wind;
- Cover all trucks hauling soil, sand and other loose materials or require all trucks to maintain at least two feet of free board; and
- Sweep adjacent public streets daily (with water sweepers) if visible soil materials are carried off site onto public streets.

Noise Levels During Construction:

- The name and telephone number of the individual empowered to manage construction noise and respond to noise complaints shall be posted at the project site for the duration of construction in locations that are easily visible from the adjacent public right-of-way. The responsible individual shall record all noise complaints received and actions taken in response, and submit written reports of such complaints and actions to the project planner on a weekly basis.
- Construction activity is generally limited to between the hours of 8:00 a.m. and 6:00 p.m. on Monday through Friday, and between 9:00 a.m. and noon on

Saturday. No construction-related activity shall occur on Sunday. Furthermore, no grading, boring, or use of heavy machinery shall occur after 5:00 p.m. or on Saturdays or Sundays.

[3] Policy S-23 in the Safety Element of the General Plan, 2003 revision.

[4] The Environmental Initial Study conducted by the city identified the following mitigation actions to eliminate environmental impacts from this action:

- Before initiating conversion of any natural area into historic coastal grasslands, City staff shall consult with natural resource regulatory agencies (e.g., United States Fish and Wildlife Service, California Department of Fish and Game) to ensure that such conversion would not result in any take of any special status species, and to ensure that critical wildlife breeding or foraging habitat would not be lost.
- The construction of new fire roads, trails, or pedestrian paths shall require environmental review to identify the presence of biologically sensitive species or erosion-prone soils and identify project-specific measures to mitigate any potentially significant impacts.

[5] Portion of policy S-20 in the Safety Element of the General Plan, 2003 revision.

[6] The Environmental Initial Study conducted by the city noted that while actions that promote the retrofit of potentially hazardous buildings could prevent the loss of housing and other structures following a major seismic event, such programs could also result in the displacement of existing housing if the cost of retrofit made it infeasible to repair and maintain existing units. The proposed Plan does not establish any new requirements for retrofit that would displace housing units or residents but proposes the investigation and adoption of incentives to ensure that such impacts would not result from any new retrofit programs.

[7] FTE refers to Full time equivalent of a staff member.

[8] Policy S-3 in the Safety Element of the General Plan, 2003 revision.

[9] Portion of policy S-20 in the Safety Element of the General Plan, 2003 revision.

[10] The Environmental Initial Study conducted by the city noted that while actions that promote the retrofit of potentially hazardous buildings could prevent the loss of housing and other structures following a major seismic event, such programs could also result in the displacement of existing housing if the cost of retrofit made it infeasible to repair and maintain existing units. The proposed Plan does not establish any new requirements for retrofit that would displace housing units or residents but proposes the investigation and adoption of incentives to ensure that such impacts would not result from any new retrofit programs.

[11] Portion of policy S-20 in the Safety Element of the General Plan, 2003 revision.

[12] The Environmental Initial Study conducted by the city noted that while actions that promote the retrofit of potentially hazardous buildings could prevent the loss of housing and other structures following a major seismic event, such programs could also result in the displacement of existing housing if the cost of retrofit made it infeasible to repair and maintain existing units. The proposed Plan does not establish any new requirements for retrofit that would displace housing units or residents but proposes the investigation and adoption of incentives to ensure that such impacts would not result from any new retrofit programs.

[13] Policy S-16 in the Safety Element of the General Plan, 2003 revision.

[14] The Environmental Initial Study conducted by the city identified the following mitigation actions to eliminate environmental impacts from this action:

- Before initiating conversion of any natural area into historic coastal grasslands, City staff shall consult with natural resource regulatory agencies (e.g., United States Fish and Wildlife Service, California Department of Fish and Game) to ensure that such conversion would not result in any take of any special status species, and to ensure that critical wildlife breeding or foraging habitat would not be lost.
- The construction of new fire roads, trails, or pedestrian paths shall require environmental review to identify the presence of biologically sensitive species or erosion-prone soils and identify project-specific measures to mitigate any potentially significant impacts.

[15] Portion of policy S-10 in the Safety Element of the General Plan, 2003 revision.

[16] Policy S-9 in the Safety Element of the General Plan, 2003 revision.

[17] Portion of policy S-26 in the Safety Element of the General Plan, 2003 revision.

[18] The Environmental Initial Study conducted by the city identified the following mitigation action to eliminate environmental impacts from this action:

- Non-emergency projects involving construction work or other physical alteration of previously undisturbed areas outside of the existing right-of-way, along creeks, or in other riparian zones shall require environmental review to identify the presence of biologically sensitive species or erosion-prone soils and identify project-specific measures to mitigate any potentially-significant impacts.

[19] Policy S-11 in the Safety Element of the General Plan, 2003 revision.

[20] Policies S-5, S-7 and S-12 in the Safety Element of the General Plan, 2003 revision.

[21] Portion of policy S-26 in the Safety Element of the General Plan, 2003 revision.

[22] Policies S-26 and S-28 in the Safety Element of the General Plan, 2003 revision.

Chapter Three: Analysis of Hazards in Berkeley

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

[24] The Berkeley community is exposed to a number of natural hazards besides earthquake, fire, flood and landslide that are of concern. Other natural hazards that could impact the city include severe storms, which can produce prolonged low temperatures, heavy rainfall and hail; severe heat; tsunami and seiche triggered by local or distant earthquakes; 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 comparable amounts of damage. Berkeley's moderate environment 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. California is not exposed to the large tornado events experienced in the Midwest. The city's position on the Bay rather than the open ocean provides some protection from tsunami, and any waves striking Berkeley are estimated to be of moderate size and unlikely to inundate areas east of Interstate 80.

[25] These requirements are described in The Disaster Mitigation Act of 2000, 44 CFR part 201.

[26] The Working Group on Earthquake Probabilities (WG02), *Summary of Earthquake Probabilities in the San Francisco Bay Region: 2003—2032,* USGS, April 2003.

[27] Schwab et al. Planning for Post-Disaster Recovery and Reconstruction. Planning Advisory Service Report Number 483/484. Federal Emergency Management and American Planning Association, December 1998.

[28] The California Geological Survey maps zones that may be subject to liquefaction. Statues require that cities and counties use these zones as part of their permitting process. The stability of soils in these zones must be investigated and reflected in foundation design of new development. Liquefaction zones in Berkeley are shown in Figure 3-2.

[29] These buildings are categorized as SPC-2 according to the Hospital Seismic Safety Act. 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.

[30] These buildings are categorized as SPC-3 and SPC-4.

[31] "Sutter tags $3.5 billion for retrofits, upgrades." The East Bay Business Times, April 8, 2002.

[32] City Toxics Management Division, as of May 2003.

[33] 2000 US Census figures

[34] Consultants evaluated Berkeley's soft-story earthquake risk in 2001 for the Building Department.

[35] 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.

[36] Figures are from the UC Berkeley website and the Berkeley Downtown Association.

[37] 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.

[38] 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 at Berkeley, July 2000.

[39] Building Department statistics.

[40] That report is available to the public at http://www.lbl.gov/ehs/esg/tableforreports/assets/SER02Vol1.pdf

[41] Information provided by Valerie Quigley, Emergency Preparedness/Site Access Program Manager for LBNL.

[42] Debbi Belush, Manager of Community Relations and Development Compliance, Bayer Corporation.

[43] The 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. 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.

[44] The Bay Bridge East Span reconstruction project schedule appears on the CalTrans website, http://www.dot.ca.gov/dist4/eastspans/index.html

[45] Information provided by Ron Bianchetti of EBMUD's Seismic Improvement Program and John Eidinger, an EBMUD contractor.

[46] EBMUD Claremont Corridor Seismic Improvements Project Environmental Impact Statement, State clearinghouse #2003022140.

[47] Information provided by Stuart Nishenko and PG&E

[48] For more information, contact Ed Matsuda, BART's Earthquake Program Manager

[49] From discussions with Ed Matsuda, BART's earthquake program manager.

[50] Information provided by Craig Whitman, Office of Earthquake Engineers and Steve Prey, Energy Conservation Program Coordinator, both at Caltrans.

[51] Information provided by Larry Wong, Area Manager at SBC Communications

[52] Information provided by Jerry Englehardt of the Kinder Morgan Corporation.

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

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

[55] The California Department of Forestry developed this ranking to prioritize pre-fire projects. See http://frap.cdf.ca.gov/data/fire_data/fuel_rank/index.html .

[56] 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.

[57] Tsunamis striking the Berkeley coastline are predicted to be a maximum of 4 feet tall. Interstate 80 provides good protection to most areas of the city from Tsunami floodwaters.

[58] 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 at Berkeley, July 2000, pages 23-24.

[59] 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.

[60] City Toxics Management Division, as of May 2003.

[61] 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.

[62] LBNL memo, "LBNL Information Regarding Potential Radiation Dose in the Event of a Fire at the National Tritium Labeling Facility." March 2001. [http://www.lbl.gov/Science-Articles/Archive/tritium-franke-report.html]

[63] Sacramento Bee Unabomber Website, http://www.unabombertrial.com/

Chapter Four: Current Mitigation Programs and Resources

[64] As of 2003.

[65] Findings of a 2001 study of soft-story buildings in Berkeley conducted for the Building Department.

[66] http://www.ci.berkeley.ca.us/disasterresistant/Default.html

Chapter Five: Community Profile and Trends

[67] 2000 US Census

[68] General Plan, Land Use Element

[69] For more details, refer to the University's *Strategic Plan for Loss Reduction and Risk Management* and *The Economic Benefits of a Disaster Resistant University,* both published by the University in 2000.

[70] General Plan.