SEISMIC SAFETY/SAFETY ELEMENT

INTRODUCTION

Berkeley could be hit by a major disaster any time. It could be an earthquake, fire, flood or other natural disaster affecting many Berkeley residents. The resultant damage to people and property is usually decreased considerably if natural hazard considerations are emphasized in the planning/development process of the City and if the community and its public officials are prepared for emergency operations.

Although earthquakes are a part of California's heritage, seismic hazard considerations have played a minor role in the planning/development process of urban areas. Recent State legislation, however, has greatly altered this situation by requiring each California county and city to include a Seismic Safety Element in its Master Plan. State legislation (Government Code, Section 65302(b) specifies that the Seismic Safety Element shall consist of:

> “an identification and appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to effects of seismically induced waves such as tsunamis and seiches."

> “...an appraisal of mudslides, landslides and slope stability as necessary geologic hazards that must be considered simultaneously with other hazards..."

In addition, Government Code (Section 65302.1)* mandates the inclusion of a Safety Element in cities' Master Plans for the protection of the community from fires and geologic hazards and for instituting emergency operations.

Since there is a strong interrelationship between the Seismic Safety and Safety Elements, they have been combined into a single document. According to the General Plan Guidelines (California Council on Intergovernmental Relations, 1973), the fundamental goal of the Seismic Safety and Safety Elements is to reduce loss of life, injuries, damage to property, and economic and social dislocation resulting from natural disasters such as fires, floods and seismic-related hazards. The consideration of nuclear disaster is not within the Safety Element.

This preliminary draft is organized into three major sections: Inventory/ Evaluation Section presents a discussion on seismic, fire, flood and related hazards. Areas in Berkeley *which exhibit* such potential hazards are generally delineated. Given the documentation of local hazards, some of the implications for planning are presented in the findings. In addition, Berkeley's current state of emergency preparedness in the event of natural disasters is discussed. The second major section, Policy Recommendations, furnishes the City's overall policy framework to deal with seismic and related hazards, fire and flood hazards and emergency preparedness and recovery for the City. The section on implementation Programs suggests specific short and long-range programs to implement the City's policies and alleviate Berkeley's potentially hazardous condition.

*Please see Appendix A for copy of mandate.

INVENTORY EVALUATION

SEISMIC AND RELATED HAZARDS

The San Francisco-Oakland Bay Area is hit by numerous earthquakes every year. Fortunately, most of them cause little or no damage and are not large enough to be felt by many people. A few of these earthquakes such as the ones in Hayward (1868), San Francisco (1906) and Santa Rosa (1969) were very prominent and left behind them considerable damage (see Figure 1 on California's historic earthquakes).

Earthquakes in the Bay Area originate along three major faults: the San Andreas, the Hayward, and the Calaveras Faults (see Figure 2). The most important of these faults is the San Andreas Fault system. It is by far the largest fault in the State of California extending from south of Los Angeles to north of San Francisco. In addition, there are numerous other smaller faults that branch out from the San Andreas. The fault zones that exist in the Bay Area are all part of a larger System known as the Circum-Pacific Seismic Belt which includes most of California. This thin band surrounding the Pacific Ocean is responsible for about 80% of the world's earthquakes (see Figure 3).

For planning purposes, there are two basic kinds of faults, active and inactive. According to the California State Mining and Geology Board, an active or potentially active fault is defined as a fault which has moved in holocene time (within the last 11,000 years). An inactive fault is one which has been dormant for longer periods of time. In some cases, inactive faults are so labeled due to lack of knowledge rather than actual state.

Berkeley has the San Andreas Fault to the west and Calaveras Fault to the east. Moreover, Berkeley is traversed by the Hayward Fault. All three faults are known to be active as evidenced by the damaging earthquakes they have produced in the last 100 years and can, therefore, be expected to do the same in the future. Of primary concern to Berkeley is the Hayward Fault, a branch of the San Andreas, which extends from Fremont through Hayward, San Leandro, Oakland, Berkeley, El Cerrito, Richmond and San Pablco Figure 4 shows the Hayward Fault system and indicates where its location is accurately known, approximately known, inferred or concealed. In addition, the Special Study Zone Boundaries encompassing active or potentially active faults are outlined on the Map as mandated by the Alquist Priolo Geologic Hazard Zones Act of 1972) see Appendix for provisions of the Act).

Understanding Earthquakes

It is believed that the earth's surface is composed of -a massive plates which are gradually shifting. A fault or fault zone is the place of contact between these massive plates. For example, the San Andreas fault is the place of contact between the Pacific Plate and the North American Plate. A fault creep occurs where there is a smooth and very slow periodic movement due to the gradual shifting of one plate past another unaccompanied by earthquakes. Before an earthquake occurs, stresses steadily accumulate along both sides of the fault as the earth's crust continues to shift (at a rate of about two inches per year along the San Andreas Fault). As the stresses build up, massive rocks become deformed on either side of the fault but retain their basic positions because of frictional forces holding them together. Eventually, the stresses overcome the strength of the rocks causing the masses of. rock to snap along the fault and move into a position of lower stress.

GRAPHICS- PGES 98-102

The Hayward fault, belonging to the San Andreas Fault System, transects the city of Berkeley. Like the main San Andreas fault, its displacement is right lateral strike slip, that is, the portion of the City lying on the west side of the fault is moving progressively northward.

Cracks in pavement, culverts and masonry walls indicate that right lateral creep has continued progressively since the last major earthquake. Recent studies by the U. S. Geological Survey suggest that sudden fault displacements on the order of ten feet are possible along the Hayward Fault in the event of a major earthquake.

<u>Seismically Induced Hazards</u>

<u>Fault Displacement</u>

A fault displacement occurs when the plates on one side of a fault move relative to the one on the other side. The San Francisco Bay Area is literally interlaced with numerous faults. There are three essential aspects of fault displacement that have to be considered: 1) the location of the fault displacement; 2) the am amount of displacement; and 3) the sense of fault movement are all extremely important in assessing the likelihood, am amount and type of damage that might be produced. First, while fault movement starts at a single point, the accumulated stresses can be relieved along many miles of the fault line. Within a fault zone, displacement may take place along a branch or secondary fault although the greatest probability is that it will occur along the trace of an active fault.

Second, the amount of relative fault displacement is dependent upon the total length of the fault itself. The longer the fault, the greater the amount of displacement that is likely to occur. The greatest single shift in the Bay Area in recent times was 20 feet during the 1906 San Francisco earthquake. It is believed that a high magnitude earthquake along the Hayward fault would produce a displacement of several feet. Displacements do not have to be large to cause damage. In fact act, a displacement as small as one or two inches could cause damage to a building, depending on the building's design/construction and the shaking stresses it experiences. Since in general, buildings cannot withstand major ground displacement, a reasonable approach to reducing structural damage might well be to avoid construction across or immediately adjacent to active faults.

The third aspect to be considered in assessing the dangers of fault displacement is the sense of movement involved. The sketches below show various types of fault movement:

A) Fault movements must always be expressed in relative terms, since it is impossible to tell which side actually does the moving;

EARTH BLOCK BEFORE MOVEMENT

B) There are two kinds of vertical movement, the normal one involves the downthrow of one block while the reverse fault involves the upthrust of the block. Some mountains in Southern California indicate that during ancient times displacements totaled 10,000 to 15,000 feet;

NORMAL FAULT-

REVERSE FAULT

C) Horizontal movement can be either left lateral or right lateral. Horizontal movement of 20 feet occurred on the San Andreas fault during the 1906 earthquake;

LATERAL FAULT

D) Monoclinal fold movement is characterized by a permanent flexure or bending of the surface rocks as a result of earthquakes or other geologic phenomena occurring at tremendous depths but without fault displacement at the ground surface.

MONOCLINAL FOLD

The San Andreas and its branch faults, including the Hayward Fault, all behave right-laterally so that a future earthquake on the Hayward Fault will most likely produce a right-lateral horizontal displacement of several feet. Vertical displacement along the Hayward Fault (where the crustal plate slips up or down past each other) has not been documented to date.

<u>Ground Shaking</u> (See Figure 4A)

The ground shaking effect due to earthquake is, by far, the source of greatest damage to buildings and the most apparent sensation felt by people. Ground shaking is the oscillating ground response of earth materials during earthquakes caused by the release of energy in the form of surface and body waves.

The effects of ground shaking on structures is dependent on a combination of several factors such as the magnitude, duration and distance of the earthquake itself, the local soil/water saturation conditions, the relationship between predominant period of a structure and the predominant period of ground vibration and the structural integrity of the building.

The variation in the severity of the effects of ground shaking on structures is dependent on the following factors, or combination thereof:

1) Magnitude of the shock and the duration and intensity of the accompanying ground shaking;

2) Distance from the structure to the causative fault;

3) Site characteristic and site-structure interaction; and

4) Degree of integrity of the structure as a result of design and/or construction.

The site characteristic related to site-structure interaction is, for most properties in the City outside the area along the waterfront, not highly variable and this factor of the ground shaking effects can be considered as having minimal effect on variation in damage to structures.

Records from past earthquakes tend to suggest that the greatest damage to buildings occurs when tall structures are built over thick, relatively soft, water saturated sediments and the least damage when they are constructed on very firm bedrock. This characteristic is attributed to the nature of seismic waves whose frequency is reduced as they pass from rocks to less dense materials but whose amplitude is generally increased. The increase in amplitude leads to shaking at the surface which lasts for a longer period of time. History has shown that a flexible structure built next to a fault but on solid ground has withstood ground shaking better than the same structure located on loosely compacted water-saturated material many miles away.

One way of assessing potential building damage is to relate the predominant vibration period of a building to the ground on which it rests. A building can be subjected to greatly modified earthquake motions depending on the local geology (rock, firm soil, or thick wet soil). The greatest damage is more likely to occur when the building and the ground approach the same vibration period. The predominant vibration period of a building can be related in a general way to its height or number of stories. Taller buildings have a longer predominant vibration period (two or more seconds). Consequently, they are oftentimes subject to greater damage when they are located on ground with a longer predominant vibration period (thick, water saturated sediments). Conversely, one or two story buildings with a short predominant period may experience more damage if located on firmer ground.

Figure 5 on the following page shows several types of surficial deposits that exist in Berkeley. If the analysis presented above is generally applied to various parts of the city, one can surmise that severe ground shaking would produce considerable damage to the tall buildings in the downtown area because they are located on alluvial deposits (poorly consolidated deposits of mud, silt, sand and gravel deposited in stream beds) whose longer vibration period would be coincident to that of the tall buildings. One or two story buildings with short vibration periods may not experience as much damage when resting on relatively soft and wet grounds.

As mentioned previously, local soil conditions and the relationship between predominant periods are only two of many considerations concerning the effects of ground shaking. Other considerations such as the magnitude, distance, frequency and duration of a particular shock plus structural design and integrity of construction (quality of materials and workmanship) are also important and therefore should be part of a more complete analysis.

Ground Failure

Another major effect of earthquakes is ground failure in the form of landslides, subsidence, liquefaction and ground lurchings. These hazards are often the result of complete loss of strength of water-saturated soils.

a) Liquefaction

Liquefaction is a process by which an unconsolidated, water-saturated sediment such as silt or sand experiences a sudden loss of strength and behaves like a liquid when shaken (as during an earthquake. The potential for liquefaction increases when the duration and intensity of shaking increases and when soil density and confining pressures decrease. The consequences of liquefaction are varied and are dependent upon many factors. An unconfined sand layer (i.e., one surface exposed to the atmosphere) will, upon liquefaction, become like quick sand and have very little bearing strength. Liquefaction of a con fined silt, sand or gravel may cause differential settlement of the ground surface and/or landsliding along the liquefied layers.

Liquefiable soils could pose a very serious hazard in Berkeley particularly if the City is subjected o intense and prolonged seismic shaking during the wet season when all alluvial deposits are saturated. Liquefaction hazard while not very serious generally would occur in the flatland area of Berkeley because of the prevalence of alluvial deposits which are irregularly stratified, poorly consolidated deposits of mud, silt, sand and gravel.

There may be isolated or local areas within the City limits (e.g., along some of the creek beds) where cohesionless soils are present and liquefaction potential can exist.

b) Landslide

Landslides involve the downslope movement of soil and rock material over relatively well-defined failure surfaces. Their lateral boundaries are also often well-defined. In Berkeley, landslides occur principally in the eastern and northeastern hill areas. Individually, their lengths range in excess of a thousand feet in depth.

Although the force of gravity is ultimately responsible for their failure and subsequent movement, man's activities as well as earthquake shocks often lead to the triggering of new slides and the reactivation of existing dormant landslides. Major earthquakes in hilly terrain are almost always associated with widespread landslide activity, and much of the damage and many of the casualties associated with major earthquakes in populated areas have been caused by earthquake triggered landslides.

The stability of hillsides in Berkeley fluctuates seasonally. During each rainy season, the voids a and fracture openings become saturated as the water table rises.

Frictional resistance to sliding is reduced as the ground water table rises and cohesive strength diminished as clays swell with available water. on steep artificial and natural slopes, seepage pressure associated with ground water flow may further reduce stability. As a result of seasonal loss of strength the factor of safety of natural and man-made slopes decreases and their susceptibility to failure caused by earthquake-induced shocks increases.

Manmade cuts and fills, depending on their location and design in relation to existing and potential slides, may have significantly adverse effects on static as well as an earthquake induced landslide stability. Grading operations involved in the construction of streets and building foundations have often had adverse effects on natural slope stability. Improper concentration of storm runoff in landslide zones has also adversely affected stability and the resulting soil creep and landslide movements may fracture sewer and water in mains, leading to further deterioration of stability.

The hazard from seismically-triggered and reactivated landslides is not limited to the Alquist-Priolo geologic hazard zone, but extends throughout a broad area in the hills of Berkeley. Landslides have destroyed and damaged buildings, streets and interrupted water supply, gas and other utility lines. The various types of landslides which occur in Berkeley present significantly different types and degrees of hazard. In order to specifically define the type, degree and location of hazard zones subject to earthquake-induced slides, it is essential to delineate and classify all existing slides in Berkeley and the geologic and other site factors which control their occurrence and distribution.

c) Other Forms of Ground Failure.

In addition to liquefaction and landslides, there are other forms of ground failure associated with earthquakes such as subsidence, ground cracking and ground lurching.

Ground lurching, the permanent lateral movement of relatively level ground by cracking and spreading toward a free face, occurs during strong earthquakes and generally in loose and/or weak deposits. The presence of both a free-face and weak materials is present along the waterfront in Berkeley and, to a lesser degree, adjacent to creeks. At these locations ground lurching is a potential geologic hazard.

Ground cracking occurs in still surface materials and is associated with changes in surface topography or materials. Cracks may be only hairline or several feet wide and from a few feet to hundreds of feet long.

Subsidence of the ground surface is a common phenomenon in alluvial soils, particularly long-term settlement which takes place over many years. However, strong ground motion, such as that from major earthquakes, may cause rapid and uneven local settlement of the ground surface. Subsidence damages structures because of the uneven and rapid nature of the settlement**.** In Berkeley, the area of potential hazard from subsidence is generally restricted to areas of reclaimed land along the western waterfront where artificial fills are underlain by compressible bay muds.

Where dry, loosely compacted granular materials, such as sands, exist, there is a potential for differantial compaction during strong, seismically induced ground shaking. Also, soils in any liquefied layer would tend to densify subsequent to liquefaction, and settle. While both of these phenomena are potential hazards, there probably are only isolated areas in Berkeley which could be subjected to these hazards.

Generally speaking, existing and future bay fill areas present great potential hazard because of their special susceptibility to all kinds of ground failure.

Seismic Waves

In addition to fault displacement, ground shaking and ground failure, an additional effect of earthquakes is seismically-induced sea waves (tsunamis) or sloshing (seiches) which can result in inundation of some areas.

a) Tsunamis

Tsunamis are large seismic sea waves usually caused by underwater seismic disturbance, volcanic eruption or large submarine landslides resulting in waves of destructive force that can travel thousands of miles from the source area. The highest wave recorded in the San Francisco Bay Area occurred in 1964 (Alaskan earthquake). The tsunami had wave height of 711 feet near the entrance to San Francisco Bay and about 3 3/4 feet at the City of Richmond. Studies of the tsunami hazard in San Francisco Bay assume a 25% risk of a 20 foot high wave at the Golden Gate bridge would occur once every 200 years. The wave would be reduced 50% due to travel distance when it reaches the Berkeley shoreline. So the wave would theoretically only be ten feet high. This height, however, is the crest to trough distances so that the actual height would be only five feet above the tide level at that time.

In Berkeley-, all of the waterfront area plus a few blocks of the industrial area south 'of University Avenue would be subject to flooding in the event of a 20-foot high tsunami at the Golden Gate Bridge (See Figure 8). The Southern Pacific Railroad embankment actually provides a 15-foot barrier for such a wave between University Avenue and Ashby Avenue. Major damage and loss of life would be confined to the near shore and harbor areas. It is in this area that the greatest force of the waves would occur. Both the depth of inundation and the water velocity diminishes rapidly as the wave travels inland.

b) Seiches

Seiches are ear earthquake- generated waves within enclosed or restricted bodies of water (such as lakes and reservoirs) which act like the sloshing of water in a bowl during ground shaking. Earthquake-generated ground waves, which have a period that matches the natural period of the lake or reservoir, may cause the water to oscillate. Waves generated in areas where the water is constricted can reach heights of tens of feet. Obviously such waves can cause considerable damage to people and property within their reach. In reservoirs, seiches may overtop the dam or cause failure, releasing large volumes of water which could inundate downstream developed areas. No significant seiche-related damages were reported during the 1906 San Francisco earthquake.

Aquatic Park lake in the waterfront area could present a seiche hazard. It would be most susceptible to a short frequency seismic wave since it is relatively shallow. Damage might occur to the boat sale business, various docks and to the restroom facilities; however, these are expected to be of a minor nature.

In Berkeley, the ten water reservoirs found predominantly in the hill area should not present a major seiche problem. According to the City's Public Works Department, all the reservoirs are covered so that water will most likely not spill over the top during an earthquake. There is, nonetheless, the possibility of dam failure. The East Bay Municipal Utility District has prepared and submitted inundation maps to the Office of Emergency Services (as required by the State). Berkeley should be receiving shortly, copies of the appropriate maps even though the State has hot yet reviewed and approved them.

Structural Hazards

In a City as fully developed as Berkeley, a very important aspect of seismic safety is the mitigation of property damage and injury in existing structures that can be caused by seismically induced hazards, in particular ground shaking.

Although seismic design standards and techniques have advanced considerably in the last three to four decades, the complete interrelationships of earthquake forces, underlying geology and construction type are not fully understood. Based on today's level of seismic design, a building can can be constructed to withstand major shocks with minimal damage and reduced life hazards, but no buildings can be made totally earthquake resistant.

Berkeley adopted the Uniform Building Code as its standard for design and construction. The Uniform Building Code has had seismic design and construction provisions incorporated in the Code since the 1927 edition. These provisions have been updated with each succeeding edition, which are published at three year intervals. Major changes occurred in the design provisions in the 1946 to 1949 edition based on work being done by interested engineering groups. The Structural Engineers Association of California published recommended design criteria in 1959 and has been updating these criteria regularly. These recommendations have provided the basis for the seismic provisions in the Uniform Building Code since 1960. Before seismic criteria appeared in the Code, wind forces provided the only lateral force design criteria.

Design and construction of some structures in Berkeley, such as schools, hospitals and State and Federal owned properties, are outside the jurisdiction of the City's building code regulations. Agencies responsible for regulation of these structures generally have adopted seismic criteria as restrictive as Berkeley's and in some cases more restrictive.

Because of time and financial limitations, no field survey was conducted to estimate the number of structures in Berkeley that could be classified as seismically deficient. Based on 1970 U. S. Census statistics, at least 60% of the housing stock was built before seismic design standards became part of the Uniform Building Code (See Figure 9). Many of non-wood older structures probably present a hazardous condition.

In very general terms, types of construction can be related to seismic resistance performance even though such relationships can be somewhat misleading based solely on materials or types of construction. The historical record provides evidence that certain building types respond to seismic forces with little damage incurred while other types have suffered excessive damage and collapse.

Buildings of weaker and/or more brittle materials, such as unreinforced masonry (brick, stone or hollow concrete masonry walls without embedded steel bars) experience greater damage due to severe ground shaking than buildings of stronger and/or more flexible materials. In addition, portions of buildings such as unreinforced masonry chimneys, unreinforced parapets and appendages or appendages whose reinforcing has deteriorated will be damaged by severe ground shaking and do present a hazard. The City has taken one step toward reducing the hazard involved with these features by adoption of the "Parapet Ordinance" in 1972. Buildings in the central core of the City which have unreinforced parapets and ornamental appendages subject to the provisions of the Ordinance have been preliminarily mapped. (See Figure 10).

Various other structural deficiencies which may be present in some of Berkeley's buildings Are inadequately secured elevator equipment; inadequately secured mechanical equipment, such as motors, water heaters and heating equipment; inadequately braced openings in walls; and large exterior glass areas with inadequate framing to transfer lateral forces from the building to the ground.

In addition to buildings, there are other types of structures which are of major importance with respect to seismically induced hazards. Structures such as utilities, transportation and communications systems are essential to the City's welfare, safety and continued functioning.

Gas and electrical facilities are likely to be damaged by strong ground shaking or fault displacement, particularly since some of the utility lines cross the Hayward Fault. Fortunately, Pacific Gas and Electric Company designs its installations to much more rigid standards than required by building codes and incorporates seismic considerations so that hazards are decreased considerably. Nonetheless, the probability of fires and explosions still exists *which could* result from exposed transmission lines or ruptured pipelines. Potential hazards may be alleviated by constructing lines above grade or by installing shut-off valves.

Water related facilities such as pumping stations, reservoirs, and pipelines could also experience some damage. In Berkeley, there are various water supply lines that run through the Hayward Fault and through potential landslide areas. In the event of a major earthquake, Berkeley's fire-fighting capability could be affected. There is also the possibility of inundation due to failure of water reservoirs up in the hill area.

A total breakdown of the communication system is not envisioned, although telephone systems could be damaged. Pacific Telephone Company, like PG&E, considers seismic effects in its design of facilities. Emergency communication is nonetheless possible over commercial radio, television, and short wave radio.

Berkeley's transportation system could be seriously affected by a major earthquake. The Eastshore Freeway may liquefy and fail under heavy shaking or it may be inundated by a tsunami- Panoramic Way and other hill areas with narrow and winding streets may face the problem of isolation from the rest of the City since the flow of rescue vehicles, fire fighting equipment and supplies could be seriously hindered. Great potential damage can be related to the likely collapse of freeway overpasses which would have an adverse effect on the accessibility and usability of the Bay Bridge.

SUMMARY.

Strong seismic activity in the Bay Area could cause any or all of the following effects: ground or fault displacement, ground shaking, liquefaction, landsliding, tsunami, seiche and structural hazards. The action of these resultant effects on man, building and essential community facilities may create minor to catastrophic disruption of urban life in Berkeley.

It is believed that the next major earthquake along the Hayward Fault will have a 7+ magnitude on the Richter Scale, probably producing a ground displacement of several feet. Ground movement is expected to be mainly a right lateral movement with some minor vertical movement. Areas of Berkeley immediately adjacent to the Hayward Fault that contain structures and utilities built across the fault itself or traces of it will definitely experience damage.

Generally speaking, the city's flatlands will experience a greater amount of seismic ground shaking than the Berkeley hills since soft water-saturated alluvial type of sediments underlie most of these areas. In particular, tall unreinforced concrete and masonry structures situated on relatively deep soils will be subjected to strong ground shaking because of the amplifying effects that occur when the vibrational period of the soil is similar to that of the tall building.

Liquefaction involves a ground surface's sudden loss of bearing strength. Areas likely to liquefy consist of poorly-compacted artificial fill or wet and unconsolidated alluvial/ colluvial soils. The waterfront area and areas in the Berkeley flatlands immediately adjacent to creeks and water streams present a major potential for liquefaction hazard.

There are several conditions that increase the likelihood of landslides during an earthquake. Factors such as the steepness of slope, the presence of soft and unconsolidated sediments, plus extensive water content in the ground are all present in the north hills area. This section of Berkeley is therefore most susceptible to landslides.

In terms of seismically-induced waves, the waterfront area will be inundated by a tsunami in the event of an earthquake that produces a 20-foot high wave at the Golden Gate Bridge. In addition, Aquatic Park could seiche producing minimal damage to some existing docks and boat sales businesses. The various water reservoirs, located primarily in the hills area, do not present a seiche problem since all of them are covered. A major shake could, nonetheless, lead to dam failure and inundation of surrounding areas.

Structural hazards associated with earthquakes include damage to buildings as well as to major utilities, transportation and communication systems. Berkeley has numerous unreinforced masonry buildings, particularly in the downtown area, which could be expected to incur considerable damage. Residential wood frame houses will most likely perform well in earthquakes, although deficiencies such as inadequately secured mechanical equipment and large exterior glass areas might present potential danger.

Furthermore, Berkeley is faced aced with the problem of the water, electricity and natural gas distribution systems crossing the Hayward Fault. Most of the service lines will be ruptured by any major amount of displacement from a 7+ magnitude earthquake, thereby presenting potential fire, safety and health risks. It is not expected that communications facilities will be severely affected although the city might have to resort to commercial radio, television and short-wave radio. In terms of damage to the transportation system, freeway overpasses could collapse, forcing the use of alternative routes and isolating parts of the city from emergency services. The hill areas with narrow winding roads and the potential for landslides pose such potential risk.

It should be strongly emphasized that the potentially hazardous areas of Berkeley have been outlined very roughly on the basis of available information. People should not necessarily feel that their homes will all experience damage just because they are located within a hazardous area. Conversely, people should not feel "safer" because they live just outside the roughly outlined hazardous areas of Berkeley. There are many variables that contribute to the danger or safety of an area. For example, a very well constructed wood-frame house immediately adjacent to a fault could experience less damage than a poorly-constructed house located farther away from the fault in a less hazardous area. In order to assess the risk potential of individual parcels of land or particular buildings (especially in high risk areas and where not much information is available), a more detailed soils, geologic and/or structural report should be prepared.

FIRE HAZARDS

General

Under normal circumstances Berkeley's fire-fighting capabilities are quite good. The Berkeley Fire Department, although somewhat understaffed, has an adequate number of engine companies (eight of them) to -meet the basic requirements of the city. There is one engine company, consisting of four men, per fire station with the exception of the downtown fire station which has two companies. Figure 11 on the following page shows the location of Berkeley's seven fire stations. In addition, the Fire Department has three ladder companies and one squad company in service. If, however, under abnormal circumstances, Berkeley is threatened by a very extensive fire, most likely due to a major earthquake, it can rely on its mutual aid pacts with adjoining cities such as Oakland, Albany, and El Cerrito. (These cooperative agreements are not always reliable because in the event of a major disaster, adjacent cities will be quite busy taking care of their own communities.)

An adequate supply of water is available to the City. Water in Berkeley and several neighboring communities in Alameda and Contra Costa counties is provided by the East Bay Municipal Utility District(EBMUD). Reliability of the water system is generally very good, but supply could be severely reduced by a major movement along the Hayward Fault since it cuts all major channels of supply to the regions west of the Berkeley Hills. In particular, earthquake damage to the Claremont Water Tunnel, which normally supplies approximately 90% of the water used in Berkeley, could be quite detrimental.

As of August 1973, Fire Department records showed a total of 1644 municipally owned hydrants in the City. The University of California campus has an additional 48 hydrants. The average area served by each hydrant is 150,000 square feet in "typical" residential districts.

Berkeley's fire alarm system is generally quite reliable and well-maintained. There are 260 alarm fire boxes in service throughout the City. 43 are in underground cable and the remainder are of aerial wire construction. Moreover, the University of California has 54 privately-owned boxes installed on two circuits which terminate in the Fire Department's communications center, a one-story building of fire resistive construction at the rear of the downtown Fire Station #2 headquarters on Henry Street.

Fire Damage Potential of Specific Districts

The following analysis of fire damage potential in different sections of Berkeley is based on a Municipal Survey report completed in February 1974.

Commercial

According to the report, the Berkeley downtown business district may not experience major fires unless there is a severe earthquake in which case fires would involve several blocks but not the entire district. Although not many of the buildings in this area are fire-resistive and even fewer have sprinkler systems, the generally low building height, good accessibility to block interiors, and fairly good street widths should prevent a fire from involving a whole block or crossing a street.

Berkeley's other business districts found throughout the City are generally similar to the downtown business district where most of the one, two or three story buildings do not have automatic sprinklers and are characterized by ordinary construction (that type of *construction in* which exterior walls are of noncombustible construction having a minimum fire resistance of two hours and stability under fire *conditions). Figure* 12 on the following page shows the general location of the City's business districts. Again, in the event of a big earthquake, fires may not involve more than a large group of buildings or an entire block front.

One other area of the City with commercial facilities is the Marina, where no major fire hazard is posed by the few buildings there. This is due to the good spacing between the buildings and to the buildings' fire-resistive construction or full sprinkler systems.

Industrial

The industrial section of Berkeley is primarily the area west of San Pablo Avenue (See Figure 13 on the following page). Most of the one and two-story buildings in this area are wood frame units (less fire resistant than ordinary construction). Where there is a high concentration of these wood frame buildings, a few large group and block fires would take place unless there are frequent open spaces to contain the fires to the group of origin.

Institutional

Institutional activities constitute a major land use in Berkeley. Hospitals, schools, plus the University of California and its affiliated laboratories and research institutes, are scattered throughout the City. Building heights for these uses range from one to ten stories. Most of the structures are fireresistive with a few wood frame units, some protected by automatic sprinklers. In general, fires will not spread because of the good building separation.

Residential

The higher density areas of the City are found immediately to the north and south of the University campus and in the downtown area. These areas have concentrations of rooming houses, apartment buildings, fraternity and sorority houses where single-person households reside. A number of the housing units are of wood frame construction and are up to five stories in height. Because of building congestion, heights and wood shingle roof coverings and siding, fires could involve large groups of buildings in these areas. Other apartment buildings scattered throughout the City, most of them three stories, do not present a major-fire hazard because of the moderate spacing between them.

Most of the City's single family one or two story residences are wood frame units with wood shingle and shake roofs. With the exception of the Berkeley hills area, fires in the low density residential districts will not involve large groups of buildings.

The residences in the Berkeley hills, however, present a potential fire danger, especially the houses near Tilden Park which are exposed to brush, grass and other thick vegetation. During periods of high winds and hot, dry weather, many of the existing one or two story wood frame dwellings could be endangered by spreading fires. In addition, unusually cold winters could kill the eucalyptus trees in the hills and in Tilden Park. In fact, unusually severe weather in the winter of 1972-1973 resulted in the freezing death for thousands of eucalyptus trees, creating an extremely dangerous source of fuel and therefore increasing the fire hazard in Berkeley.

The Panoramic Hill neighborhood, consisting of approximately 200 dwelling units, is the only neighborhood in Berkeley that is designated a fire hazard area by the Fire Department. (See Figure 14 for location of this neighborhood.)

The proximity to the densely wooded wildland hillside owned by the University of California and the East Bay Regional Park District is the main reason for concern. However, the wood houses surrounded by thick vegetation within the neighborhood itself constitutes a dangerous fire hazard situation. This situation is made even worse by the negative effects of high wind conditions during the dry season of the year, very steep topography and extremely poor vehicular access. The Hayward Fault, which is close to the Panoramic Hill neighborhood, could potentially create a big fire since movement on the fault could simultaneously disrupt gas lines and water supplies for fire fighting.

FLOOD HAZARDS

General

According to estimates by the California Division of Mines and Geology losses in the State due to flooding in the next 25 years will be about $6 billion (compared to about $20 billion for earthquake ground shaking alone.) Most of the hazards presented by flooding involve damage to structures, although life losses are often an outcome too. A direct hazard presented by flooding is the erosion of soils which often leads to landslides.

Berkeley's storm drainage system is designed, operated and maintained by the City's Public Works Department (not the Alameda County Flood Control District). Storm drainage is provided in large part by a series of creeks which originate from the crest of the hills to the east. The creeks generally follow steep natural channels until they reach the flatlands where, in most instances, they have been placed underground in culverts to their point of discharge in the Bay (See Figure 15 on the next page for location of creeks).

In general, the City's drainage system are adequate to carry the ten and even 25 year storm runoffs. However, with larger storms, some flooding would occur, primarily as "sheet flow" in the streets. As storm magnitude increases, water would overflow the creeks producing additional flooding damage. Due to the ground slope to the bay, flood waters in the streets tend to flow to the lower areas of the City.

Figure 16 on the following page delineates the flood hazard areas of Berkeley based on a 100-year flood (by definition, a 100-year flood is a major flood that occurs only once every 100 years). The map shows all of the waterfront area and parts of West Berkeley plus some areas along Claremont Avenue as flood-prone areas. The source of information is a 1973 U. S. Geological Survey study.

Flooding in Berkeley would come about as a result of: 1) overflow from the bay; 2) swelling of creeks; 3) overriding of curbs in the hill areas; and 4) dam failure. During a very heavy storm, water could conceivably overflow from the bay depending on whether there is a high or low tide. In addition, during a major earthquake, seismically induced sea waves of tsunamis would flood the waterfront area plus small parts of the industrial district in the West Berkeley area. As stated previously, the creeks in Berkeley serve as a major component of the storm drainage system. In the event of heavy rains, the creeks could swell and overflow producing some damage, particularly Harwood and Temescal creeks near Claremont Avenue. The overriding of curbs in the hills area will be prevalent where the curbs are marginally defined or nonexistent, resulting in the flooding of some basements. Finally, flooding from dam failures could be costly, both in terms of lives and property. Dams and reservoirs could collapse due to strong groundshaking or landslides, releasing a tremendous volume of water to inundate downstream development (See Figure 17 for the location of Berkeley's water reservoirs). The East Bay Municipal Utility District, as required by the State, has prepared a dam failure inundation map for its reservoirs. So far, inundation maps for Slim-it and Berryman Reservoirs have been received (See Figure 18). Copies of other maps will be made public as soon as they are approved by the State Office of Emergency Services.

With the exception of dam failure which could cause considerable damage to life and property, most flooding in Berkeley would occur only as "sheet flow" with depths of less than several feet of water. The most serious dangers would therefore be potential damage to property, rather than a threat to life.

The National Flood Insurance Program

Across the country, the most common natural disaster is flooding. The Federal Government has therefore initiated a National Flood Insurance Program through

through the Federal Insurance Administration of the Department of Housing and Urban Development. This program offers comprehensive flood damage protection at subsidized rates to owners of property in flood-prone areas. In order for property owners to participate in this program, a city has to qualify by submitting an application to the Flood Insurance Administration (FIA) and adopting at least simple building permit requirements such as proper anchoring of buildings to prevent them from floating away. Once a City is accepted in the program, local insurance agents will sell policies. Failure by a City to qualify for the program by July 1, 1975 (assuming it was notified at least one year earlier by the FIA of its potential flood hazards, (will make individuals and businesses ineligible to receive federal assistance for financing the purchase or construction of buildings in identified flood-prone areas.

If a city qualifies for the program, then individual property owners can purchase low-cost insurance to cover losses up to $35,000 on a single unit dwelling, up to $100,000 on multi-unit dwellings and up to $100,000 on non-residential buildings. The cost is 25¢ per $100 valuation for residential structures and 40C per $100 valuation for non-residential structures. Berkeley has already qualified and is currently a participant in this program.

COMPOSITE MAP OF NATURAL HAZARDS

The map on the following page (Figure 19) is a composite diagram showing the more readily identifiable seismic, fire and flood hazards that exist in Berkeley. The Hayward Fault and the Special Studies Zone are generally delineated along with areas subject to liquefaction, landslides and tsunamis. In addition, the Panoramic Hill fire hazard area and flood hazard areas due to water reservoir inundation and the 100-year flood are also outlined. There are certain parts of Berkeley which are subject to various risks. For example, the waterfront area is exposed to liquefaction, tsunami and 100-year flood hazards. The area near Berryman Reservoir and the Rose Garden is in the Alquist-Priolo Special Studies Zone as well as in landslide and reservoir inundation areas.

Emergency Preparedness

A major thrust of the Safety Element is to encourage cities to develop community plans to better cope with unexpected natural disasters. A community emergency plan establishes a comprehensive framework for the conduct and coordination of emergency operations during a disaster. The assumption is that government federal, state, county and city-has a responsibility to protect its citizens from catastrophies and should, therefore, prepare a plan which outlines a local jurisdiction's response to disasters.

Berkeley's Fire Department is currently continuing its coordination efforts to update the City's 1961 basic Civil Defense and Disaster Plan as mandated by -Ordinance #4721-N.S. (November 7, 1974). A revised comprehensive emergency plan for the City has been prepared and submitted to the State Office of Emergency Services. It has received tentative approval by the State and will eventually be presented for official adoption (it is not yet available for public review).

The Plan should, hopefully, contain the new assignment of tasks and responsibilities, the designation of emergency centers, plus an intensive program to inform the public (particularly people and organizations with specific responsibilities) of emergency operations and procedures.

The rough overview presented below describes the City's Civil Defense and Disaster Plan of 1961. It is obviously outdated although its general provisions are still applicable today, pending final adoption of the revised Community Emergency Plan.

A. Civil Defense and Disaster Plan of 1961

Berkeley has had a Civil Defense and Disaster Plan since August of 1961. This plan was developed during the time when communities were fearful of a nuclear attack. It is therefore heavily oriented toward potential enemy nuclear attack. Natural disasters such as fire, earthquake and flood are mentioned in the Plan and the implication is that the operational steps taken during a natural disaster are very similar to those taken during a war-caused disaster.

According to this Plan, the City's mandate during a disaster is to minimize the effects of the disaster by saving lives and property, caring for the injured, preserving law and order and carrying out recovery operations. Moreover, to the extent possible, Berkeley will assist neighboring cities and counties during times of disaster.

Berkeley's original Disaster Organization, as provided for in Ordinance #3216-N.S. (October 2, 1951) called for the establishment of a Disaster Council consisting of the Mayor, City Manager, a coordinator of Civil Defense and Disaster, City department heads and other representatives of organizations having an official responsibility in the event of a disaster. In addition., Berkeley's Civil Defense and Disaster Plan outlines the distribution of powers and duties, the succession of command, the assignment of functions among the 14 services and the relations with the American Red Cross, the University of California and the Berkeley Unified School District (as provided for in Resolution #39,014-N.S., July 3, 1962.) The 14 services mentioned above are as follows: Fire, Law Enforcement, Engineering, Transportation, Medical and Health, Operational Information, Manpower, Emergency Welfare, Registration and Inquiry, Supply, Communications, Rescue, Radiological Safety and Utilities. Each one of these basic services is headed by a department head or a major division chief. Detailed tasks and responsibilities assigned to each service are contained in individual annexes (i.e., emergency operations plans). There is also a University of California annex and a Berkeley Public School annex.

Communications during a disaster will be available through the Police Department radio network in the Hall of Justice on-McKinley Street, the Fire Department radio network in Fire Station #2 on Henry Street, the Public Works Department radio network located at the City Corporation Yard, and amateur radio stations. According to the Plan, the primary control center is located in the Police Control Center on the 2nd floor of the Hall of Justice with alternate control centers at dispersed locations throughout the City.

During a major disaster, the designation of medical care centers where people can receive treatment is quite essential. The Plan proposes using school buildings as care centers. Figure 20 on the following page shows a map of mass rare, medical centers and related field stations with approximate addresses.

In terms of evacuation routes from Berkeley% the 1961 plan designates streets to be used as exit routes during a disaster (See Figure 21). If one is on the Eastshore Freeway or San Pablo Avenue, one should travel north and continue as directed by the State Highway Patrol; if on Arlington Avenue, travel north to the end of Arlington and then to San Pablo Dam Road as directed; if on Spruce, Euclid or Shasta Road, cross into Tilden Park and continue east as directed; if on Tunnel Road, travel east to Orinda crossroads and continue as directed by the State Highway Patrol.

Mutual Aid Agreement

Since no community has the resources to effectively handle all potential emergencies, a major component of emergency planning and operations is mutual aid. Mutual aid is an agreement in which two or more jurisdictions agree to furnish resources, facilities and services to one another to prevent and cope with any type of disaster or emergency. Each local jurisdiction relies first on its own resources, then, in accordance with prior formal agreements, seeks assistance from its neighbors as needed.

The foundation of California's emergency planning is a statewide system of mutual aid. The California Master Mutual Aid Agreement developed in 1950 and adopted by Berkeley along with 391 cities and all 58 counties, creates a formal structure within which each jurisdiction retains control of its personnel and facilities, but can give and receive help whenever it is needed. The State of California is a co-signer of this agreement and provides available resources through its Office of Emergency Services to assist local jurisdictions in emergencies.

The State is divided into six Mutual Aid Regions to coordinate emergency activities. Berkeley is in Mutual Aid Region II, which includes Alameda, Contra Costa, Lake, Marin, Mendocino, Monterey, Napa, San Benito, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano and Sonoma Counties (Please see Figure 22 on next page). Mutual aid regions are in turn divided into operational areas, with service chiefs in each area. Berkeley is part of the Alameda County Operational Areas. The law enforcement chief for this area is the Sheriff of Alameda County.

GOAL AND POLICY RECOMMENDATIONS

Berkeley is highly susceptible to natural hazards because of location, topography, soil conditions and other factors. Earthquakes and related seismic activity, fires and floods could create minor to catastrophic disruption of urban life in the city.

Berkeley is definitely earthquake country, with the hills and UC campus straddling the Hayward Fault. A 7+ magnitude earthquake along this fault will probably produce strong ground shaking and a ground displacement of several feet. Other seismic-related activities such as landslides, liquefaction, structural damage and flooding due to seismically-induced waves could also occur during a major earthquake.' Even without an earthquake, parts of the Berkeley hills pose a fire hazard problem because of the nearby densely wooded wildland, steep topography and narrow, winding roads. Flooding is a potential hazard in the Waterfront and West Berkeley areas and above Claremont Avenue in the southeast portion of the city.

GOAL

TO REDUCE TO A MINIMUM RISKS ASSOCIATED WITH NATURAL HAZARDS, TO GUIDE ACTIVITIES DURING AN EMERGENCY AND TO MINIMIZE PROBLEMS RELATED TO THE REBUILDING OF THE CITY AFTER A MAJOR DISASTER.

ACCEPTABLE EXPOSURE TO RISK

POLICY 5.00

ESTABLISH CRITERIA FOR ACCEPTABLE EXPOSURE TO SEISMIC, FIRE AND FLOOD RISK FOR LAND USES AND STRUCTURE TYPES BASED ON THE NATURE OF USE, THE IMPORTANCE OF THE USE TO THE TOTAL COMMUNITY AND THE DENSITY OF OCCUPANCY.

SPECIAL REGULATIONS

POLICY 5.01

ENACT SPECIAL DEVELOPMENT REGULATIONS FOR KNOWN SEISMICRELATED HAZARD AREAS AND FOR CRITICAL, ESSENTIAL OR HIGHOCCUPANCY STRUCTURES THROUGHOUT THE CITY.

In 1972, the State Legislature adopted the Alquist-Priolo Geologic Hazard Zones Act which provides for the identification and mapping of all known active faults in California by the State Geologist. In addition, a Special Studies Zone is delineated which generally encompasses the area contained within 650 feet from either side of identified active faults. Some of the restrictions imposed on development in this zone are as follows:

- The area within 50 feet of an active fault shall be assumed to be underlain by active branches of the fault unless proven otherwise by a registered geologist.

- Application for all proposed developments within the Special Studies Zone shall be accompanied by geologic reports prepared by registered geologists.

The city should develop similar regulations for areas of known seismic-related hazards outside of the Special Studies Zone. For example, more restrictive requirements should be imposed which would not allow future construction of Group1 through Group 3 structures within the Special Studies Zones and areas of known hazards, unless appropriate structural design reinforcement is provided. Compensating structural designs should be implemented for those structures whose failure could be catastrophic to the community which are essential during emergencies or which involve high occupancy. Berkeley could acquire lands subject to severe seismic and geologic hazards for open space of low intensity park and recreational activities.

TABLE A

LEVEL OF ACCEPTABLE EXPOSURE TO RISK	EXPLANATIONS	KINDS OF LAND USES & STRUCTURES
Group 1. Lowest level of acceptable exposure to risk	Failure of a simple structure may affect substantial populations Structures whose continued functioning is critical to the community welfare or whose failure might be catastrophic. These structures should experience no structural/mechanical failure or damage to interior equipment. These structures must be fully operational Immediately following a major earthquake.	Critical structures such as nuclear reactors, large dams, Plants manufacturing or storing explosives or toxic materials
Group 2. Very low level of acceptable exposure to risk	Failure of a single structure may affect substantial populations Structures whose use is critically needed after a disaster. These structures must not experience structural/mechanical failure, with little or no damage to interior furnishings and equipment. They must be fully operational following a major earthquake.	Essential structures such as hospital, fire stations important utility centers, critical transportation elements such as overpasses, fire, police, and emergency communication facilities
Group 3. Low Level of acceptable exposure to risk	Failure of single structure would affect primarily the occupants. Structures of high occupancy or whose use after a disaster would be particularly convenient though not critical. No structural collapse should occur or damage that cannot be repaired quickly.	High occupancy structures such-as schools, churches, civic buildings, theaters, large hotels, jails, dormitory high-rise apartment or office buildings
Group 4. Ordinary level of acceptable exposure to risk	Failure of a single structure would affect primarily the occupants. No structural collapse should occur; damage may occur to mechanical systems and contents of building.	Relatively low occupancy structures such as most industrial or commercial buildings, small hotels and apartment buildings
Group 5. More than ordinary level of	Failure of a single structure would affect primarily the	Single family residences, warehouses

acceptable exposure to risk	occupants. A vast majority of Berkeley's structures are in this group. No structural collapse should occur. Damage may occur to mechanical systems and contents of building
Group 6. Highest level of acceptable exposure to risk	Open Space only

SOURCE: scale of Acceptable Risks,," Meeting the Earthquake Challenge, California Joint Committee on Seismic Safety (January 1974)

HAZARD ABATEMENT

POLICY 5.02

INITIATE AN ORDERLY ABATEMENT OF SIE8MIC, FIRE AND FLOODRELATED HAZARDS. PRIORITY FOR ABATEMENT ACTION SHOULD BE BASED ON THE SEVERITY OF THE RISK, THE DENSITY OF OCCUPANCY AND THE IMPORTANCE OF THE STRUCTURE TO THE COMMUNITY AS A WHOLE. IN ALL CASES, ADEQUATE MEASURES SHOULD BE PROVIDED TO PREVENT UNDUE ECONOMIC HARDSHIP OR RELOCATION PROBLEMS TO THE AFFECTED PEOPLE.

In a city like Berkeley which is almost totally developed, existing hazardous **structures** represent perhaps the greatest threat to the lives and safety of the community. Immediate action should, therefore, be taken to identify these structures and begin to evaluate ways to correct the hazards. The city should establish a program to have critical, essential and high-occupancy structures highly susceptible to damage either reinforced, relocated or demolished.

FIRE IN THE HILL AREAS

POLICY 5.03

MINIMIZE FIRE HAZARDS IN EXISTING AND FUTURE DEVELOPMENT OF THE HILL AREAS, ESPECIALLY NEAR THE DENSELY WOODED WILDLAND, THROUGH CAREFUL SITE DESIGN, VEGETATION CONTROL AND PROVISION OF ADEQUATE ACCESS.

A special fire hazard that exists in the Berkeley hills area is the potential for a major forest fire after an earthquake or after a very dry and windy slimmer. One way to reduce the risk is through fuel control that eliminates highly combustible vegetation, thereby providing a fuel break to prevent conflagration. A careful vegetation management program should guide the replanting of cleared areas with mature, 1 low growing plants that are fire-resistant and produce very little heat. Good site design and vegetation control are essential fire prevention measures for the hill areas.

PUBLIC CODES

POLICY 5.04

CONTINUALLY UPDATE THE PUBLIC CODES THAT REGULATE THE DESIGN AND CONSTRUCTION OF NEW STRUCTURES TO INCORPORATE THE MOST RECENT KNOWLEDGE AND HIGHEST STANDARDS OF EARTHQUAKE, FIRE AND FLOOD DESIGN TECHNIQUES.

New knowledge on improved design techniques and the impact of natural hazards on land uses should be incorporated in appropriate codes.

EMERGENCY PLANS

POLICY 5.05

MAINTAIN AND UPDATE PERIODICALLY A COMPREHENSIVE COMMUNITY EMERGENCY OPERATIONS PLAN FOR BERKELEY.

The City of Berkeley Disaster Council should be activated immediately to conduct periodic revisions of the Plan and acquaint the total community with the procedures and operations suggested by the Plan. Periodic test exercises of the emergency plan network--communications, medicine, personnel-should be conducted.

POLICY 5.06

EXPAND AND MAKE MORE EFFECTIVE EXISTING MUTUAL AID PACTS BETWEEN BERKELEY AND NEARBY JURISDICTIONS TO INCLUDE A WIDER VARIETY OF PUBLIC SERVICES BEYOND FIRE AND POLICE.

In California 392 cities, 58 counties and the State have all signed the California Disaster and Civil Defense e Master Mutual Aid Agreement which enables a city, following a major disaster, to seek assistance from other jurisdictions when the city's own resources have been depleted or incapacitated. Some fire and police departments have utilized mutual aid successfully, but it is essential that Berkeley and nearby participating cities expand the coverage of such pacts to include public works, building inspection and other personnel with critical post disaster skills.

POLICY 5.07

INITIATE A MAJOR COMMUNITY AWARENESS PROGRAM ON SEISMIC, FIRE, FLOOD AND RELATED HAZARD SAFETY. ACQUAINT ALL RESIDENTS WITH THE CITY'S COMMUNITY EMERGENCY OPERATIONS PLAN.

Risk could be reduced in local neighborhoods if the residents are made more aware of public safety measures that can be taken at minimal cost to them. For example, the city is already participating in the National Flood Insurance Program and property owners whose structures are located in flood-prone areas should be informed and encouraged to participate in the program. Areas that pose known potential hazards should be delineated and made available to the public without causing alarm. In particular, current property owners, businesses, prospective property owners and real estate salespersons should have all natural hazard information relating to specific private developments of interest to them. In addition, Berkeley residents should be made aware of emergency services, operations and procedures (contained in the city's community emergency operations plan) that will be in effect during a major disaster.

GLOSSARY*

ACTIVE FAULT

A fault which has moved in recent geologic time and which is likely to move again in the relatively near future. For planning purposes, a .fault which has moved in the last 10,000 years is considered active.

ALLUVIAL DEPOSITS

Irregularly stratified, poorly consolidated deposit of mud, silt, sand and gravel found in stream and water beds and on adjoining flood plains. The surface of these deposits generally are relatively flat or gently sloping. These deposits may be water bearing, are commonly porous and permeable and may compact slightly upon loading.

ALLUVIAL FAN DEPOSITS

Irregularly stratified, unconsolidated to poorly consolidated, fan-shaped sediments of mud, silt, clay and gravel deposited by stream and mudflows. Fan deposits are generally easy to excavate and not very resistant to erosion. Natural slopes are normally stable, although stream undercutting can produce stream bank failure and some compaction or local subsidence of the fan surface face may take place.

ALLUVIAL TERRACE DEPOSITS

Irregularly stratified alluvial deposits of clay-sized materials, silt, sand, and gravel that underlie horizontal to gently inclined flat surfaces that are adjacent to but above present streambeds.

AMPLIFICATION

The increase in earthquake ground motion that may occur to the principal components of seismic waves as they enter and pass through different earth materials.

BEDROCK

Solid rock underlying surface materials (sand, clay, soil, etc.).

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*SOURCES FOR GLOSSARY TERMS:

Civil Defense and Disaster Plan, City of Berkeley, 1961 Seismic Hazards and Land Use Planning, USGS, 1974.
Tri-City Seismic Safety Study, Cities of El Cerrito, Richmond and San Pablo, 1973.

ALLUVIAL TERRACE DEPOSITS

Irregularly stratified alluvial deposits of clay-sized materials, silt, sand, and gravel that underlie horizontal to gently inclined flat surfaces that are adjacent to but above present streambeds.

AMPLIFICATION

The increase in earthquake ground motion that may occur to the principal components of seismic waves as they enter and pass through different earth materials.

BEDROCK

Solid rock underlying surface materials (sand, clay, soil, etc.).

COLLUVIAL DEPOSITS

Poorly stratified and poorly consolidated deposits composed of fresh and weathered rock fragments, soil, or irregular mixtures of these materials that accumulate near the foot of a slope by slow down slope movement of surficial material. Colluvial deposits are easily eroded. They may be water bearing and will probably compact under loading. Grading, (resulting in steeper slopes) may accelerate the rate of down slope movement and produce landslides.

DIFFERENTIAL SETTLEMENT

Process whereby the loss of strength or water through liquefaction leads to uneven ground settlement.

EMERGENCY OPERATIONS CENTER

A facility with some degree of fallout protection and the necessary staff and communication capability from which essentially all emergency functions are directed and controlled by the principal officials of government.

FAULT

A plane or surface in earth materials along which failure has occurred and materials on opposite sides have moved relative to one another in response to the accumulation of stress in the rocks.

FAULT CREEP

Slow and imperceptible movement along a fault, unaccompanied by an earthquake.

GROUND CRACKING

A condition where the ground fails to hold together as in mudslide, liquefaction and landslide.

GROUND LURCHING

Undulating waves in soft saturated ground that may or may not remain after the earthquake.

GROUND RESPONSE

The reaction of the ground to earthquake shaking.

HAYWARD FAULT

A large and active fault of the San Andreas Fault System. It has been the center of many earthquakes, including the 1868 earthquake which was one of largest ever to hit Northern California.

HAZARDOUS BUILDING

Building considered unsafe owing to poor design, poor construction techniques or materials, defects in foundation conditions, lack of maintenance, or damage from any one of several possible causes.

INACTIVE FAULT

A fault which has not moved in recent geologic time (about 10,000 years) and which is not expected to move again in the relatively near future. Sometimes, inactive faults are so labeled due to lack of knowledge rather than actual state.

INTENSITY

A subjective measure of earthquake size at a particular place as determined by its effects on persons, structures and earth materials. The principal scale used in the United States today is the modified Mercalli (1956 version). Intensity is a measure of effects whereas magnitude is a measure of energy released.

INUNDATION

Flooding caused by water topping a dam or water released by dam **reservoir failure** or other breaks.

LANDSLIDE

The rapid downward movement of loose masses of rock, earth or artificial fill on a slope.

LIQUEFACTION

A process whereby water saturated and cohesionless soil loses its cohesiveness when subjected to intense ground shaking. The soil loses all strength and acts like quicksand.

LOCAL EMERGENCY

Shall mean the existence of conditions within the territorial limits of a local agency, in the absence of a duly proclaimed State of Emergency, which conditions are a result of an emergency created by great public calamity such as air pollution, extraordinary fire, flood, storm earthquake, civil disturbances or other disaster which is or is likely to be beyond the control of the services, personnel, equipment and facilities of that agency and require combined forces of other local agencies to combat. (California Emergency Services Act, Chapter 7 of Division 1 of Title 2 of the Government Code - 1970 Statutes)

MAGNITUDE

A measure of the energy released in an earthquake. The rating of a given earthquake is defined on a logarithmic scale where each upward step of one magnitude unit is equivalent to a 32 fold increase in energy release. The Richter Scale is used to measure earthquake magnitudes.

MUTUAL AID

An agreement in which two or more parties agree to furnish resources and facilities and to render services to each and every other party of the agree to prevent and combat any type of disaster or emergency.

MUTUAL AID REGION

A subdivision of the State's fire and rescue services organization, established to facilitate the coordination of mutual aid and other emergency operations within a geographical area of the state, consisting of two or more county operational areas.

OPERATIONAL AREA

An intermediate level of the state fire and rescue services organization, normally consisting of a county and all fire and rescue organizations within the county.

PREDOMINANT BUILDING VIBRATION PERIOD

A number representing the time between seismic wave peaks to which a building on the ground is most vulnerable.

SEDIMENT

Solid material settled from suspension in a liquid.

SEICHE

Earthquake-induced waves within enclosed or restricted bodies of water (such as lakes and reservoirs) which act like the sloshing of water in a bowl during ground shaking.

SEISMIC HAZARDS

Hazards related to seismic or earthquake activity.

STATE OF EMERGENCY

Means the duly proclaimed existence of conditions of extreme peril to the safety of persons and property within the state caused by such conditions as air pollution, fire, flood, storm, civil disturbances or earthquake, or other conditions, except as a result of war-caused emergencies, which conditions by reason of their magnitude are, or are likely to be beyond the control of the services, personnel, equipment and facilities of any single county, city and county, or city and would require the combined forces of a mutual aid region or regions to combat. "State of Emergency" does not include, nor does any provision of this plan apply to any condition resulting from a labor controversy. (California Emergency Services Act, Chapter 7 of Division 1 of Title 2 of the Government Code - 1970 Statutes)

SUBSIDENCE

Shrinking of a large area of land.

SURFACE RUPTURE

Break in the ground surface resulting from fault movement.

TSUNAMI

A sea wave produced by large areal displacements of the ocean bottom, often the result of earthquakes or volcanic activity. Also known as seismic sea waves.

A P P E N D I X A

SEISMIC SAFETY ELEMENT MANDATE

Government Code Section 65302(f) requires a Seismic Safety Element of all city and county general plans, as follows:

> "A Seismic Safety Element consisting of an identification and appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures or to the effects of seismically induced waves such as tsunami and seiches.
>
> The Seismic Safety Element shall also include an appraisal of mudslides, landslides and slope stability as necessary geologic hazards that must be considered simultaneously with other hazards such as possible surface ruptures from faulting, ground shaking, ground failure and seismically induced waves."

SAFETY ELEMENT MANDATE

Government Code Section 65302.1 requires a Safety Element of All city and County general plans, as follows:

> "A Safety Element for the protection of the community from fires and geologic hazards including features necessary for such protection as evacuation routes, peak load water supply requirements, minimum road widths, clearances around structures and geologic hazard mapping in areas of known geologic hazard."

A P P E N D I X C

Senate Bill No. S20

CHAPTER 1354

An act to amend Section 660, 661, and 662 of, and to odd Chapter 75 (commencing with Section 26-01) to Division 2 of, the Public Resources code, relating to earthquake protection, and making an appropriation therefore.

(Approved by Governor December 22. 197L Red with Secretary of State December 22. 1972)

LEGISLATIVE COUNSELS DIGEST

SB 520, Alquist. Earthquake protection.

Increases the membership of the State Mining and Geology Board from 9 to 11 persons and declares that persons with specified occupations should be selected for membership on the board. Designates the board as a policy and appeals board for the purposes of provisions re earthquake hazard zones.

Requires the State Geologist to delineate, by December 31, 1973, special studies zones encompassing certain areas of earthquake hazard. Requires State Geologist to compile maps delineating the special studies zones and to submit such maps to affected cities, counties, and state agencies for review and comment. Requires the State Geologist to continually review new geologic and seismic data and revise special studies zones and submit such revisions to affected cities, counties, and state agencies for review and comment Appropriates $100,000 for such purposes. Requires affected cities, counties, and state agencies to submit their comments to board.

Requires cities and counties to exercise specified approval authority with respect to real estate developments or structures for human occupancy within such delineated zones. Requires applicants for a building permit within such zone to be charged a fee according to a fee schedule established by the board. Limits maximum amount of such fee. Provides for retention of *1/2* of the proceeds of any such fee by the city or county having jurisdiction and transfer of *1/2* to the state.

The people of the State of California do enact as follows

Section 1. Section 660 of the Public Resources Code is amended to read:

660 'Mere is in the department a State Mining and Geology Board, consisting of 11 members appointed by the Governor, subject to confirmation by the Senate, for terms of four years and until their successors are appointed and qualified. The State Mining and Geology Board shall also serve as a policy and appeals board for the purposes of Chapter 7.5 (commencing with Section 2621) of Division

SEC. 2. Section 661 of the Public Resources Code is amended to read:

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661. Members of the board shall be selected from citizens of this state associated with or having broad knowledge of the mineral industries of this state, of its geologic resources, or of related technical and scientific fields, to the end that the functions of the board as specified in Section C67 are conducted in the best interests of the state. Among the 11 members, two should be mining geologists, mining engineers, or mineral economists, one should be a structural engineer, one should be a geophysicist, one should be an urban or regional planner, one should be it soils engineer, two should be geologists, one should be a representative of county government, and at least two shall be members of the public having an interest in and knowledge of the environment.

SEC. 3. Section 662 of the Public Resources Code is amended to read:

662. The terms of the members of the board in office when this article takes effect in 1965 shall expire as follows: one member January 13, 1966, two members January 15,1967; and two members January 15, 1968. The terms shall expire in the same relative order as to each member as the term for which he holds office before this article takes effect The terms of the -two additional members first appointed pursuant to the amendment of this section at the 1968 Regular Session of the Legislature shall commence on January 15, 1969. The terms of the two additional members first appointed pursuant to the amendment of -Section 660 at the 1970 Regular Session of the Legislature shall commence on January 15, 1971, but the term of one of such additional members, who shall be designated by the Governor, shall expire on January 15, 1974. The terms of -the two additional members first appointed pursuant to the amendment of Section 660 at the 1972 Regular Session of the Legislature shall commence on January 15, 1973, but the term of one of such additional members, who shall be designated by the Governor, shall expire on January 15,1976.

SEC. 4. Chapter 7.5 (commencing with Section 2621) is added to Division 2 of the Public Resources Code, to read:

CHAPTER 7.5. HAZARD ZONES

2621. This chapter shall be known and may be cited as the Alquist-Priolo Geologic Hazard Zones Act.

2621.5. It is the purpose of this chapter to provide for the adoption and administration of zoning laws, ordinances, rules, and regulations by cities and counties, as well as to implement such general plan as may be in effect in any city or county. The Legislature declares that the provisions of this chapter are intended to provide policies and criteria to assist cities, counties, and state agencies in the exercise of their responsibility to provide for the public safety in hazardous fault zones.

2622. In order to assist cities and counties in their planning, zoning, and building-regulation functions, the State Geologist shall delineate, by December 31, 1973, appropriately wide special studies zones to encompass all potentially and recently active traces of the San Andreas, Calaveras, -Hayward, and San Jacinto Faults, and such other faults, or segments thereof, as he deems sufficiently active *and* well-defined as to constitute a potential hazard to structures from surface faulting or fault creep. Stich special studies zones shall ordinarily be one-quarter mile or less in width, except in circumstances which may require the State Geologist to designate a wider zone.

Pursuant to this section, the State Geologist shall compile maps delineating the special studies zones and shall submit such maps to all affected cities, counties, and state agencies, not later than December 31, 1973, for review and comment. Concerned *jurisdictions and'* agencies shall submit all such comments to the State Mining and Geology Board for review and consideration within 90 days. Within 1.10 days of such review, the State Geologist shall provide copies of the official maps to concerned state agencies and to each city or county having jurisdiction over lands lying within any such zone.

The State Geologist shall continually review new geologic and seismic data and shall revise the special studies zones or delineate additional special studies zones when warranted -by new information. The State Geologist shall submit all such revisions to all affected cities, counties, and state agencies for their review -and comment. Concerned jurisdictions and agencies shall submit all such comments to the State Mining and Geology Board for review and consideration within 30 days. Within 30 days of such review, tile State Geologist shall provide copies of the revised official maps to concerned state agencies and to each city or county having jurisdiction over lands lying within any such. zone.

2623. Within the special studies zones delineated pursuant to Section 2622, the site of every proposed new real estate development or structure for human occupancy shall be approved by the city or county having jurisdiction over such lands in accordance with policies and criteria established by the State Mining and Geology Board and the findings of the State Geologist. Stich policies and criteria shall be established by the State Mining and Geology Board not later than December 31, 1973. In the development of such policies and criteria. the State Mining and Geology Board shall seek the comment and advice of affected cities, counties, and 'state agencies. Cities and counties shall not approve the location of such a development or structure within a delineated special studies zone if an undue hazard would be created, one approval may be withheld pending geologic and engineering studies to more adequately define the zone of hazard If tile or county finds that no undue hazard exists geologic and

studies may be waived, with approval of the Stale
Geologist and the local ion *or* tile proposed development or structure

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may be approved.

2624. Nothing in this chapter is intended to prevent cities and counties from establishing policies and criteria *which* are stricter than those established by the State Mining :in(] Geology Board, nor from imposing and collecting fees in addition to those required under this chapter.

2825 Each applicant for a building permit within a delineated special studies zone shall be charged a reasonable fee according to a fee schedule established by the State Mining and Geology Board. Such fees shall be set in an amount sufficient to meet, but not to exceed, the costs to state and local government of administering and complying with the provisions of this chapter. Such fee shall not exceed one-tenth of I percent of the total valuation of the proposed building construction for *which* the building permit is issued, as determined by the local building official. One-half of the proceeds of such fees *shall* be retained by the city or county having jurisdiction over the proposed development or structure for the purpose of implementing this chapter, and the remaining one-half of the proceeds shall be deposited in the General Fund.

SEC 5. There is hereby appropriated from the General Fund in the State Treasury to the Department of Conservation the sum of one hundred thousand dollars ($100,000) for the purposes of Section 2622 of the Public Resources Code.

POLICIES AND CRITERIA OF THE STATE MINING AND GEOLOGY BOARD WITH REFERENCE TO THE ALQUIST-PRIOLO GEOLOGIC HAZARD ZONES ACT (CHAPTER 7.5, DIVISION 2, PUBLIC RESOURCES CODE, STATE OF CALIFORNIA)

(Effective July 1, 1974)

The legislature has declared in the ALQUIST-PRIOLO GEOLOGIC HAZARD ZONES ACT that the State Geologist and the State Mining and Geology Board are charged under the Act with the responsibility of assisting the Cities, Counties and State agencies in the exercise of their responsibility to provide for the public safety in hazardous fault zones. As designated by the Act, the policies and criteria set forth hereinafter are limited to hazards resulting from surface faulting or fault creep. This limitation does not imply that other geologic hazards are not important and that such other hazards should not be considered in the total evaluation of land safety.

Implementation of the ALQUIST-PRIOLO GEOLOGIC HAZARD ZONES ACT by-affected cities and counties fulfills only a portion of the requirement for these counties and cities to prepare seismic safety and safety elements of their general plans, pursuant to Section 65302 (F) and 65302.1 of the Government Code. The special study zones, together with these policies and criteria, should be incorporated into the local seismic safety and safety elements of the general plan.

The State Geologist has compiled and is in the process of compiling maps delineating special studies zones pursuant to Section 2622 of the Public Resources Code. The special studies zones designated on the maps are based on fault data of varied quality. It is expected that the maps will be revised as more complete geological information becomes available. Also, additional special studies zones may be delineated in the future. The Board has certain responsibilities regarding review and consideration of those maps prior to the time that they are finally determined. Cities, Counties and State agencies have certain opportunities under the Act to comment on the preliminary maps provided by the State Geologist and these Policies and Criteria. Certain procedures are suggested herein with regard to those responsibilities and comments.

Please note that the Act is not retroactive. Section 2623 of the Public Resources Coda provides that it applies to every proposed new real estate development or structure for human occupancy.

REVIEW OF PRELIMINARY MAPS

The State Mining and Geology Board suggests that each reviewing governmental agency take the following steps in reviewing the preliminary maps submitted for their consideration:

1. All property owners within the preliminary special studies zones mapped by the State Geologist should be notified by the Cities and Counties of the inclusion of their lands within said preliminary special studies zones by publication or other means designed to inform said property owners. Such notification shall not of necessity require notification by service or by mail. This notification will permit affected property owners to present geologic evidence they might have relative to the preliminary maps.

2. Cities and Counties are encouraged to examine the preliminary maps delineating special studies zones and to make recommendations, accompanied by supporting data and discussions, to the State Mining and Geology Board for modification of said zones in accordance with the statute and within the time period specified therein.

3. For purposes of the Act, the State Mining and Geology Board regards faults which have had surface displacement within Holocene time (about the last 11,000 years), as active and hence as constituting a potential hazard. Upon submission of satisfactory geologic evidence that a fault shown within a special studies zone has not had surface displacement within Holocene time and thus is not deemed active, the Mining and Geology Board may recommend to the State Geologist that the boundaries of the special studies zone be appropriately modified.

The definition of active fault is intended to represent minimum criteria only for all structures. Cities and Counties may wish to impose more restrictive definitions requiring a longer time period of demonstrated absence of displacements for critical structures such as high-rise buildings, hospitals, and schools.

SPECIFIC CRITERIA

The following specific and detailed criteria shall apply within special studies zones and shall be included in any planning program, ordinance, rules and regulations adopted by Cities and Counties pursuant to said GEOLOGIC HAZARD ZONES ACT:

A. No structure for human occupancy, public or private-, shall be permitted to be placed across the trace of an active fault. Furthermore, the area within fifty (50) feet of an active fault shall be assumed to be underlain by active branches of that fault unless and until proven otherwise by an appropriate geologic investigation and submission of a report by a geologist registered in the State of California. This 50-foot standard is intended to represent minimum criteria only for all structures. It is the opinion of the Board that certain essential or critical structures, such as high-rise buildings, hospitals, and schools should be subject to more restrictive criteria at the discretion of cities and counties.

B. Applications for all real estate developments and structures for human occupancy within special study zones shall be accompanied by a geologic report prepared by a geologist registered in the State of California, and directed to the problem of potential surface fault displacement through the site, unless such studies are waived pursuant to Section 2623

C. One (I) copy of all such geologic reports shall be filed with the State Geologist by the public body having jurisdiction within thirty days of submission. The State Geologist shall place such reports on open file.

D. Requirements for geologic reports may be satisfied for a single 1 or 2 family residence if, in the judgment of technically qualified City and County personnel and with the approval of the State Geologist, sufficient information regarding the site is available from previous studies in-the same area.

E. Technically qualified personnel within or retained by each City or County must evaluate the geologic reports required herein and advise the body having jurisdiction and authority.

F. Cities and Counties may establish policies and criteria which are more restrictive than those established herein. In particular, the Board believes that comprehensive geologic and engineering studies should be required for any "critical" or "essential" structure as previously defined whether or not it is located within a special studies zone.

G. In accordance with Section 2625 of the Public Resources Code each applicant for a building permit within a delineated special studies :tone shall pay to the City or County administering and complying with the ALQUIST-PRIOLO GEOLOGIC HAZARD ZONES ACT a fee of one-tenth of one-percent of the total valuation of the proposed building construction for which the building permit is issued as determined by the local building official.

H. As used herein the following definitions apply:

1. A "structure for human occupancy" is one that is regularly, habitually or primarily occupied by humans; excluding there from freeways, roadways, bridges, railways, airport runways, and tunnels. The excluded transportation structures should be sited and designed with due consideration to the hazard of surface faulting. Mobile homes, whose body width exceed eight (8) feet, are considered as structures for human occupancy.

2. Only a geologist registered in the State of California is deemed to be technically qualified to evaluate geologic reports.

3. A "new real estate development" is defined as any new development of real property which contemplates the eventual construction of "structures for human occupancy."