

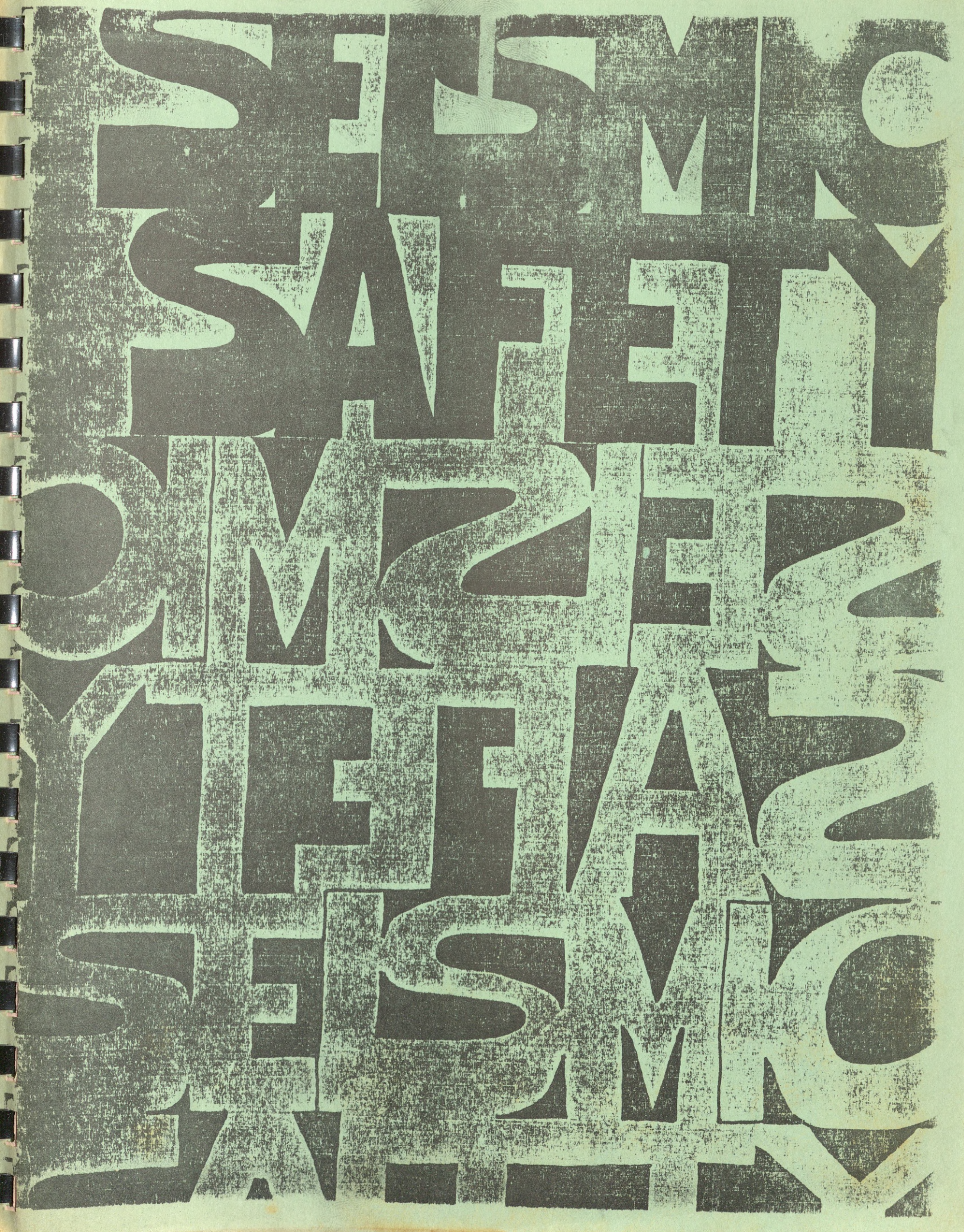
SEISMIC AND SAFETY ELEMENT

APPROVED BY

CITY OF OXNARD  
PLANNING COMMISSION

December 4, 1975







RESOLUTION NO. 4861

A RESOLUTION OF THE PLANNING COMMISSION OF THE CITY OF OXNARD CERTIFYING THE ADEQUACY OF THE DRAFT ENVIRONMENTAL IMPACT REPORT E-75-11 FOR SEISMIC AND SAFETY ELEMENT OF THE GENERAL PLAN FILED ON PLANNING COMMISSION RESOLUTION OF INTENTION NO. 4644; AND DIRECTING PREPARATION OF A FINAL REPORT FOR SUBMISSION TO THE CITY COUNCIL.

WHEREAS, this commission has thoroughly considered the draft Environmental Impact Report E-75-11 for the Seismic and Safety Element of the General Plan in accordance with the Environmental Quality Act of 1970, as amended, and as implemented by the Environmental Quality Protection Ordinance of the City of Oxnard and Resolution No. 6179 of the City Council; and

WHEREAS, this commission finds and determines that the information contained within the Report does wholly and adequately describe and evaluate the proposed project in accordance with the State environmental procedures and standards established by Title 14, Division 6, Chapter 3 of the California Administrative Code and said City legislation.

NOW, THEREFORE, BE IT RESOLVED by the Planning Commission of the City of Oxnard that the adequacy of the draft Environmental Impact Report E-75-11 be, and it is hereby, certified to the City Council of the City of Oxnard; and

BE IT FURTHER RESOLVED by the Planning Commission of the City of Oxnard that the Secretary of the commission be directed to prepare and submit to the City Council the final Environmental Impact Report E-75-11 for the Seismic and Safety Element of the General Plan.

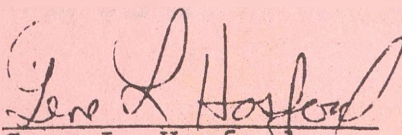
PASSED AND ADOPTED by the Planning Commission of the City of Oxnard on this 4th day of December, 1975, by the following vote:

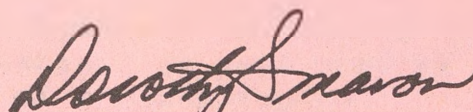
AYES: Commissioners: John, Takasugi, Flores, Stoll,  
Lopez, Duff, Maron

NOES: Commissioners: None

ABSENT: Commissioners: None

ATTEST:

  
Gene L. Hosford  
Secretary

  
Dorothy S. Maron  
Chairman



RESOLUTION NO. 4862

A RESOLUTION OF THE PLANNING COMMISSION OF THE CITY OF OXNARD APPROVING AND RECOMMENDING TO THE CITY COUNCIL THE ADOPTION OF AN AMENDMENT TO THE REVISED 1969 GENERAL PLAN IN ACCORDANCE WITH SECTIONS 65302(f) AND 65302.1 OF THE GOVERNMENT CODE TO INCLUDE A "SEISMIC AND SAFETY ELEMENT".

- WHEREAS, the Planning Commission of the City of Oxnard has considered an amendment to the Revised 1969 General Plan as provided in Sections 65355 of the Government Code of the State of California; and
- WHEREAS, said commission has held a public hearing and considered in depth the proposed amendment to the Revised 1969 General Plan to include a Seismic and Safety Element; and
- WHEREAS, said commission having previously considered the environmental impact report submitted and finding it to conform to the requirements of law and finding further that the benefits of the proposed General Plan amendment outweigh any possible detrimental effects to the environment; and
- WHEREAS, said commission finds that the public health, safety and general welfare requires the adoption of an amendment to the Revised 1969 General Plan to include a "Seismic and Safety Element" pursuant to the provisions of Article V, Chapter 3, Title 7 of the Government Code of the State of California.
- NOW, THEREFORE, BE IT RESOLVED that the Planning Commission of the City of Oxnard hereby approves and recommends to the City Council the adoption of an amendment to the Revised 1969 General Plan to include a Seismic and Safety Element attached and labeled Exhibit "A".
- BE IT FURTHER RESOLVED that the commission recommends additional study and consideration be given to the following items for possible revision at a later date:
1. Further study and review be given to recommendations 1 through 7 of Section IV, Flooding, with emphasis on recommendations 5 and 6 for possible redundancy and conflict.
  2. Further study be given concerning the effect to elevators and other mechanical devices used by the public in the event of a catastrophe.



3. Further study be given concerning the effect of fixtures and furniture as instruments of injury or damage in the event of a catastrophe.

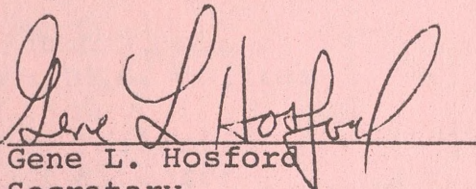
PASSED AND ADOPTED by the Planning Commission of the City of Oxnard on this 4th day of December, 1975, by the following vote:

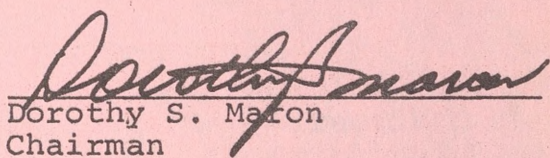
AYES: Commissioners: Duff, Lopez, Flores, Stoll, John, Takasugi, Maron

NOES: Commissioners: None

ABSENT: Commissioners: None

ATTEST:

  
Gene L. Hosford  
Secretary

  
Dorothy S. Maron  
Chairman



OXNARD CITY COUNCIL

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IN ELEMENT

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Division Chief\*  
Project Manager  
Chief Author  
Co-Author

\* Resigned

Special appreciation is extended to the Secretarial and Graphics sections for the time and effort they have spent in the preparation of this element, to Tom Zanic for production management and especially to Rick King for the cover design. Thanks should also be given to the Ventura County Association of Governments' General Plan Elements Policy Advisory Committee who provided valuable input to the element, and the numerous departments and individuals within the County and the cities whose expertise made the element possible. Special credit is given to individual authors: Blase Cilweck - Fault Displacement, Ground Shaking and Landslide/Mudslide; Diana Schott - Flooding and Aircraft Accidents; Michael Armstrong - Beach Erosion; John Lien - Subsidence and Expansive Soils; JoAnne Yokota - Structural Deficiencies.



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# STANDARD SAFETY

INTRODUCTION



## BACKGROUND

In 1971, the California Legislature passed legislation requiring two new elements to be added to the General Plans of all cities and counties in the State. These were the Safety Element and the Seismic Safety Element.

The impetus for this legislation was a series of natural disasters which had occurred in Southern California in the preceding 2 years. The winter of 1969 saw particularly heavy rains, especially during January and February. Serious flooding occurred in many areas of Southern California but especially in Ventura County. These heavy rains caused substantially increased growth in the Chaparral vegetation belts of the Southern California hills and mountains. Then during thirteen days of September and October, 1970, a series of disastrous fires broke out, fanned by dry desert Santa Ana Winds. The fires burned over half a million acres of brush and timber land, destroyed 722 homes, killed 16 people and cost \$233 million to control. The following winter landslides and mudslides occurred in the hills and damaged many of the structures that had escaped the Fall fires.

In response to these disastrous floods, fires and landslides, the 1971 Legislature enacted Government Code Section 65302.1, which requires of each city and county general plan:

*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 hazards mapping in areas of known geologic hazard.*

The impetus for the Seismic Safety Element was the February 9, 1971, San Fernando Valley earthquake. This earthquake of 6.6 magnitude took 65 lives and caused almost \$1 billion of damage to freeway interchanges, hospitals (accounting for the greatest loss of life), utilities, dams, and public, private, commercial and industrial buildings. The earthquake also pointed up major discrepancies in building design and a laxness in land use planning.

This disaster prompted the Legislature to require another element to the general plan, a Seismic Safety Element. Government Code Section 65302 (F) requires:

*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 failure or to the effects of seismically induced waves such as tsunamis 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.

Both elements are required to be adopted by September 20, 1974; however, time extensions may be granted under special circumstances. While there was no penalty attached to the original September 20th due date, State authorities have hinted that citizens may be able to bring class action suits against the jurisdictions not complying with the deadlines. Specific penalties may be created if the mandated adoption date is extended by the Legislature; such was the case when the deadline for the Open Space Element was extended.

The preparation of the Seismic Safety and Safety Elements (hereafter referred to as the Seismic and Safety Element) is a coordinated effort between the County of Ventura and the nine cities within the county. It was felt that since most of the hazards are regional rather than local in scope, that a general countywide treatment of each hazard would be more valuable than ten separate, locally oriented elements. The element, then, represents the culmination of participation either directly or indirectly by all cities within Ventura County.

#### PURPOSE

In preparing the Seismic Safety and Safety Elements, a number of purposes will hopefully be achieved. Among these are:

1. To meet the requirements of State law.
2. To integrate the Seismic Safety and Safety Elements into one coherent document.
3. To investigate the various hazards from a regional as well as a local perspective so as to provide a more integrated picture of the hazardous conditions within Ventura County.



4. To develop a framework which will permit the investigation of all types of hazards and the resources they impact.
5. To present the information collected in a form which will allow decision makers and the public to quickly evaluate the pertinent aspects of a given hazard.
6. To offer a range of response measures from which decision makers may choose as they attempt to alleviate a given hazard.
7. To provide a framework in which future inventory and analysis can be performed.
8. To provide an informative matrix of balance risk alternatives in order to determine proper land use and physical development.

#### ORGANIZATION

#### INTEGRATED ELEMENTS

Because of the confused and overlapping nature of the mandated Seismic Safety and Safety Elements and the cause and effect one has on the other, it was decided to merge the two into one integrated discussion of hazards. This procedure was also recommended by the State General Plan Guidelines.

#### REGIONAL EMPHASIS

In discussing hazards which affect both incorporated and unincorporated portions of Ventura County, it was necessary to conduct a comprehensive regional study while also providing detailed treatment of local areas and problems. To this end, each hazard is discussed from a regional standpoint prior to being examined at the local level.

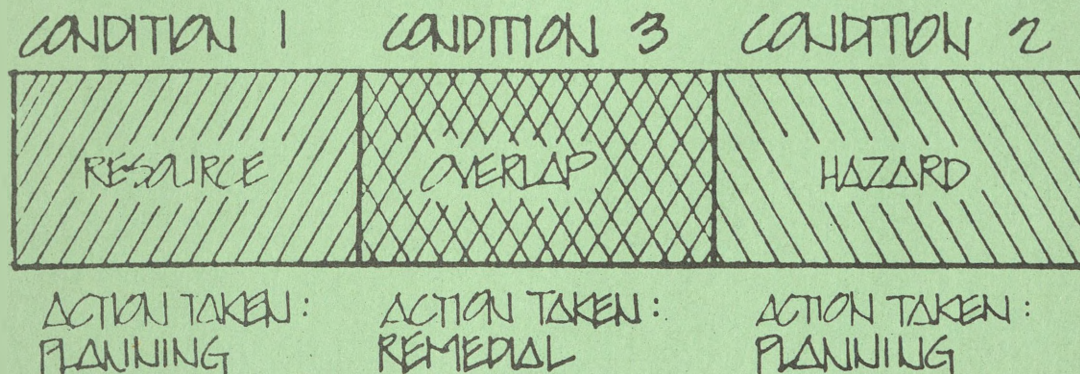
The result of this approach to the two elements, is that each entity will receive one document whose general discussion of the various hazards will be the same as that received by the other entities. Each entity, however, will receive its own individualized discussion of the hazard within its jurisdiction.

#### ANALYSIS FRAMEWORK

Before embarking on the preparation of the two hazard related elements it was necessary to devise a framework for analysis that would allow the integration of the two elements into one document and permit the systematic investigation of hazards not set out in State law.

The framework decided upon, views hazardous conditions as an interrelationship between resources (natural, human, and man-made) and hazards (natural and man-made). Hazards and resources often exist apart from one another and under such conditions, it is generally concluded that a problem does not exist. For example, landslides in the north half of the county or on Sulphur Mountain are not thought of as hazards because they generally do not affect people or property. Landslides in the Camarillo Hills or immediately above the City of Ventura, however, are usually considered hazardous because they may impact people and property.

The analytic framework, then, identifies three types of conditions: one in which a hazard exists apart from resources; one in which a resource exists apart from hazards; and one in which hazards and resources exist in proximity to one another. In the first two cases, there is an opportunity to plan around the resource or hazard - to prevent hazards from encroaching on resources or to locate resources away from hazards. In the third case where there is an overlap of resources and hazards, planning may not be as effective as various remedial measures.



The Seismic-Safety document has been developed along the lines of this framework in that it identifies resources and hazards, and the instances where they overlap. The hazards are mapped on 1" = 4000' scale maps for the county, 1" = 1000' for the cities and on 11" x 17" sheets contained within the document. Resources will be plotted on transparent sheets which can overlay the 11" x 17" hazard maps.

#### HAZARD EVALUATION

One of the purposes of the Seismic and Safety Elements is to provide decision makers with the information necessary to evaluate the nature of a given hazard and possible courses



of action. To facilitate this, it is felt that decision makers and the general public should have a general knowledge of a hazard, know where it exists and who is managing it.

In addition, one should know the probability of the hazard occurring, the severity of the hazard should it occur, the resources that are apt to be affected, and the validity of the information which leads to conclusions in the above areas. This information is summarized in the FINDINGS Section of each hazard and should be evaluated and used as a basis for responding to various hazards.

OK

In addition to the written text, there are a number of maps that accompany each hazard discussed. These maps are an essential part of any hazard evaluation. ~~On the~~ hazard zones appear on these maps which depict varying degrees of severity for a given hazard. *The maps included in this element are reductions of the original maps, and these original maps should be consulted for planning purposes.*

New  
wording

~~for the purpose of the detailed plotting of data make these maps useful only for general discussion.~~

For these reasons, the zones that are defined should not be used for specific planning purposes, but rather, should be used to direct more precise studies which would specifically delineate the location and nature of the hazard in question. The various hazard zones, then, define areas of probable hazard which should undergo further study. Additional studies, for example, might be done to allow for more precise planning, or to determine the conditions at a specific construction site.

## OPTIONS

After evaluating the information presented on a given hazard and in particular the FINDINGS, an entity must decide on an appropriate response. Responses may range from doing nothing

at all to enacting new ordinances. As the assessment of a hazard must ultimately be made by the local jurisdiction, so must the jurisdiction decide what type of response is warranted by its assessment. To assist in this matter, this document offers a range of responses for each hazard from which the jurisdiction may select what it feels are appropriate responses. These prospective responses are termed "Recommended Actions".

The options that are found with each hazard represent a range of implementation measures or concepts from which formal recommendations can be drawn. Before adopting any options, they should be carefully evaluated and coordinated with the agencies and interests, both public and private, which may be affected. They are not intended to be recommendations, but rather a series of alternatives which individually or collectively can be employed to correct a situation or condition identified in the FINDINGS section, which preceded the OPTION section of each hazard.

## County Agreed To Deletion

In addition to the specific options offered with each hazard, there is an Options Matrix in the appendix to the Seismic and Safety Elements document which is designed to offer additional response alternatives. A discussion of the Matrix and how to use it can be found in the appendix.

### RECOMMENDATIONS ON OPTIONS

To assist the various staffs and decision makers in selecting the appropriate responses to conditions identified in this element, the recommendations of various authorities and advisory groups have been included in the rear of the document. The adoption of these recommendations is not required; they are only intended to guide in the selection of appropriate responses.

### ACCEPTABLE RISK

Implicit in the State law mandating a Safety Element, and explicit in the General Plan Guidelines published by the



State, is the notion of "acceptable risk" - "The level of risk below which no specific action by local government is deemed to be necessary."

This issue is addressed by an entity when it performs a Risk Analysis of a given hazard and subsequently decides on an appropriate response. The response that is decided upon implicitly identifies the level of risk that was perceived. If the response is "no action," then it may be concluded that the level of risk is acceptable and perhaps quite low. If on the otherhand, a strong response is issued (such as the immediate abatement of certain structures), then it might be concluded that the level of risk is unacceptable and possibly quite high.

#### ADDITIONAL INFORMATION

In early 1974 the County of Ventura entered into an agreement with the State Division of Mines and Geology for the preparation of a Geologic Hazards investigation of Ventura County. This 50/50 matching study of \$50,000 will provide additional information relative to the geologic hazards discussed in the Seismic and Safety Elements, upon its completion in June of 1975.



# SAFETY

FAULT DISPLACEMENT



FAULT DISPLACEMENT - II-1 thru II-25

The pages listed below have not been changed.

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# GENERAL DISCUSSION

## GENERAL DESCRIPTION

### Surface Faulting (D. R. Nichols, U.S. Geological Survey)

The earth is laced with faults - planes or surfaces 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. Most of these faults have not moved for hundreds of thousands or even millions of years and thus can be considered inactive. Others, however, show evidence of current activity or have moved sufficiently recently to be considered active, i.e., capable of displacement in the near future. (Any <sup>surface</sup> fault movement beneath a building in excess of an inch or two could have catastrophic effects on the structure, depending upon its design and construction, and the shaking stresses it experiences at the same time. Therefore, it is important to know not only which faults may move but how they might move.) ~~reinclude in element~~  
with addition of word surface

The definition of what constitutes an "active fault" may vary greatly according to the type of land use contemplated or to the importance of the structure. For example, the Atomic Energy Commission regards a fault as active or "capable" with respect to nuclear reactor sites if it has moved "at or near the ground surface at least once in the past 35,000 years;" or "more than once in the past 500,000 years" (Atomic Energy Commission, 1971). Commonly, faults are regarded as active and of concern to land-use planning when there is evidence that they have moved during historic time, or, through geologic evidence there may be a significant likelihood that they will move during the projected use of a particular structure or piece of land. Because geologic evidence may be lacking, obscure, or ambiguous as to specific times of past movement, geologists may be able to estimate relative degree of activity only after a regional analysis that may extend far beyond the locality under consideration. Such analysis may be based on historic evidence of fault movement, seismic activity (occurrence of small to moderate earthquakes along the fault trace even though not accompanied by obvious fault movement), displacement of recent earth layers (those deposited during the past 10,000 years), and presence of topographically young fault-produced features (scraps, sag ponds, offset stream courses and disruption of man-made features such as fences, curbs, et.) Movement, however, seldom is limited to a single fault surface throughout the lifetime of a fault system. Faults that commonly produce significant displacement (more than several inches at a time) often have related branches that diverge from the main fault but usually have less movement along them. They may also have secondary faults that are not directly or obviously connected physically to the main



fault trace. Secondary faults are usually nearby (within hundreds of feet of the main rupture) but they may extend as much as several miles away. As with branch faults, displacement along secondary faults is usually only a fraction of that along a main fault.

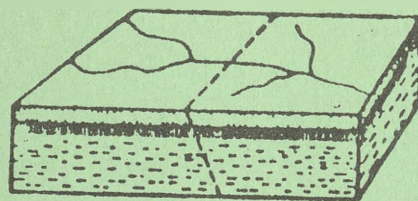
The amount of displacement that can occur during a single earthquake can be related in a general way to the total length of a fault. However, in addition to the location and amount of displacement, the sense of movement is extremely important in estimating the amount and type of damage that might be produced. This was evidenced by the great damage over faults during the moderate (magnitude 6.6) San Fernando Earthquake, which produced a reverse or thrust fault movement. (See Figure 1a). Movement occurred along a similar plane, but in an opposite direction on the normal Wasatch Fault in Utah. (See Figure 1b). Left-lateral movement (Figure 1c) and right-lateral movement, which is common to the San Andreas Fault, probably are less potentially damaging to most structures than normal or thrust faulting.

Not all surface faulting need be rapid nor need it occur during major earthquakes. Imperceptibly slow movement, called "fault creep," occurs along the Hayward, Calaveras, and some other faults, and may be accompanied by micro-earthquakes. Similarly, not all deformation of the earth's surface produces fault displacements. Strains in the earth deform the rocks until their strength is exceeded and they rupture, producing the earthquake. Accompanying this bending, however, is a certain amount of plastic deformation. Both rupture and plastic deformation commonly occur along active fault zones and may be sufficient to damage or destroy structures over particularly strongly deformed rocks. Earthquakes deep within the earth may result from rupture of deeply buried rocks but without fault displacement at the ground surface, although the surface rocks may be deformed (see Figure 1d). This may have been the case along a part of the Newport-Inglewood Fault zone where movement along the fault during the last 10,000 years or so has merely caused a permanent flexuring or bending of the surface rocks.

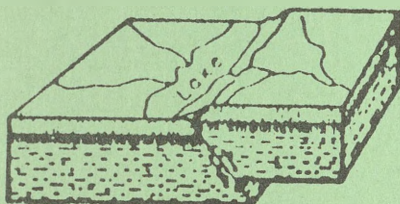
For planning purposes there are two kinds of faults: (1) active faults which have experienced displacement in recent geologic time, suggesting that future displacement can be expected on these faults; and (2) inactive faults that have shown no evidence of movement in recent geologic time, suggesting that these faults are dormant. However, some faults labeled as inactive are so termed due to lack of knowledge. Increased research and monitoring of these faults could reveal some of them as active.

The State Division of Mines and Geology ("Urban Geology," 1973, Bull. 199) indicates that on a state-wide basis the potential hazard to structures from the surface displacement of faults

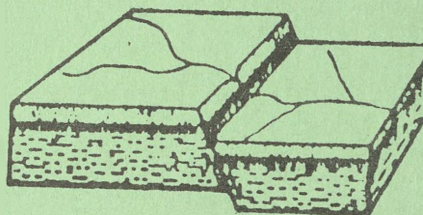
ILLUSTRATION 2.1    EXAMPLES OF SOME TYPES OF FAULT  
DISPLACEMENT AND EARTH FLEXURE



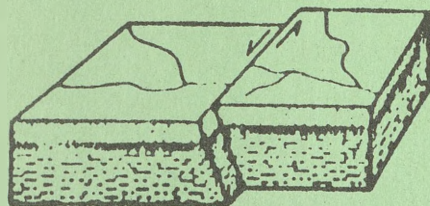
Earth block before movement



1a Thrust or Reverse fault



1b Normal fault



1c Left lateral fault



1d Monoclinal fold caused by  
faulting at depth

Source: Tri-Counties Seismic Safety Study, 1973, pg. 68.

is low compared to such geologic phenomena as earthquake shaking and landsliding. Historically, major losses due to fault displacement have been limited to the San Fernando Earthquake of 1971. Structural losses due to fault displacement in the 26 other major earthquakes in California are unknown but were probably small. Most of the losses incurred during the 1906 San Francisco Earthquake and 1952 Tehachapi Earthquake were caused by earthquake shaking and ensuing fires.



## GENERAL EFFECTS OF THE HAZARD

### **PRIMARY EFFECTS**

Nearly all man-made structures are susceptible to damage ranging from severe to total when affected by displacement along faults passing beneath their foundations. Current standards of design which are continuously being improved upon, range from minimum code requirements to incorporating an indefinite degree of safety. The San Fernando Earthquake of 1971 has shown that no structures designed under present minimum standards are safe from severe damage or destruction as a result of surface fault displacement of foundations. Structures designed above the minimum standard with emphasis on costly earthquake resistance construction are also susceptible to damage. It is difficult to determine whether or not any structure can be designed at any cost to resist stresses resulting from surface fault displacement. It is widely acknowledged that design of most structures, such as single family homes or larger structures, roads, bridges, pipelines, or other conduits, to resist fault displacement is generally not practical.

Permanent effects of surface displacements along faults can also include, but are not limited to:

1. Abrupt elevation or depression of ground surfaces of several feet for distances of many hundreds of feet along the fault
2. Disruption of surface drainage
3. Changes in groundwater levels in wells
4. Blockage and surface seepage of groundwater flow
5. Changes in survey benchmark elevations
6. Dislocations of street alignments and property lines of many feet if lateral (horizontal) displacement also occurs along a fault, etc.
7. Displacement of drainage channels and drains

### **SECONDARY EFFECTS**

Secondary effects of surface displacements along faults within an urban area could include:

1. Disruption of movement along roadways due to abrupt depressions or elevation of pavement surfaces.
2. Possible flooding due to disruption of drainage channel and storm drain flow.

3. Disruption of utility services such as water, gas, fuel, telephone and electric power lines.
4. Temporary impact on industry and commerce similar to that resulting from the occurrence of most kinds of regional natural catastrophic events such as hurricanes or floods.

## GENERAL INVENTORY OF THE HAZARD

### LOCATION AND HISTORY

The greatest potential for fault activity is along any of the faults which lie within the several major fault systems which transect the County from east to west. The recent San Fernando Earthquake which occurred along one of these major fault systems illustrates the high level of activity that some faults within these systems may have and foretells the future occurrence of other such earthquakes in the Los Angeles, Ventura-Santa Barbara region.

The San Fernando Earthquake of 1971 may be an example of the typical type which could occur along some of the east-west trending faults which transect the County. Based upon that earthquake, it is most likely that a surface fault displacement within the County will be sudden, occurring over a period of less than one minute. The displacement would be accompanied by sharp earthquake shaking lasting perhaps several tens of seconds.

The following is a description of the major active and potentially active faults and fault systems within Ventura County (refer to Hazards Plate I):

#### Malibu-Santa Monica-Raymond Fault System

This fault system is believed to consist of a series of major north-dipping thrust faults which extend along the coast and onshore for a total of over 40 miles and perhaps a much greater distance offshore in the Santa Barbara channel. It begins in the San Bernardino area and extends along the southern base of the Santa Monica Mountains and passes offshore a few miles west of Point Dune.

Geologic evidence for activity of the fault system during recent geologic time up through the present are faulted Terrace and near surface sedimentary deposits, groundwater barriers and the recent Point Mugu Earthquake (February, 1973) which is believed to have originated on the Malibu Fault.

The faults within this system are considered active.



### Simi-Santa Rosa Fault

This fault is associated with reverse or high angle thrust movement. From the Santa Susana Mountains westward along the northerly margin of the Simi and Tierra Rejada Valleys, along the south slope and crest of the Las Posas Hills to their westerly termination. The presence of the Springville and Camarillo Faults short distances to the north and south, respectively, of the westerly projection of the Simi-Santa Rosa Fault suggest a relationship to these faults which project into the Oxnard Plain along the trend of the subject fault.

Surface evidence north of Simi Valley indicates that at least the easterly portion of this fault has been active during Pleistocene time (11,000 to 3,000,000 years before present). However, available information is considered insufficient to conclude that westerly portions of the Fault have not been active during the Pleistocene or more recent time. No earthquake epicenters of magnitude 4.0 or greater (Richter Scale) have been recorded along the fault during historic time.

The fault is designated as potentially active until more information is available for evaluation.

### Bailey Fault

This fault marks the boundary between the western Santa Monica Mountains and the Oxnard Plain. It extends from the Mugu Lagoon area northerly to an apparent intersection with the Camarillo Fault near Calleguas Creek and State Highway 101. The presence of the fault is based primarily upon water well data.

No evidence of surface expression of the fault is known nor have any earthquakes been recorded as having originated on it. The fault trace is obscured by geologically young alluvium over its entire length. Available information is insufficient to conclude that the fault has not been active during Pleistocene or more recent time.

The fault is designated as potentially active until more information is available for evaluation.

### Camarillo Fault

This fault extends in an east-west direction immediately south of Camarillo from Calleguas Creek to the Oxnard Air Force Base. The presence of the fault is based primarily upon the apparent abrupt uplift along the north side of the fault linear uplift of the southern portion of Camarillo.

The apparent uplift of the north side of the fault is believed to be a surface expression of the fault. The fault trace, however, is obscured by geologically young alluvium over its entire length. Available information is insufficient to conclude that the fault has not been active during Pleistocene or more recent time.

The fault is designated as potentially active until more information is available for evaluation.

#### Sycamore Canyon and Boney Mountain Faults

These faults are the most prominent of a series of northeast trending breaks extending from the Point Mugu and south coast area to the Thousand Oaks area. The presence of the faults is evident by surface exposures showing displacement of sedimentary and volcanic rocks of pre-Pleistocene age. Younger rocks are not known to have been displaced by these faults.

Surface evidence of displacement of sedimentary and volcanic rocks of pre-Pleistocene age indicate that the faults have been active since deposition of those rocks. Younger rocks are not known to have been displaced by them. However, no specific investigations have been reported indicating that displacement of younger deposits has not occurred. Special areas of concern would be in the Potrero, Conejo, and Hidden Valleys and the Thousand Oaks area.

The faults are designated as potentially active until more information is available for evaluation.

#### Oak Ridge Fault System

The Oak Ridge Fault is a steeply southerly-dipping reverse or thrust fault which extends from the Santa Susana Mountains where it has been overridden by the north-dipping Santa Susana Thrust Fault, westward along the southerly side of the Santa Clara River Valley and thence into the Oxnard Plain. The relationship of possible westerly extension of the fault to the McGrath and offshore faults is unclear and may be complex. None of the faults beyond the westerly terminus of South Mountains have surface expression nor have any been shown to cut near surface sediments. It is conceivable that past movement of these faults in the Oxnard Plain area has not resulted in surface displacements but, instead, has resulted in only broad warping or tilting of the near surface alluvial sediments.

The Oak Ridge Fault System probably contains many branching faults and is believed to be associated with one or more faults of similar trend present in the Santa Barbara Channel



west of the Oxnard Plain. The system is over 50 miles long on the mainland and may extend an equal or greater distance offshore.

The rugged, steep terrain of the north slope of South Mountain suggests that at least that portion of the Oak Ridge Fault is active. The lack of surface evidence of fault displacement in the Oxnard Plain is not necessarily indicative of past activity in the recent geologic past as surface features could easily have been obscured by fluvialite processes (erosion or deposition of alluvium). Several recorded earthquake epicenters in the offshore as well as mainland area during historic time may have been associated with the Oak Ridge Fault or others within close proximity and associated with it.

The fault system is considered active. Future information may result in portions being designated as inactive.

#### Ventura Foothills and Country Club Faults

The Ventura Foothills Fault has been postulated to exist along the base of the hills south of Sulfur Mountain extending from north of Saticoy westerly to the mouth of the Ventura River thence westerly an unknown distance into the Santa Barbara Channel area. The possible existence of this fault as well as the nearby Country Club Fault northerly of Montalvo is reported in "Geology, Seismicity and Environmental Impact." (1973), a special publication of the Association of Engineering Geologists.

Evidence for the existence of the Ventura Foothills Fault is based mainly upon minor faulting of Terrace deposits north of San Buenaventura and evidence of faulting from the Tidewater Oil Company corehole #5. The fault is believed to be north-dipping. The existence of the Country Club Fault is based mainly upon discontinuities of water wells located in the Saticoy vicinity.

At present, sufficient information to verify the presence of past or potential future activity of these faults is lacking.

Future studies will provide information regarding existence and potential activity of these faults. It is considered prudent, however, to acknowledge the presence of these faults and consider them as potentially active, at least until further information is available.

#### Red Mountain-San Cayetano-Santa Susana-San Fernando Fault System

This fault system consists of a major series of north-dipping thrust faults which extend over 150 miles from Santa Barbara County into Los Angeles County. The system is associated

with an intense zone of folded and faulted bedrock. Relationships within the system become obscure over an 8 mile wide gap between the Red Mountain and San Cayetano Faults where these north-dipping faults give way to several large, south dipping faults.

Geologic evidence that the fault system should be considered active throughout its length is shown by location of earthquake epicenters (including the San Fernando Earthquake of 1971), groundwater barriers, and displaced alluvial sediments. In addition, the unusually high fluid pressures in the Ventura and San Miguelito oil fields are believed to indicate that tectonic stress has accumulated along that section of the fault system between the Red Mountain and San Cayetano Faults. It is possible that continued build up of this stress will eventually result in sudden release, probably in the form of an earthquake resulting from movement along one of more of the faults within the Ventura County portion of the system.

Research has shown that the San Cayetano Fault has 20,000 feet of displacement several miles east of Ojai Valley. The epicenter of an earthquake of magnitude 4.0 to 4.4 (Richter Scale) was located above the San Cayetano Fault between Fillmore and Piru.

The system is considered active.

#### Lion Mountain-Big Canyon Faults

These faults and several others present in the 8 mile gap between the Red Mountain and San Cayetano Faults dip southerly beneath Sulfer Mountain. The general area is complexly broken and folded by faulting which may be associated with the high fluid pressures (stress) present in the Ventura Oil Field to the south.

Although the general area of these faults has not experienced earthquake activity during historic time, their position within the Red Mountain-San Cayetano-Santa Susana-San Fernando Fault System and the possible displacement of terrace deposits (Pleistocene time) indicates that they should be considered at least potentially active.

#### Arroyo Parida-Santa Ana Fault

This fault extends from Montecito to the Ventura River and probably along the south side of Ojai Valley. Evidence as to the direction of dip is conflicting.

Although no earthquake activity has been recorded during historic time the fault does apparently form a groundwater barrier in the alluvium beneath the Ventura River. On this basis, it



should be considered potentially active. Future information may require reclassification.

### Santa Ynez Fault

This fault extends from Point Conception in Santa Barbara County, across the central portion of Ventura County, to near the east County line. It is considered to be one of the major faults in the region and is about 90 miles long. Past displacement has been about 10,000 feet of relative uplifting of the south side of the fault. The fault lies about 4 miles north of Ojai.

Left lateral displacement of streams crossing this fault has been cited as evidence for recent fault movement. Several earthquake epicenters have been located along this fault and one or two of these were in Ventura County. The strong 1927 earthquake centered west of Point Conception may have originated on the westerly, offshore extension of this fault.

This fault is considered potentially active until additional information is available for evaluation.

### Faults Between the Santa Ynez and the North County Line

Several large faults occur in the mountainous area north of the Santa Ynez Fault and within Ventura County. The most significant of these faults are the Tule Creek, Munson Creek, Agua Blanca, Frazer Mountain and Big Pine Faults. Of these the more important appear to be the Pine Mountain Thrust and Big Pine Faults (9 and 16 miles north of Ojai, respectively). The Pine Mountain Thrust is north-dipping and favorably oriented for generating earthquakes in response to the north-south compressive forces which have triggered activity along such similar faults as the Malibu, San Fernando and San Cayetano.

Terrace deposits and stream channels have been offset by geologically recent movement along the Big Pine Fault. More importantly, it is reported to have ruptured the ground surface for a distance of 30 miles along its length during the northern Ventura County earthquakes of November, 1852.

Both of these faults are considered active.

### San Andreas Fault

The San Andreas is the longest and most important fault in California. It transects a 4 mile section of the extreme northeast corner of the County, about 27 miles northeast of Ojai. It is the only fault within Ventura County which the

State has designated as being within a Special Studies Zone. Several Special Studies Zones have been established by the State Division of Mines and Geology along several of the major active faults within the State. Development proposed within these zones will require special site investigations prior to approval to insure that structures for human occupancy are not placed over a fault or fault branch. The State anticipates it will establish similar zones along other faults as funds become available for evaluation of potential activity.

Due to clearly established historical earthquake activity; this fault has been designated as active by the State Division of Mines and Geology. The last major earthquake generated along that portion of the fault which transects the northeast portion of the County was in 1857. The earthquake is estimated to have been on the order of magnitude 8.0 (Richter Scale) and would have caused considerable damage to structures in the southern County area had they been there. The occurrence of another such major earthquake along this fault is considered possible within the near future.

#### DEFINITION OF FAULT HAZARD ZONE

The fault hazard zones define a boundary where active or potentially active faults are believed to be located. These zones, based on available geologic data and the judgment of the County engineering geologist, are plotted on Hazard Plate 1. Faults shown on the Fault Hazard Area Map, but not included in either the Primary or Secondary Fault Hazard Areas are presently considered inactive.

The extent of Fault Hazard Zone boundaries are controlled by the traces of potentially active faults which are based on the best data available at the time the map was compiled. However, the faults shown on the maps were not field checked during the compilation of these maps. Because available fault data are highly varied in quality and the locations of some faults are known imprecisely, the zone boundaries have been positioned at a reasonable distance (about 660 feet or an eighth of a mile) from the trace of the nearest potentially active fault. However, zone boundaries generally are more or less than 660 feet away from mapped faults because of 1) curved or multiple fault traces, 2) of the need to keep the number of turning points to a reasonable minimum, or 3) the quality of the data dictates a narrower or wider zone.

In many places the zone boundaries have been tentatively extended beyond the mapped limits of faults, such as occurs westerly of Camarillo and westerly of Saticoy. These zone extensions are considered necessary because, even though faults have not been mapped in these areas, it is considered



likely that extensions of known faults or branches of faults do extend into these areas. Future investigations or studies would be required for confirmation of any fault extensions.

The primary fault hazard zones designate areas which are believed to contain active faults. The secondary fault hazard zones include those faults for which less evidence is available concerning their potential for activity. More precise analysis requires further study. For the purpose of the Seismic Safety and Safety Elements, all primary and secondary fault hazard zones designated on Plate I should be considered equivalent to those established by the state for other faults within and outside of the County. No degree of relative potential for future surface displacement or degree of hazard is implied for the faults shown.

A fault is defined as a fracture or zone of closely associated fractures along which rocks on one side have been displaced with respect to those on the other side. Most faults are the result of repeated displacement which may have taken place suddenly and/or by slow creep. A fault zone is a zone of related faults which commonly are braided and subparallel, but may be branching and divergent. It has significant width (with respect to the scale at which the fault is being considered, portrayed, or investigated), ranging from a few feet to several miles.

A fault trace is the line formed by the intersection of a fault and the earth's surface. It is the representation of a fault as depicted on a map.

Any fault considered to have been active during Quaternary time (last 3,000,000 years) - on the basis of evidence of surface displacement - is considered to be potentially active. An exception is a Quaternary fault which is determined, from direct evidence, to have become inactive before Holocene time (last 11,000 years). Such a fault is presumed to be essentially inactive and has been omitted from the map in most cases. Although faults shown on the maps may have been active during any part of, or throughout, Quaternary time, evidence for the recency of displacement is incompletely preserved and often is equivocal. In contrast, the State Mining and Geology Board, in their Policies and Criteria (adopted November 21, 1973), has defined any fault which has had surface displacement within Holocene time as "active and hence as constituting a potential hazard."

The following geologic time scale is provided for reference and perspective:

ILLUSTRATION 2.2 GEOLOGIC TIME SCALE  
(abbreviated)

Geologic Age			Years before present (estimated)	
Era	Period	Epoch		
CENOZOIC	QUATERNARY	"Historic"	200	Faults defined as <u>active</u> by Policies & Criteria of the State Mining & Geology Board.
		HOLOCENE	11,000	
		PLEISTOCENE		
	TERTIARY		2,000,000 - 3,000,000	Faults defined as <u>potentially active</u> for the purpose of delineating special studies zones.
		PLIOCENE		
		pre-PLIOCENE	7,000,000 - 10,000,000	
pre-CENOZOIC time			65,000,000	Source: State Mining and Geology Board
Beginning of geologic time			4,600,000,000	

### Uses and Limitations of the Hazard Zones

The best use of the fault zones is to define those areas within the zone as areas where special studies would be required prior to building structures for human occupancy. Such a criteria may require a developer or builder to evaluate specific sites within the zone to determine if a potential hazard from any fault whether heretofore recognized or not, exists with regard to proposed structures and their occupants.

Such studies should be required both for Primary and Secondary Fault zones. The latter should be included since future studies of these secondary zones could result in the redesignation of some of these to primary fault zones.

Users of the map should be fully aware that the zones are delineated to define those areas within which special studies may be required prior to building structures for human occupancy. Traces of potentially active faults are shown on the



maps mainly to justify the locations of zone boundaries. These fault traces are plotted as accurately as the sources of data permit; yet the plots are not sufficiently accurate to be used as the basis for set-back requirements.

Potentially active faults have been identified in a broad sense, although the evidence for the potential activity of some faults may be only weak or indirect.

The fault information shown on the map is not sufficient to meet the requirement for special studies. The onus is on the local governmental units to require the developer to evaluate specific sites within the special studies zones to determine if a potential hazard from any fault, whether heretofore recognized or not, exists with regard to proposed structures and their occupants.

Secondary Fault Hazard Zones designate areas which may contain faults which should be considered potentially active. Future studies as well as experience could result in redesignation of some of these areas to Primary Fault Hazard Zones. Special studies, as required for Primary Fault Hazard Zones, should therefore continue to be required prior to approval of residential or other proposed permanent development within the Secondary Fault Hazard Zones.

Faults shown on the Fault Hazard Area map but not included in either the Primary or Secondary Fault Hazard Areas are presently considered inactive. In general, they are not considered to be associated with the major, regional, potentially active fault zone trends. Special studies should, however, continue to be made of such faults prior to approval of any individual residential or other permanent developments which may be proposed over or in the near vicinity of any known faults.

### Special Studies Zones

In 1972 the California State Legislature enacted the Alquist-Priolo Geologic Hazard Zones Act. Pursuant to this act the "State geologist shall delineate . . . 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 . . . as to constitute a potential hazard to structures from surface faulting or fault creep." (Alquist-Priolo Act).

The extreme northeast corner of Ventura County lies within the special study zone established for the San Andreas Fault transecting that area. It is anticipated that the State will, after appropriate evaluation, establish other such special studies zones along other faults transecting the county.

The intent of the zone is to provide for public safety from the hazard of fault rupture by avoiding, to the extent possible, the construction of structures for human occupancy astride hazardous faults. However, the precise location and identification of hazardous faults within or near a zone of potentially active faults can be determined only through detailed geologic investigations. Therefore the State Mining and Geology Board has adopted policies and criteria for the implementation of these zones.

The complete text of the Policies and Criteria is in appendix B. Its most significant criteria is that no structure may be built across the trace of an active fault. Furthermore, the area within fifty feet of an active fault shall be assumed to be underlain by active branches and therefore, before any structure can be built within the zone, a geologic investigation and submission of a report by a geologist registered by the State of California are required.

#### NATURE OF INFORMATION

The geologic information relating to the location of faults and their potential for activity is based largely upon past regional geologic studies conducted by universities and petroleum geologists, as well as information compiled by the State Division of Mines and Geology and the County Department of Public Works. The most recent geologic information used was that covering the south half of the County which is contained in a report entitled "Geology and Mineral Resources Study of Southern Ventura County," Preliminary Report 14, 1973, prepared by the Division of Mines and Geology in cooperation with the County of Ventura Department of Public Works.

The evaluative system utilized in estimating the potential or past activity of individual faults and fault systems is discussed under General Inventory of the Hazard. The basis and method of designation of the Fault Hazard Zones is similar to that used by the State Division of Mines and Geology in establishing the Special Study Zones along active and potentially active faults within the State (see FAULT HAZARD ZONES section.)

The current cooperative Geologic Hazards Investigation being conducted by the State Division of Mines and Geology for the Ventura County area will provide additional necessary information for future up dating of the Seismic Safety and Safety Elements. The State investigation will be especially useful for improving our knowledge of those faults and fault systems which have been herein designated as potentially active (Secondary Fault Zones). The investigation may include study of



the following faults and fault systems: Simi-Santa Rosa, Springville, Camarillo, Oak Ridge, Ventura Foothills, Country Club, Bailey, Arroyo Parida-Santa Ana and the Big Pine.

## GENERAL MANAGEMENT RESPONSIBILITY

### Investigation

Research and experience dealing with the nature and mechanism of faults and fault activity is being conducted by various Federal and State agencies as well as by universities and professional organizations. Much of this work is being conducted on a statewide basis, however, indirect benefit to Ventura County will be gained through developed technology.

The State Division of Mines and Geology is currently investigating the extent of the hazard to Ventura County as part of the cooperative Geologic Hazards Investigation scheduled for completion by July of 1975.

Additional investigation is being conducted on a continuing basis by:

Private Geologic Consultants who provide original information during investigations for private developments.

### Warning

Presently there is no way to prevent or accurately predict when an earthquake and surface displacement is apt to occur

along a given fault. The state-of-the-art is such that at best only the recency of past activity can be determined along some faults. In addition, in some cases, regional studies can indicate those systems of faults which may be potentially most active. In the southern California area, those faults which have general east-west trends or are associated with the northwesterly trending San Andreas Fault are considered to be potentially the most active. There are indications that earthquake prediction will be possible in some areas of the United States in the near future. It is not known whether this will be one of those areas. However, there are serious social and economic problems with predicting earthquakes that must be evaluated before these predictions can be utilized, when they are perfected. The National Science Foundation is presently instituting studies on these problems.

### Alleviation

Regulation of public and private land development within both incorporated and unincorporated areas is administered by:

City and County Departments of  
Planning  
Public Works  
Building & Safety  
City Councils  
Board of Supervisors

Enforcement of the Uniform Building Code and City and County regulations and policies can be effected by the above agencies through requirement of review of proposed land use and evaluation of investigations and engineering studies for private development of public projects. Such reviews and evaluations can be performed by qualified geologic and soils engineering staff or by retention of consultants. Effective control of the Fault Hazard can only be achieved through knowledge of the location and potential for activity of faults and implementation of development controls within the hazard zones.

Since alleviation of the hazard is largely accomplished through land use controls, the agencies, departments and legislative bodies making land use decisions have the primary responsibility for alleviating the hazard. City and County Planning departments can utilize available hazard information to avoid improper land uses. Decisions concerning adoption of these recommendations rest ultimately with the Planning Commissions, City Councils and the Board of Supervisors. Other bodies making land use decisions include Port Districts and redevelopment agencies.

Alleviation of existing hazards can be effected by removal of structures located over, or strengthening structures in



hazardous proximity to, potentially active faults. Determination of whether structures are hazardously located would require detailed investigation of geologic conditions and of the potential for activity along any faults found.

# LOCAL DISCUSSION

## LOCAL INVENTORY OF THE HAZARD

Little is known of the possible presence of faults or potential for surface displacement in the vicinity of Oxnard. No faults have been mapped within the area of the City. This, however, does not necessarily indicate that potentially active faults are not present but simply reflects our lack of knowledge. The area is underlain by alluvial sediments which have been deposited within the recent geologic past, with deposition in some areas having occurred within the last few thousand years. A surface expression of faulting could easily have been obscured.

The fault mapped south of Port Hueneme Harbor may extend into the Cities of Port Hueneme and Oxnard. The westerly extensions of the Springville and Camarillo Faults may also extend into the Oxnard area. The report on the Oxnard Oil Field published in the Summary of Operations, California Division of Oil and Gas, Vol. 50, No. 1, 1974, indicates several faults which could be significant in regard to location and recency of displacement. Unfortunately, however, insufficient study has been completed to indicate the surface projections or extent of the faults.

In addition, it is conceivable that some of the faults found in the Santa Barbara Channel beyond 3 miles off-shore may extend into the Oxnard area. At present, insufficient information is available on their location to determine where they may extend to on-shore areas.

No earthquakes of significant magnitude (4.0 or greater on the Richter Scale) have been recorded on any faults which might transect the Oxnard area. Several shocks of greater than 4.0 magnitude have been centered in the Santa Barbara Channel to the west on faults which may extend into the on-shore areas. Several shocks of less than 4.0 magnitude have occurred in the vicinity of Ventura but it is unknown what faults they could have originated on. In February of 1973, an earthquake did occur in the Malibu Coast Fault. This is the fault that just touches the southeast corner of Ventura County. The magnitude of this quake was 6.0 on the Richter scale.

## LOCAL RESOURCES AFFECTED BY THE HAZARD

Comparison of Hazard Plate I with present land uses within the City of Oxnard indicates that many structures including residential, industrial and commercial buildings could be affected. Present information is not adequate, however, to conclude that any structures or facilities are definitely underlain by active faults.



The following resources inventoried for the City of Oxnard may be of significant concern in a time of disaster. These include schools, hospitals, city halls, police and fire stations, major buildings, major utility lines, uses which may create a potentially hazardous condition (i.e. oil plants and storage facilities) and uses which are located directly over any possible fault itself.

Within the Springfield Fault Zone are several schools - Fremont Junior High, Our Lady of Guadalupe, Juanita Schools, St. John's Lutheran, Ramona School, Bernice Karen School, Brittel School and portions of Oxnard High School. St. John's Hospital and the Fremont Square Shopping Center are also within the zone. Other significant land uses are the County Airport, Southern California Edison's Mandalay Power Plant and transmission lines and Oil Storage tanks near the Mandalay Plant. Major sewage lines which cross the fault zone run along Rice Road, Oxnard Boulevard and Ventura Road.

# FINDINGS

## PROBABILITY OF OCCURRENCE

No faults have actually been mapped within the area of the City but it does not necessarily indicate that potentially active faults are not present. The fault zones extending into Oxnard are extensions of the Springfield and Camarillo Fault. However, no earthquakes of significant magnitude (4.0 or greater on the Richter scale) have been recorded on any faults which might transect the Oxnard area, though several shocks have been centered in the Santa Barbara Channel to the west which may extend into the on-shore areas.

## SEVERITY OF THE HAZARD

The actual level of the hazard from fault displacement within Oxnard is unknown. At present it is estimated that only that portion of the City northerly of the City Hall could likely be affected should surface fault displacement occur. As indicated by comparison of Hazard Plate I with the land use map, many structures including residential, industrial and commercial buildings lie within the potentially hazardous zone.

It is highly possible that any displacement along faults which may project into the City area within the Hazard Zone would not actually displace the ground surface because of lack of rigidity of the relatively unconsolidated alluvial deposits underlying the Oxnard Plain.

## RESOURCES AFFECTED

Comparison of Hazard Plate I with present land uses within the City of Oxnard indicates that many structures including residential, industrial and commercial buildings could be affected. Present information is not adequate, however, to conclude that any structures or facilities are definitely underlain by active faults and are indeed hazardous.

## NATURE OF THE INFORMATION

Present information is not considered sufficiently accurate to warrant special investigation for most existing development. Consideration should be given, however, to the safety of vital or emergency facilities over or near known faults. Future, more detailed information on fault locations may indicate that further evaluation of some existing structures or facilities is warranted.



The Secondary Fault Hazard Zone indicated within the northerly portion of the City is based only upon the potential linear projection of faults mapped further to the east in the Camarillo area. The existence and boundaries of the potentially hazardous zone is, at best, highly conjectural.

## RECOMMENDED ACTIONS - FAULT DISPLACEMENT

1. Consider all faults (whether zoned or not) shown on Hazards Plate I as potentially hazardous unless detailed seismic-geologic investigation confirms the contrary.
2. Encourage performance of regional studies by qualified Federal and State agencies such as the U. S. Geological Survey and the State Division of Mines and Geology.
3. Encourage and participate in cooperative studies with the above agencies.
4. If necessary, retain private consultants for more detailed determination and study of potential hazards.
5. Utilize the latest uniform codes accepted by the State in the design of buildings and structures to resist fault displacement.
6. Require structural evaluation of all existing structures used as places of public assembly to insure conformance to life safety items of the latest Uniform Building Code requirements in regard to fault displacement.
7. Adopt current investigation guidelines for proposed land development within the Primary or Secondary Fault Hazard Zones and for all major projects such as those published by the Structural Engineers Association of Southern California.
8. Define major projects such as multi-story buildings, industrial installations and buildings, large commercial buildings, large utility and storage facilities, and major trunk lines and bridges proposed anywhere within the County or cities, and require geologic-seismic investigation for these.
9. Evaluate geologic conditions for important or vital buildings and facilities within hazard zones for which such determinations have not been made. Structures which could be considered for evaluation include hospitals, churches, rest homes, large commercial buildings, important industrial structures, schools, residential or commercial buildings over two stories in height, or buildings of unusual construction over one story designed for human occupancy, utility facilities and other vital or critical structures.



10. In the interest of consistency and standardization, the Specific Criteria Section (modified) of the Policies and Criteria of the State Mining and Geology Board and the State Geologist's Explanation of the Special Studies Zones Maps (modified) should be adopted for administration of these zones and are as follows:

- A. No structure for human occupancy shall be permitted to be placed across the tract 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. Certain essential or critical structures, such as high-rise buildings, hospitals, and schools should be subject to more restrictive criteria at the discretion of the City and County.
- B. Application for all real estate developments and structures for human occupancy within fault hazard 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 studies are waived pursuant to Section 2623 (State Code).
- C. Requirements for geologic reports may be satisfied for a single 1 or 2 family residence if, in the judgement of technically qualified City or County personnel, sufficient information regarding the site is available from previous studies in the same area.
- D. Licensed personnel within or retained by the City or County must evaluate the geologic and engineering reports required herein and advise the body having jurisdiction and authority.
- E. The City and County may establish policies and criteria which are more restrictive than those established herein. In particular, 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 fault hazard zone.
- 35000

- F. Construction should not occur across the mapped traces of faults. Where it is inevitable that such construction as roads, streets, highways, utility lines, etc., must cross faults, it is important that the possibility of fault movement should be considered in their design. Critical facilities, such as hospitals, schools, utility structures and communication centers should not be planned within Primary Fault Zones. Those that may presently be in Primary Fault Hazard Zones should be replaced as soon as possible or confirmed to be safely located.
- G. Those facilities which are not critical but which do have high occupancy potential such as theatres, churches, major markets, apartment complexes, etc., should not be planned within Primary Fault Hazard Zones. Those that may presently be in Primary Fault Hazard Zones should be replaced as soon as possible or confirmed to be safely located.
- H. Unless entire Primary Fault Hazard Zones were to become open space, which may not be feasible, low density, well-built, timber construction homes are an acceptable planned use within the area. However, since any construction in fault corridors presents some additional hazard to life, and certainly may result in considerable property loss, it would be best if these areas could be devoted to open space of some sort.
- I. Important facilities must be kept off areas where ground ruptures and potential ground ruptures are located. When such facilities must be located in those areas, provisions must be made to accommodate the expected movement.
- J. Non-critical facilities should be kept off actual breaks but could be located adjacent to them if compensation is made in the construction for the fault movement.
- K. In the future, when public facilities are built within or near a Primary Fault Hazard Zone, justification should be included as to why the public facilities were deemed essential for the public welfare. Similarly, any existing public facilities in such hazardous areas should be reviewed and official statements made as to why they must continue to exist in these areas.



L. As used herein, the following definitions apply:

1. A "structure for human occupancy" is one that is regularly, habitually or primarily occupied by humans.
2. An engineering geologist certified in the State of California is deemed to be technically qualified to evaluate geologic reports to be used in the design of civil works.
3. Any engineer registered in the State of California in the appropriate specialty is deemed to be technically qualified to evaluate engineering reports in that specialty.

NOTE: Model ordinance for implementation of Special Studies Zones has been developed by the State Division of Mines and Geology.



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# SAFETY

EARTHQUAKES &  
GROUND SHAKING



EARTHQUAKES & GROUND SHAKING - III-1 thru III-30

The pages listed below have not been changed:

III-1

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# GENERAL DISCUSSION

## GENERAL DESCRIPTION

By far the greatest damage done by an earthquake is caused by the ground shaking, not the fault displacement. This section, therefore, is the companion section to the fault displacement hazard section. One of the very serious side effects of ground shaking is liquefaction, which is covered as a separate hazard.

The probability of an earthquake is determined by a number of factors but basically by the location of active faults to an area and the tensional and compressional forces exerted against these faults.

California is interlaced with hundreds of active faults. The most important system is the San Andreas Fault which extends from south of Los Angeles to north of San Francisco. The main branch of this fault runs through the extreme northeast corner of Ventura County. This fault has been responsible for at least two major earthquakes; the San Francisco earthquake of 1906 and the Fort Tejon earthquake of 1857. The earthquake of 1857 is reported to have caused severe shaking in the, then undeveloped, southern portion of Ventura County.

In addition to the forces causing horizontal movement such as that predominant along the San Andreas Fault, Ventura County and portions of adjacent areas are subject to compressional forces acting in north-south directions. These latter forces tend to compress or try to shorten the distance from the San Andreas Fault south to the coast. The San Fernando Earthquake of 1971, resulting in the thrusting of the southern margin of the San Gabriel Mountains several feet southward over the north margin of the San Fernando Valley, was caused by these compressional forces. Several faults in Ventura County have been formed by and are related to these same forces (See Illustration 3.1). These fault systems are described in the Fault Displacement Hazard section.

When an earthquake occurs, the break along the fault plane begins in a small area and rapidly propagates out along the fault planes. The point of first release of stress located below the earth's surface on the fault plane is called the earthquake focus. The point at the earth's surface vertically above the focus is the epicenter.

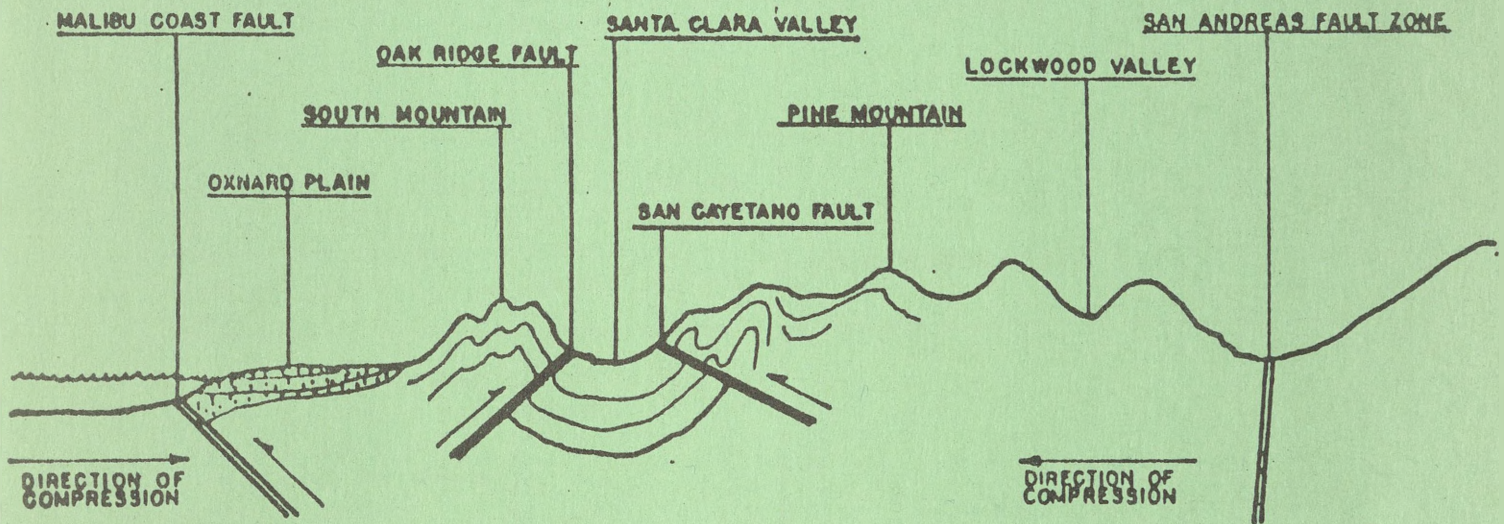
When a fault breaks, all of the accumulated strain energy is released as seismic waves. These waves travel



outward in all directions from the earthquake focus. Seismograms (records of earthquake motion) indicate that several kinds of motions are created by the passage of seismic waves. These motions can be classified as: Longitudinal Waves, Shear Waves, Rayleigh Waves, and Love Waves. Illustration 3.1 is a summary of the names and properties of the various types of seismic waves.

### Illustration 3.1

A simplified north-south cross section showing the relationship of thrust faulting to presently active compressional forces.



SOURCE: Ventura County Public Works

Each of these waves has different types and directions of movement. Each can affect buildings slightly differently depending on many diverse variables. The combined effect of these waves makes up the ground shaking component of an earthquake.

In general, research of many past earthquakes indicates that the intensity of ground shaking at any given location during an earthquake is a function of several factors including:

1. Magnitude of the earthquake
2. Distance from the epicenter
3. Depth at which the earthquake was generated or focus
4. Type of ground motion
5. Geologic foundation of area
6. Type of ground surface

Of these, the only variable which can be assessed very accurately in advance is the type of ground. Determination of ground response (ground wave motion) can

Illustration 3.2

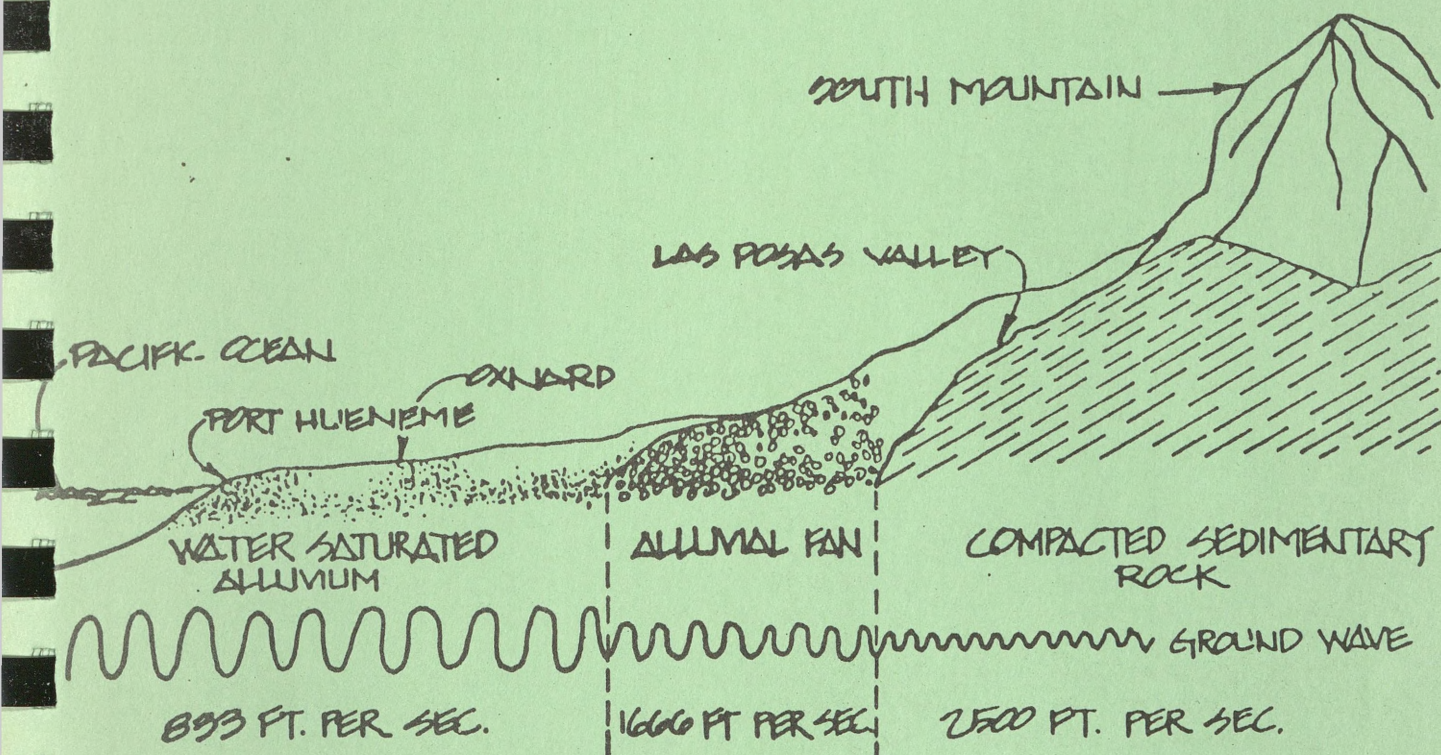
NAMES AND PROPERTIES OF SEISMIC WAVES

Particle Motion Created by Pas- sage of Wave	Synonymous Names of Waves	Standard Letter Desig- nation in Seismology	Names Based on Travel Paths in Earth
Oscillation along lines in direction of wave travel	Longitudinal waves Compressional waves Push-pull waves Sound waves	P (for Primary)	Body waves
Oscillation along lines at right angles to direc- tion of wave travel	Shear waves Transverse waves Shake waves	S (for Secondary)	
Around in circles lying in vertical planes; in same direction as wave advance under troughs, in op- posite direction under crests	Rayleigh waves	L (for Large)	Surface waves
Oscillation at right angles to direction of wave travel along lines lying in hori- zontal planes	Love waves		

Source: Longwell and Others, 1969, p. 432.



Illustration 3.3 Change in speed of ground wave as it enters different materials, with a concurrent increase in amplitude.



be estimated based largely upon existing earthquake records, though only for a predicted location and magnitude of an earthquake.

The intensity of ground shaking during an earthquake depends in large part on geologic foundation conditions, i.e., the thickness and physical properties of the materials comprising the upper several hundred feet beneath the area. In general, the greatest amplitudes and longest durations of ground shaking usually occur on thick, water-saturated, unconsolidated alluvial sediments. Recent studies of groundmotion in San Francisco generated by underground nuclear explosions in Nevada indicated that the peak groundmotion velocities were as much as 10 times larger on soils adjacent to the bay than on nearby bedrock.

Illustration 3.3 is a diagram of the area from South Mountain near Fillmore to Port Hueneme which shows the slowing down of the ground wave as it passes from consolidated sedimentary rocks on South Mountain to the alluvial fan materials of the Las Posas Valley along with a corresponding increase in wave amplitude. An increase in wave amplitude generally means an increase in intensity of ground shaking. There is even a more marked decrease in speed and increase in amplitude between the alluvial fan materials of the Las Posas Valley and the water saturated sediments of the Oxnard Plain.

Two separate indexes, or scales are commonly used in the United States in describing seismic or earthquake disturbances. The qualitative rating of the degree of earthquake shaking based upon feeling and visual observation is indicated by an intensity scale. The size or energy release of earthquakes is measured by a magnitude scale.

Measurement of the radiated energy released by an earthquake was originally proposed by C.F. Richter in 1932 and utilizes a system of tables and charts to deduce from seismological instruments a method of measuring the magnitude of an earthquake. The magnitude assigns a number to the calculated energy release, this system can rank earthquakes and compare them one to the other. By this method, an earthquake is rated independently of the place of observation.

The magnitude is the logarithm (base 10) of the maximum amplitude of a seismogram referred to a distance of 100 kilometers (62 miles) from the epicenter. Under this system, an increase of one unit in magnitude is equal to 32 times the next lower degree of energy release. Thus an earthquake of magnitude 7 represents about 32 times as much energy release as one of magnitude 6;



magnitude 8 represents 32 times the energy of magnitude 7 and, therefore, about  $(32 \times 32)$  1000 times the energy of magnitude 6.

The other index is much more of a reflection of the damage caused by ground shaking as it measures effects. It varies from place to place, not necessarily in direct relationship to the distance from the earthquake. The intensity is more or less independent of the magnitude.

The scale used to measure the intensity of an earthquake is the Modified Mercalli Scale with intensities ranging from I to XII (See Illustration 3.4). The scale is a description of the physical effects of earthquakes. The lowest intensity ratings are based on human reactions, such as "felt indoors by few." The highest intensities are measured by geologic effects, such as "broad fissures in wet ground, numerous and extensive landslides, and major surface faulting." The middle intensity range is based largely on the degree of damage to buildings and other man-made structures. Intensity ratings are based on visual observation and are not measured with instruments. The degree of intensity varies from place to place during an earthquake. Specific locations in an area may have an intensity rating of VIII because of soil conditions, structural design, or distance from field epicenter. Intensity scales have generally been replaced by more quantitative measures such as the magnitude scale and ground response based upon seismograph or accelograph records.

An important factor affecting the degree of damage to structures during an earthquake is the frequency characteristics of groundmotion as related to the fundamental periods of vibration of the structure. For sites such as the plain area which are underlain by deep deposits of unconsolidated alluvium, the peak values of the acceleration response spectra tend to occur at high values of the fundamental period, resulting in high (damaging) accelerations being induced in flexible structures such as multi-story buildings. The reverse is true of the area underlain by firm bedrock, i.e., the high accelerations would be induced in rigid structures such as reinforced buildings of only a few stories in height.

In general, the greatest damage to tall structures results where they are built over thick, soft, water-saturated sediments. The least damage occurs where they are built on very firm bedrock. The structural integrity of buildings before the earthquake and whether the natural vibration period of the structure is coincident to that of the ground are both factors that complicate these general concepts.

When the building and the ground approach the same vibration period, the greatest damage is likely to occur. The predominant vibration period of a building can be related in a very general way with its height or number of stories. Taller buildings have a longer predominant vibration period (2 or more seconds). Therefore, they are subject to greater damage where they occur on ground with a longer predominant vibration period (thick, water-saturated sediments). Conversely, 1 or 2 story buildings with short predominant vibration periods on firmer ground may be in trouble. Other factors which contribute to damage potential, such as magnitude, distance, frequency and duration of a particular earthquake, influence the predominant vibration period. For the Ventura County area, unfortunately, none of the factors are predictable with any great degree of confidence.

Intense ground shaking in areas of unconsolidated, water-bearing sediments (alluvium) or wet soils could also result in soil liquifaction, ground rupture, lurching, slumping and lateral movement of nearly level areas and landsliding. The greatest hazard of ground failure in hillside areas is in the form of landsliding and other slope failures. Seismic shaking can renew movement of old landslides as well as result in formation of new slides. Many of the existing landslide features may have been triggered by past earthquake shaking. The combination of relatively weak bedrock, deep weathering, steep slopes and inclined bedding combine to make many areas highly susceptible to landslide failure during seismic shaking.



# Illustration 3.4

## MODIFIED MERCALLI SCALE OF EARTHQUAKE INTENSITIES

### THE MERCALLI INTENSITY SCALE

(As modified by Charles F. Richter in 1956 and rearranged)

If most of these effects  
are observed

then the  
intensity is:

If most of these effects  
are observed

then the  
intensity is:

Earthquake shaking not felt. But people may observe marginal effects of large distance earthquakes without identifying these effects as earthquakes caused. Among them trees, structures, liquids, bodies of water sway slowly, or doors swing slowly.....I

Effect on people Shaking felt by those at rest, especially if they are indoors, and by those on upper floors.....II

Effect on people Felt by most people indoors. Some can estimate duration of shaking. But many may not recognize shaking of building as caused by an earthquake. The shaking is like that caused by the passing of light trucks.....III

Other effects Hanging objects swing

Structural effects Windows or doors rattle. Wooden walls and frames creak.....IV

Effect on people Felt by everyone indoors. Many estimate duration of shaking. But they still may not recognize it as caused by an earthquake. The shaking is like that caused by the passing of heavy trucks, though sometimes, instead, people may feel the sensation of a jolt, as if a heavy ball had struck the walls.

Other effects Hanging objects swing. Standing autos rock. Crockery clashes, dishes rattle or glasses clink

Structural effects Doors close, open or swing. Windows rattle.....V

Effect on people Felt by everyone indoors and by most people outdoors. Many now estimate not only the duration of shaking but also its direction and have no doubt as to its cause. Sleepers awakened.

Other effects Hanging objects swing. Shutters or pictures move. Pendulum clocks stop, start or change rate. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. Liquids disturbed, some spilled. Small unstable objects displaced or upset.

Structural effects Weak plaster and Masonry D\* crack. Windows break. Doors close, open or swing.....VI

Effect on people Felt by everyone. Many are frightened and run outdoors. People walk unsteadily.

Other effects Small church or school bells ring. Pictures thrown off walls, knickknacks and books off shelves. Dishes or glasses broken. Furniture moved or overturned. Trees, bushes shaken visibly, or heard to rustle.

Structural effects Masonry D\* damaged, some cracks in Masonry C\*. Weak chimneys break at roof line. Plaster, loose bricks, stones, tiles, cornices, unbraced parapets and architectural ornaments fall. Concrete irrigation ditches damaged.....VII

Effect on people Difficult to stand. Shaking noticed by auto drivers.

Other effects Waves on ponds, water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Furniture broken. Hanging objects quiver.

Structural effects Masonry D\* heavily damaged. Masonry C\* damaged, partially collapses in some cases, some damage to Masonry B\*, none to Masonry A\*. Stucco and some masonry walls fall. Chimneys, factory stacks, monuments, towers, elevated tanks twist or fall. Frame houses moved on foundations if not bolted down. Loose panel walls thrown out. Decayed piling broken off.....VIII

Effect on people General fright. People thrown to ground.

Other effects Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes. Steering of autos affected. Branches broken from trees.

Structural effects Masonry D\* destroyed, Masonry C\* heavily damaged, sometimes with complete collapse. Masonry B\* is seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames racked. Reservoirs seriously damaged. Underground pipes broken.....IX

Effect on people General panic.

Other effects Conspicuous cracks in ground. In areas of soft ground, sand is ejected through holes and piles up into a small crater, and, in muddy areas, water fountains are formed.

Structural effects Most masonry and frame structures destroyed along with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes and embankments. Railroads bent slightly.....X

Effect on people General panic.

Other effects Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land.

Structural effects General destruction of buildings. Underground pipelines completely out of service. Railroads bent greatly.....XI

Effect on people General panic.

Other effects Same as for Intensity X.

Structural effects Damage nearly total, the ultimate catastrophe.....XII

Other effects Large rock masses displaced. Lines of sight and level distorted. Objects thrown into air.

\*Masonry A. Good workmanship and mortar, reinforced, designed to resist lateral forces. Masonry B. Good workmanship and mortar, reinforced. Masonry C. Good workmanship and mortar, unreinforced. Masonry D. Poor workmanship and mortar and weak materials, like adobe.



## newelube in city element

The following are excerpts from a manuscript in preparation by D.R. Nichols, U.S. Geological Survey.

Ground Shaking - Probably the most difficult task today, in terms of the predictive capability of the geologist and seismologist, is devising a reasonably reliable method of predicting "ground shaking" effects -- what most people and structures react to during an earthquake. Examination of damage from numerous past earthquakes, in lieu of conclusive strong-motion seismograph records, has suggested to geologists and engineers that the greatest damage to tall structures results where they are built over thick, relatively soft, water-saturated sediments and that the least damage occurs where they are built on very firm bedrock. Although engineers have shown that while great thicknesses of wet unconsolidated sediments may amplify the ground motion, perhaps a more critical measure of damage is a determination of the "predominant period" of the building and of the ground on which it rests. The predominant period of a building can be related in a very general way to its height or number of stories. Taller buildings have a longer predominant period (2 seconds or more). Therefore, they are subject to greater damage where they occur on ground with a longer predominant period (thick, saturated sediments). Conversely, one or two-story buildings with a short predominant period may be in trouble on firmer ground. Further complicating this very generalized picture are a wide variety of other factors that may contribute significantly to a damage potential: magnitude of a particular earthquake, distance and direction from the epicenter and causative fault, duration of shaking and the structural integrity of buildings before the earthquake, and many others. The greatest damage is likely to occur where the predominant ground period is coincident with that of the greatest number of high-rise buildings. However, a prediction of ground shaking at a particular spot or point is subject to a great variety of conditions, only some of which are predictable with confidence. For example, a magnitude 5 earthquake on the San Andreas Fault at Hollister may have the same damage pattern at a particular locality as a more distant 7.5 magnitude earthquake on the Hayward or Calaveras fault.

Ground Failure - Earth materials in a natural condition tend to reach equilibrium over a long period of time. In geologically active areas such as California and Alaska there are many regions where earth materials have not yet reached a natural state of stability. For example, most of the valleys and bay margins are underlain by recent loose materials that have not been compacted and hardened by long-term natural processes. Landslides are common on most of the hills and mountains as loose material moves



downslope. In addition, many activities of man tend to make the earth materials less stable and hence to increase the chance of ground failure. Some of the natural causes of instability are earthquakes, weak materials, stream and coastal erosion, and heavy rainfall. Human activities that contribute to instability include oversteepening of slopes by undercutting them or overloading them with artificial fill, extensive irrigation, poor drainage or even groundwater withdrawal, and removal of stabilizing vegetation. These causes of failure, which normally produce landslides and differential settlement, are augmented during earthquakes by strong ground motions that result in rapid changes in the state of earth materials. It is these changes, by means of liquifaction and loss of strength in fine-grained materials, that result in so many landslides during earthquakes as well as differential settlement, subsidence, ground cracking, ground lurching, and a variety of transient and permanent changes in the ground surface.

Mechanisms of Failure - Liquifaction is a common mechanism causing many types of ground failure. It occurs when strength of saturated, loose, granular materials (silt, sand, or gravel) is drastically reduced, such as may occur during an earthquake. The earthquake-induced deformation transforms a stable granular material into a fluidlike state in which the solid particles are virtually in suspension similar to quicksand. The result, where the liquified materials are in a broad buried layer, may be likened to the action of ball bearings in reducing friction in the movement of one material past another. The Juvenile Hall Landslide during the 1971 San Fernando earthquake resulted from liquifaction of a shallow sand layer and involved an area almost a mile long and a failure surface that had a slope of only 2-1/2 percent (Youd, 1971, p. 107, 108). Where the liquified granular layer is thick and occurs at the surface, structures may gradually sink downward. The tilting and sinking of buildings during the Niigata earthquake illustrate this phenomenon.

Results of Ground Failure - Although the basic causes of ground instability are simple in concept, the consequences are often complex and highly variable. They include numerous varieties of landslides, ground cracking, lurching, subsidence, and differential settlement. Moreover, these types of ground failure occur on a wide variety of ground conditions. Landslides, for example, do not require a steep slope on which to form, particularly during earthquakes. Many occur on slopes that are virtually flat, and the surface on which they fail may be very shallow (1 to 2 feet deep) or as much as hundreds of feet below the ground surface. The type of ground failure that develops in a given area is determined by the nature of the natural or man-made disturbance that occurs and partly by the topographic, geologic, hydrologic, and geotechnical characteristics of the ground.

Ground cracking usually occurs in stiff surface materials and is associated with changes in surface topography or materials. For example, during the 1964 Alaskan earthquake, much of the ground cracking that occurred along river flood plains adjacent and parallel to stream channels and along road and railroad embankments resulted from differential movement owing either to liquifaction or to lateral spreading of a relatively soft, deeper layer under a stiffer surface layer. Cracks may be only hairline or several feet wide and from a few feet to hundreds of feet long.

Ground lurching may be both a transitory and permanent phenomenon. During earthquakes, soft saturated ground may be thrown into undulating waves that may or may not remain when the ground motion ceases. The same or similar ground surface appearance may also result from permanent differential settlement of the ground, which can be caused by loss of soil strength or by liquifaction. Commonly, the water freed by liquifaction of buried and confined granular layers is forced to the ground surface, moving laterally toward steep slopes or vertically along the planes of weakness in the overlying layers. As the water moves toward the surface or "free face," it often carries with it some of the sand. Thus, "sand boils," "sand volcanoes," "sand ridges," and similar anomalous features attest to the occurrence of liquifaction. As sand and water are removed from the subsurface, the ground settles, often differentially because the sand and water are seldom removed evenly over broad areas. The resulting effects on buildings can be catastrophic.

Subsidence of as much as several feet may occur over a broad area underlain by a thick sequence of sedimentary deposits. For example, after the 1906 earthquake, a well casing was reported to have "risen" two feet out of the ground, when, in fact, the ground around it probably liquified or compacted as a result of the shaking. Subsidence is likely to be greatest in areas where there has been withdrawal of fluids (ground water or oil) over a long period of time. Lesser amounts of subsidence can occur even where fluid withdrawal has not taken place, as in the Homer area of Alaska in 1964. Compaction effects may be predicted with some degree of assurance over fairly broad areas (up to 1 or 2 miles) and even on a site basis, especially when the cause may be liquifaction.

Tectonic Deformation - Earthquakes may produce major differential vertical and horizontal movements over broad parts of the earth's crust. For example, as a result of the 1964 Alaskan earthquake, between 70,000 and 110,000 square miles of both the sea floor and land in southern Alaska were warped, elevating or depressing them as much as 6 feet; elevation changes locally exceeded 50 feet



(Hansen and others, 1966, p. 17). While the effect of compaction and tectonic subsidence may appear the same locally, the mechanisms differ greatly and the total area affected will be much greater where tectonic deformation occurs. Tectonic land changes result from major movements in the earth's crust, and neither their location nor their magnitude is predictable. Therefore, little can be done to minimize the effects of these changes before they occur.

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reinclude

All of Ventura County lies within the highly active earthquake region of Southern California. Preliminary estimates by R. Greensfelder (California State Division of Mines and Geology, unpublished preliminary research information) indicate that most of Ventura County can be subject to as strong earthquake shaking as can be expected anywhere in California. Only the area of the Santa Monica Mountain is estimated to have slightly less severe ground shaking potential.

#### GENERAL EFFECTS OF THE HAZARD

##### PRIMARY EFFECTS

The primary effect of ground shaking is the damage or destruction of structures and infrastructures and thus the potential for the loss of life or sustaining injuries. The severity of the effect is dependent on many factors such as the strength and design of the structure to withstand shaking; composition and depth and the geologic structure of underlying earth materials; the presence of free groundwater and the topography. In general, all structures in areas subject to ground shaking will be affected.

Damage to structures during ground shaking can range from minor cracking of plaster to total collapse and/or overturning. (No structure can be assured to be designed and constructed to completely withstand damage from a strong earthquake with ground motion of intensity IV or above on the Modified Mercalli Scale (Illustration 3.4). Some damage, whether it be to the structure or its contents, can be anticipated.) *reinclude in element*

Ground shaking could cause severe damage to most utilities including pipelines, power lines, generating and convertor facilities, roads and bridges, if such structures were not constructed to withstand the shaking. Ground surfaces could rupture, crack and subside up to several feet in areas of unconsolidated alluvium resulting in damage to structures located in these areas.

## SECONDARY EFFECTS

As a result of severe shaking and structural failures there are other secondary effects possible. Such effects include:

1. Cost of rehabilitation
2. Disruption of utilities and services for a substantial length of time

### Seiches

### Liquefaction

3. Possible sympathetic movement of other faults
4. Temporary and long term psychological effects
5. Adverse affect on the quality of water in ground water aquifers.

re include

## GENERAL INVENTORY OF THE HAZARD

### LOCATION OF THE HAZARD

The hazard exists throughout Ventura County and may significantly increase, wherever there is ground material that could significantly amplify the ground waves of an earthquake and produce high intensity ground shaking. Every place in the surrounding area would be shaken by an earthquake, the area affected would generally be determined by the magnitude of the earthquake. Those areas that might be shaken more than others are in the hazard zones. (Shown on Hazard Plate II).

The highest amplification of ground shaking occurs in areas where the long period wave shaking is greatest, designated as Area A on Hazard Plate II. Basically, this is the Oxnard Plain and the Santa Clara River in the south half of the County and in Lockwood, Cuyama, and Cuddy Valleys in the north half. Areas that could experience some amplification of long period shaking generally surround these areas and extend up the canyons of the major rivers and creeks.

The areas with the greatest amplification of short period shaking are along the base of the hills and in minor river valleys and in the broken bedrock along fault lines such as the San Cayetano and Simi-Santa Rosa Faults. Slight to moderate amplification of short period oscillations may occur on terrace deposits or soft bedrock, which has a thin soil covering. These materials are found in young hill areas such as South Mountain, Oak Ridge, Sulphur Mountain, and the north coastal hill lands and the Piru area in the south half of the County. In the north half these are along the margins of the valley areas such as Hungry and Lockwood Valleys and hill lands north of Cuyama.



## HISTORY OF THE HAZARD

### Southern Ventura County

The southern County area is considered that portion southerly of the east-west projection of Nordoff Ridge located immediately north of the Ojai Valley. Even though the historic record indicates that no strong earthquakes or surface displacement have occurred along the faults within the southern county area, the likelihood of the occurrence of one or more of such events within 50 to 100 years is not remote. The recent San Fernando earthquake occurred along a fault having little historic record of activity. Several of the faults within the south half of Ventura County, such as the Santa Susanna and San Cavetano, are similar in structure and subject to similar tectonic forces. Crustal deformation resulting in similar earthquakes will likely continue into the indefinite future.

County Geologist wording  
The history of strong earthquakes provides an indication of what will probably occur in the future, however, the record does not provide a statistically sound basis for prediction. It is probable that earthquakes of magnitude 6 and larger will occur in the future within the vicinity of the south half of the county area including or in the nearby offshore areas, and it would be consistent with past experience if several such shocks occurred in the next century. Surface displacement associated with the earthquakes is also possible.

The following is a portion of the summary of faulting and seismicity of the southern County area taken from the "Geology and Mineral Resources Study of Southern Ventura County" (1972) prepared by the State Division of Mines and Geology in cooperation with the Ventura County Department of Public Works:

"The earthquake history of Ventura County, particularly of the more populous southern part, is dominated by small to moderate shocks. Many of these shocks have been severe in their local, epicentral areas, but regionally have caused only light damage. No earthquake greater than magnitude 5.9 has been recorded in Ventura County, or the immediate offshore area, since 1934 when adequate instrumental records became available. These relatively minor shocks have caused local damage but no recorded loss of life. A review of the earlier less accurate record from 1769 to 1934 suggests a similar history for the southern County region. More serious than effects from local shocks have been the effects from relatively numerous moderate to large earthquakes whose epicenters are located outside of southern Ventura County. These shocks have caused considerable damage but no recorded loss of life.

Several larger, historic earthquakes are especially important to the evaluation of future seismic risk in

southern Ventura County. On December 21, 1812, an earthquake, probably located offshore south of Santa Barbara, damaged missions from Purisima Concepcion, near Lompoc, to San Fernando on the south. The tower of the San Buenaventura Mission was wrecked and much of the facade had to be rebuilt. This earthquake was accompanied by seismic sea waves which had reported runup heights of 30 to 50 feet between Santa Barbara and Gaviota and 15 feet or more at Ventura (Wood and Heck, 1966). Such waves today would do considerable damage to many parts of the now heavily settled coastal areas of Ventura County.

On January 9, 1857, the great Fort Tejon earthquake, with its epicenter probably on the San Andreas fault, close to the northeast corner of Ventura County, caused significant damage in the southern part of the County. The roof of the Mission Church at San Buenaventura fell in (Townley and Allen, 1939). Six miles from the south of the Santa Clara River the bed of the river was severely cracked. Wood (1955, p. 53) quoted a report describing the cracks as "being six or eight inches across, and extending in a direction SE and NW." Quoting further he said that "on either side of the cracks lay a ridge of wet sand." These cracks were probably due to lurching and liquifaction in the saturated alluvium of this area.

Wood continued, noting:

*These appearances were visible as far as I could see up and down the bed of the river. Near the mouth of the river the cracks were longer and wider. Persons residing within a mile of the entrance say that the water was thrown out from the cracks as high as six feet, and that large blocks of earth sank several feet below the former level, and there remain.*

A second important earthquake is the June 6, 1925 shock of magnitude 6.3, which destroyed the business section of Santa Barbara and caused some damage in Ventura. An offshore shock on June 30, 1941, magnitude 5.9, cracked some walls and plaster, broke windows and dishes and damaged considerable shelf-stock in some stores in Ventura.

The intensity of shaking reported in much of Ventura County from the February 9, 1971, San Fernando earthquake was sufficient to cause minor damage and to cause breakage of some goods thrown from store shelves. In Santa Susana, some older buildings were severely damaged, with at least one or two razed. At least a few rockfalls and one small bedrock landslide occurred north of Simi Valley in the Tapo Canyon area, just south of the Santa Susana fault. Small displacement occurred on this fault during the



earthquake in the northwestern Sylmar area. The fault extends west, where it joins the Oak Ridge fault and possibly the San Cayetano fault system in the Piru-Oak Ridge area.

The questions, "which faults of southern Ventura County are active or potentially active?" has not been answered fully. The Red Mountain and San Cayetano thrust fault zones, which together nearly span the County

should be considered active. Holocene and Pleistocene sediments are displaced by the Red Mountain thrust, and similar physiographic features on both the Red Mountain and San Cayetano thrusts, also suggest Holocene displacement. In addition, aerial photos show many ground surface lineaments and other phenomena which may reflect Holocene or later Quaternary faulting, and should be investigated. One alignment near the base of the Ventura Foothills, roughly corresponds to a fault shown in cross section by Ogle (1969), who correlates it with the offshore, Pitas Point fault.

Several reverse faults, which apparently act as barriers to ground water in the alluvial areas, were also probably active during the late Quaternary, as described by California Water Resources Board (1953). These include the Springville fault at the western Simi Valley area, the western Oak Ridge (Saticoy) fault in the Oxnard Plain area, and the Santa Ana fault in the Oak View area (a fault zone which has raised the Upper Ojai Valley relative to Ojai Valley). The Camarillo fault may not act as a ground water barrier, but California Water Resources Board (1953, p. B34) stated that the fault may have offset alluvium.

A problem in southern Ventura County equally as serious as the identification of active or potentially active faults is the problem of identifying the geologic units as to their seismic response characteristics. For example, Richter (1959, p. 143) stated that much of the alluviated area of the Santa Clara Valley and the Ventura basin should expect shaking sufficient to cause considerable damage in specifically designed buildings and great damage to normally substantial buildings. In the eastern part of the Ventura basin this was demonstrated during the San Fernando earthquake. The expected damage to areas where ground water is within 15 feet of the surface could be even greater, but would be relatively less in areas underlain by older alluvium and even less on more indurated or cemented Tertiary rocks. Older landslides may be re-activated or new landslides may originate in some areas of Tertiary rocks of the County during an earthquake. Especially landslide prone is the Pico Formation, and to a lesser extent the Modelo/Monterey and Rincon Formations."

## Northern Ventura County

The most important faults in the vicinity of the northern County area are the San Andreas, Big Pine, Garlock, San Gabriel and Frazier Mountain thrust, all of which converge at the northeast corner of Ventura County, and the Santa Ynez in the southern part of the north half of the County. All of these faults except perhaps the Frazier Mountain thrust are considered to be active, i.e., are potential focal points for the occurrence of earthquakes and displacement of the ground surface. Other mapped and unknown faults within the north half may also prove to be active by future displacement or detailed investigations.

Historic Record - Reliable accounts of California earthquakes date from about 1800. Since that year it is estimated that 35 to 40 earthquakes of magnitude 6.0 (Richter Scale) or larger have occurred in southern California. Over 20 of these occurred since 1912. Three of the earthquakes could have caused substantial damage to major structures in the north half had such structures been located there. These three earthquakes were the Northern Ventura County of 1852, Fort Tejon of 1857 and the Kern County of 1952.

The Big Pine fault, a major left-lateral fault with some oblique slip (subject to both horizontal and vertical displacement), may have had measurable movement during historic time. The earthquakes (apparently several) of November 1852 were accompanied by about 30 miles of surface faulting in Lockwood Valley. The exact location of the surface breaks is unknown, but geologic evidence and reports by others indicate that it may have been along the Big Pine Fault. Evidence of young movement along the fault includes scarplets that cut terrace deposits and apparent left-lateral offset of stream channels.

Several other faults found in the Lockwood Valley area have had recent movement by virtue of their cutting of terrace deposits and offset of other faults. These faults range from several hundred to a few thousand feet in length. Some of them indicate the region has recently undergone, and is probably still undergoing, compression along north-south directions.

Future Earthquake Potential - The historic record shows that the north half has experienced several severe shocks originating along faults both within and immediately outside of the area. The geologic record shows that a high level of tectonic activity has continue to the present time.

The history of severe earthquakes provides an indication of what will probably reoccur in the future,



however, the record does not provide a statistically sound basis for prediction. It has been found, however, that the number of large earthquakes that occur in a region is related to the number of small earthquakes.

reinclude  
in element

Movement of the land mass west of the San Andreas fault relative to the east side, has been fairly well substantiated by the geologic record as well as precise surveying, and is about 2 inches per year. That portion of the San Andreas fault immediately north of the County has not shown displacement since 1857 nor has any been reported along the Big Pine or other faults in the north half since 1852.

Geologic and survey evidence indicates that stress is building up along the San Andreas fault to the north. It is just a question of time until the fault in this area again displaces with a high probability that the resulting earthquake will be severe. Prediction of when displacement will occur is not possible at this time, however, it is likely that it will occur within 100 years and possibly much sooner.

Earthquakes and surface displacement originating along faults within the north half is also highly possible, but again, prediction of when is not possible. Determination of the potentially most active faults would require extensive field investigation and was not completed during this study. However, previous studies and published information indicates that many recently active faults may exist within the region. In addition, the apparently active compressional forces which continue to affect the area, as recently reflected by the San Fernando earthquake, provide the means through which future earthquakes could occur along the known as well as other presently unknown, faults within the area.

Since 1852 the northerly portion of the north half has experienced severe shaking probably on the order of XI on the Mercalli Modified Intensity Scale during three earthquakes. One of these may have been centered on the Big Pine Fault during which rupturing of the ground surface occurred. Earthquakes of equal or greater intensity can be expected to affect the area in the future, and it would be consistent with past behavior if at least two such events occurred in the next century. It is likely that at least one of these events will be centered along the nearby San Andreas fault.

A large earthquake (7.0 magnitude or greater) in the vicinity of the north half would cause intense shaking with possible ground deformation and rupturing in valley alluvium, man-made fills and marginally stable hillsides. The resulting damage to structures would be great especially

during the wet season when groundwater is at its highest level of in areas where groundwater is being recharged by lakes or surface irrigation.

It is impossible, based upon the meager available information and experience with earthquake activity in California, to accurately predict the degree of shaking which could result from a great earthquake such as those of the not so distant past which affected the region. However, it is not unreasonable to expect bedrock accelerations of over 1.0g (or equivalent to the acceleration of gravity) and over 45 seconds of maximum shaking duration. The degree of shaking would, of course, be much greater resulting in higher accelerations, in areas underlain by alluvium or valley sediments. Peak bedrock accelerations in the range of 0.5g to 1.0g were recorded during the relatively small San Fernando Earthquake of 1971.

Illustrations 3.5 - 3.7 indicate the approximate number, epicenter and magnitude of earthquakes recorded in the vicinity of Ventura County since 1932.

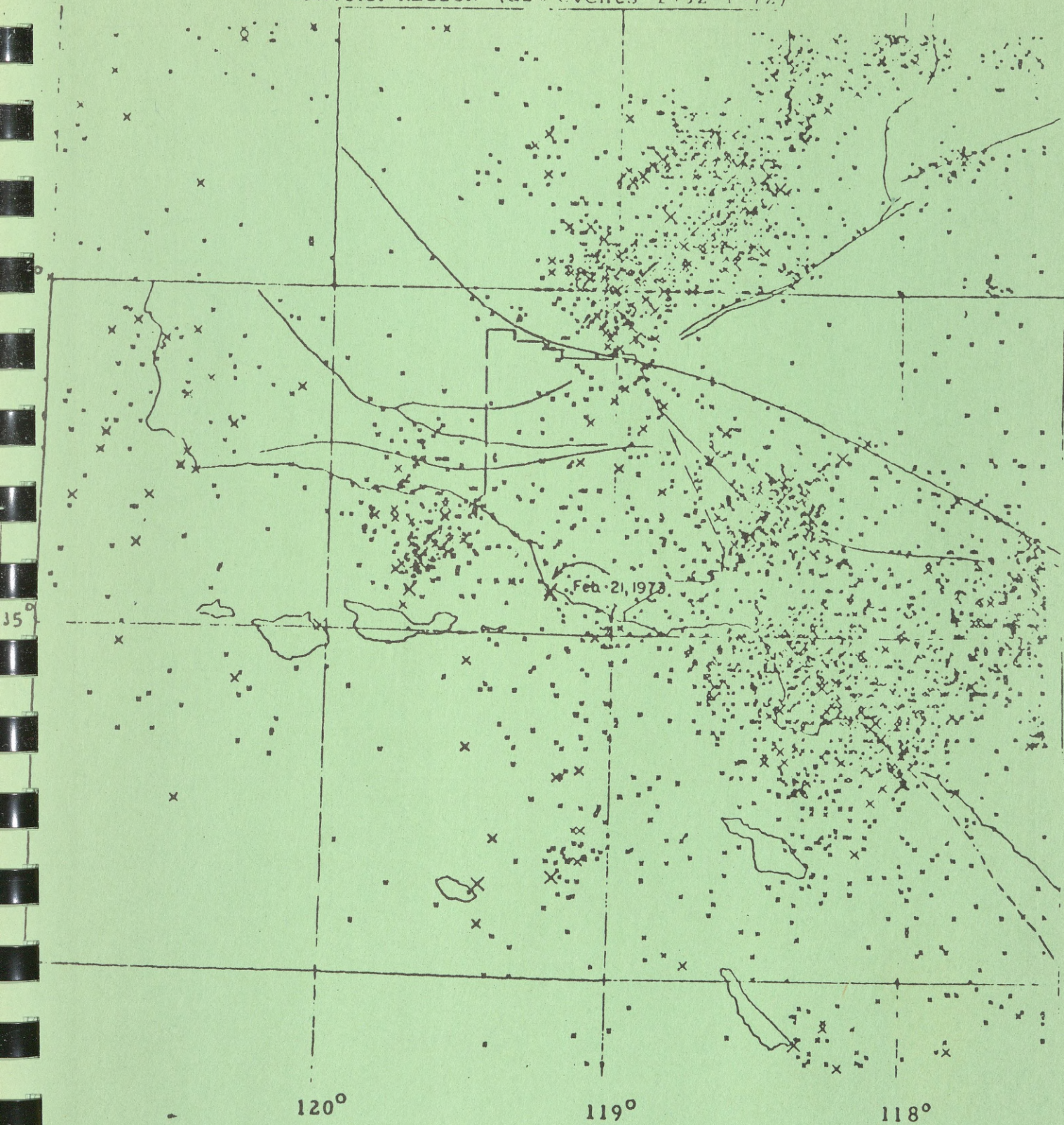


Illustration 3.5  
REGIONAL EPICENTER MAP 1932-1971





Illustration 3.6  
VENTURA REGION (all events 1932-1972)



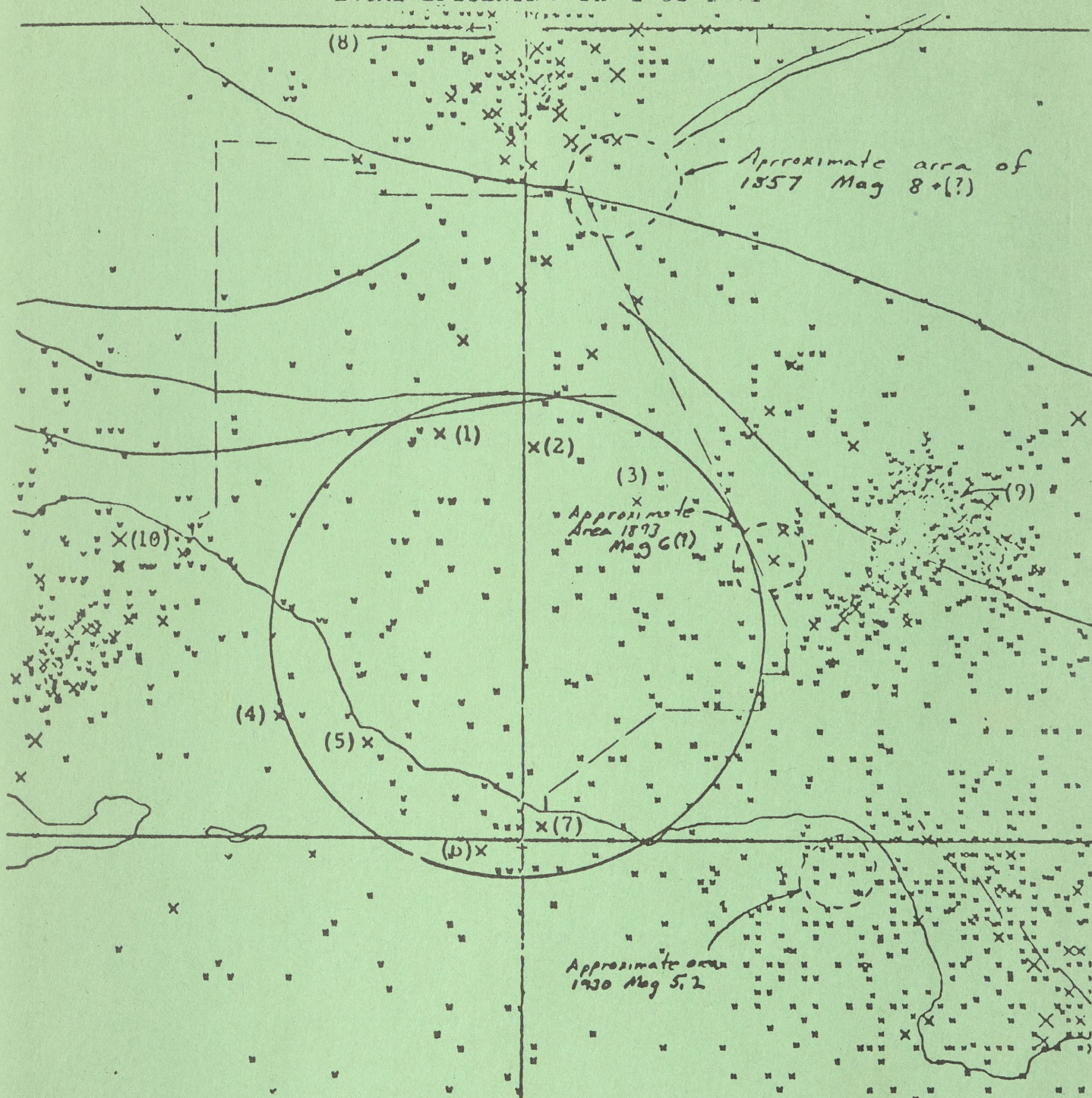
III-18

EPICENTER SYMBOLS

GUC  
 AWA  
 IIII  
 AAW  
 GUC  
 X



Illustration 3.7  
LOCAL EPICENTER MAP 1932-1971



<u>Epicenter</u>	<u>Date</u>	<u>Magnitude</u>
(1)	11/17/54	4.4
(2)	9/ 3/42	4.5
(3)	6/ 1/46	4.1
(4)	8/22/50	4.2
(5)	3/18/57	4.7
(6)	5/29/55	4.1
(7)	4/16/48	4.7
(8)	7/21/52	7.7
(9)	2/ 9/71	6.4
(10)	7/ 1/41	5.9

0 20  
MILES

EPICENTER SYMBOLS



## DEFINITION OF THE HAZARD ZONE

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Element

The ground shaking hazard zones as indicated on Hazard Plate II (Southern Ventura County and Northern Ventura County) are based on the concept that ground shaking is partly determined by the thickness of the alluvium or unconsolidated material overlying relatively firm bedrock or consolidated earth material and the depth to the ground water table. The zones identified are as follows:

Zone A. Areas underlain by alluvium more than about 50 to 100 feet in thickness and with groundwater levels at about 15 feet or less below ground surfaces. These areas could experience the greatest amplification of long period ground vibration. Therefore, buildings such as high rise structures which have long natural vibration periods could be more susceptible to damage in this zone.

Zone B. (So. County only) Areas underlain by alluvium more than about 50 to 100 feet in thickness and with groundwater levels more than 15 feet below the ground surface. These areas could experience moderate amplification of long period ground vibration. Therefore, high rise structures which have long natural vibration periods could be more susceptible to damage in this zone but less susceptible than in Zone A.

Zone B-C. (No. County only) Areas underlain by alluvium less than about 50 feet in thickness and with groundwater levels more than about 15 feet below ground surfaces. These areas could experience the greatest amplification of short period ground vibration. Therefore, low rise buildings which have short natural vibration periods could be more susceptible to damage in this zone.

Zone C. (So. County only) Areas underlain by broken bedrock adjacent to faults or where ground alluvium less than about 50 feet in thickness. These areas could experience the greatest amplification of short period ground vibration. Therefore, low rise buildings which have short natural vibration periods could be more susceptible to damage in this zone.

Zone D. Areas underlain by soft sedimentary bedrock or Terrace Deposits with some soil cover (generally thicker on lower slopes). These areas may not experience as severe shaking as the other zones, but more than Zone E because of softer materials and relatively thin soil cover. Amplification of short period ground vibration could be slight to moderate. Therefore low rise structures of short natural vibration periods could be somewhat more susceptible to damage.



Zone E. Areas underlain by hard bedrock with little or no soil cover. These areas may not experience as severe shaking as the other zones because the thin or lack of unconsolidated cover (soil) or significant free groundwater will not allow amplification of shaking.

Reinclude  
Back  
in  
Clement

Man-made structures within a zone will respond differently depending upon their natural periods of vibration. Similarly, two structures with the same natural period will respond differently in different zones. Generally those structures which have a natural frequency close to the ground frequencies that receive the greatest amplification within the zone would sustain the greatest shaking.

The boundaries of the Ground Shaking Hazard Zones should be considered as only approximate. In addition, the estimated response of structures and amplification of certain ranges of ground vibration may vary greatly within a given zone during a given earthquake depending upon its origin, i.e., magnitude, location, distance and depth.

Reinclude  
Back  
in  
Clement

The ground responses estimated for each zone represent generalizations illustrative of the possible variation in the predominant ground response possible from one area to another resulting from perhaps a large earthquake generated along the nearest portion of the San Andreas Fault. The highly complex nature of the geology of Ventura County and the great number of faults along which earthquakes could occur does not allow accurate determination of the range of predominant ground responses which could occur within any one zone.

Present technology or "state-of-the-art" will, however, allow determination of the likely ground response within an individual site proposed for development during an anticipated earthquake, but only after detailed geologic, seismologic and soils engineering investigation of the site.

#### NATURE OF INFORMATION

The information used in delineating the Ground Shaking Hazard Zones on Hazard Plate I is regional in nature and is based upon available groundwater levels and the presence of alluvium as mapped (compiled) as part of the recently completed report entitled "Geology and Mineral Resources Study of Southern Ventura County" (1973) and the Los Angeles Sheet of the Geologic Map of California, both prepared by the State Division of Mines and Geology

and estimated depths of alluvium. The hazard zone locations, boundaries and estimated ground response are not sufficiently accurate on which to base design criteria for individual site development or even provide a basis for land use planning except in the broadest sense without more detailed investigation.

The technical information is based primarily upon statistical data and seismic reports which date back to only the late 1800's and recent experience and research by various governmental agencies and universities. Much of the information utilized was from that developed and published since the San Fernando Earthquake of February, 1971.

RE INSTATE  
BACK IN  
ELEMENT

The Ground Shaking Hazard Zones designated on Hazard Plate II are only approximations and of insufficient accuracy to base any building code requirements. In addition, the estimated ground shaking characteristics are general approximations and may vary greatly within a given zone during a given earthquake.

Recent communication with the State Division of Mines and Geology indicates that the Division believes that the "state-of-the-art" for predicting ground response to waves transmitted by earthquakes has not reached the point where regional maps delineating zones showing predictable intensity or type of shaking can be made with any degree of accuracy.

#### GENERAL MANAGEMENT RESPONSIBILITY

#### INVESTIGATION

Research and experience dealing with the nature and mechanism of earthquake ground shaking is being conducted by various Federal and State agencies as well as by universities and professional organizations. Much of this work is being conducted on a state-wide basis, however, indirect benefit to Ventura County will be gained through developed technology.

The State Division of Mines and Geology is currently investigating the extent of the hazard to Ventura County as part of the cooperative Geologic Hazards Investigation scheduled for completion by July of 1975.

Additional investigation is being conducted on a continuing basis by: (private geologic consultants who provide original information during investigations for private developments.)

New  
wording



Individual site investigation to provide detailed estimates of ground shaking sufficient for design purposes would include determination and analysis of the following information:

1. Depth and character of earth materials.
2. Presence and depth to groundwater.
3. Depth to and character of bedrock.
4. Evaluation of past earthquake records.
5. Estimate of the most likely earthquake to occur within the life of the proposed structure based upon existing earthquake records and evaluation of the potential activity of nearby as well as distant faults.
6. Evaluation of applicability of ground response records from other earthquakes and modification of them as necessary to suit the site in question or determination of ground response by computer methods.

#### WARNING

There is no way to prevent or predict to any degree of accuracy earthquakes or severity or kind of ground shaking during earthquakes at the present. Although it may be that developing technology will enable earthquakes to be predicted, in the not too distant future, the potential availability of such information may have undersirable side effects, such as drastic and sudden

effects on land values, insurance rates, business and the disruptive impacts caused by the possible large, rapid migrations of the populace out of affected areas.

#### ALLEVIATION

Regulation of public and private land development within both incorporated and unincorporated areas is administered by:

City and County Departments of Planning,  
Public Works, and Building and Safety

City Councils and the Board of Supervisors

Enforcement of the Uniform Building Code and City and County regulations and policies can be effected by the above agencies through requirement of review of proposed land use and evaluation of investigation and engineering studies for private development and public projects. Such reviews and evaluations can be performed by qualified engineering geologic and soils engineering staff or by retention of consultants.

Since alleviation of the hazard is largely accomplished through land use controls, the agencies, departments and legislative bodies making land use decisions have the primary responsibility for alleviating the hazard. City and County Planning Departments can utilize available hazard information to determine the need for any additional, more detailed studies and for formulating investigation and design requirements to avoid improper land use and inadequate construction. Decisions concerning adoption of these recommendations rests ultimately with the Planning Commissions, City Councils and the Board of Supervisors. Other bodies making land use decisions include port districts and redevelopment agencies.

Alleviation of existing hazards can be effected by replacement or strengthening of structures which may not be designed to resist strong ground shaking or modification of land uses as hazardous structures are removed. Determination of whether structures are hazardous would require detailed geologic-seismic and soils engineering investigation of seismic and foundation conditions and structural engineering evaluation of the particular structure.



# LOCAL DISCUSSION

## LOCAL INVENTORY OF THE HAZARD

The Oxnard area is underlain primarily by alluvial materials consisting of clay, silt and sand of varying mixtures. Silt and sand are believed to be predominant.

The depth of alluvium is believed to be over 100 feet beneath most of the City area. The alluvium is in general, relatively unconsolidated (low density) to unknown depths but may increase in density below depths of 40 to 60 feet.

Hazard Plate II indicates that the City is located entirely within Zones A and B. Although the ground shaking (vibration or response) can be anticipated to vary greatly across the area, in regard to the degree of amplification of various periods of ground vibration, it is estimated that during regional, strong earthquake shaking long period ground vibration could be subject to the greatest amplification. Therefore, such structures as high rise buildings which have long natural periods of vibration could be more susceptible to damage unless design considerations are incorporated to withstand long period ground motion.

*New wording*

## RESOURCES AFFECTED BY THE HAZARD

Comparison of Hazard Plate II with present land uses within the City indicates that nearly all of the structures are within Zone A (long period - greatest hazard) and that the rest, a small portion including the Colonial and El Rio areas, is within Zone B (long period - slight to moderate). These zones could experience the greatest amplification of long period ground vibration.

OK

On the basis of present information, however, it cannot be concluded that any of the structures or facilities are unsafe. It is probable however that examination of some of the older structures within the City would show that the degree of structural resistance to shaking may be less than current code requirements.

*New wording*

# FINDINGS

## PROBABILITY OF OCCURRENCE

Available geologic information indicates that the potential for the occurrence of strong ground shaking over much of the county, as a result of an earthquake along one of the major faults, is high when compared to the statewide probability. Exactly where, when and how strong the next earthquake will be, however, cannot be determined.

## SEVERITY OF THE HAZARD

In the event of a strong earthquake (6.0 - 7.5 magnitude) originating in the southern county area or a major earthquake (8.0 + magnitude) along the San Andreas Fault, damage to many existing structures could be severe and some loss of life could occur. Since the city is located entirely within zones A and B, it is within and subject to the strongest potential ground shaking area based on the depth of alluvium or unconsolidated material.

## RESOURCES AFFECTED

The areas designated within Zone A encompasses most of the City of Oxnard with a small portion in Zone B. This includes all public facilities, the county airport, harbor facilities and schools.

## NATURE OF INFORMATION

The conclusions provided by this study are based primarily upon historic experience as well as the considerable scientific research which has been reported; much of the information has been required since the occurrence of the 1971 San Fernando Earthquake. Much still has to be learned, however.

The potentially hazardous boundaries as well as ground responses indicated by Hazard Plate II are at best conjectural. The information is only illustrative of the wide range of ground shaking that can be anticipated over relatively short distances based upon the type and depth of earth materials and presence of groundwater. Other factors which must be evaluated in determination of potential ground response include density of earth material, location, magnitude and depth of the earthquake, type of bedrock and type of faulting causing the earthquake.




Determin-  
ation of these factors, and even then only within certain limits,  
requires detailed investigation of an individual site.

The current cooperative GEOLOGIC HAZARDS INVESTIGATION  
being conducted by the State Division of Mines and Geology  
for the Ventura County area will provide additional nec-  
essary information for future updating of this portion of  
the Seismic Safety Element. The zone boundaries shown on  
Hazards Plate II must be considered approximate and subject  
to change as more detailed information becomes available.

*San Andreas*

## RECOMMENDED ACTIONS - EARTHQUAKES & GROUND SHAKING

1. Encourage performance of regional studies by qualified Federal and State agencies such as the U. S. Geological Survey and the State Division of Mines and Geology or private research firms in order to more accurately determine areas of potential hazardous ground shaking.
2. Encourage and participate in cooperative studies with the above agencies.
3. If necessary, retain private consultants for more detailed study and determination of areas of potential hazardous ground shaking.
4. Utilize the latest uniform codes accepted by the State in the design of buildings and structures to resist ground shaking.
5. Require geologic-seismic and soils engineering investigation of ground shaking potential for all proposed structures whose failure could result in danger to life and property or great monetary loss.
6. Require structural evaluation of all existing structures used as places of public assembly to insure conformance to the latest Uniform Building Code requirements in regard to resistance to ground shaking. 
7. Design buildings for varying requirements for ground shaking resistance based on type of use and number of occupants. *northeast*
8. Explore incentive methods of inducing owners of existing buildings or facilities to take voluntary measures to investigate the resistance of structures to ground shaking and implement corrective measures where such structures are found to be deficient structurally.
9. Determine acceptable risk to life and property through forecasts and scenarios of ground shaking effect of various earthquake intensities.
10. Develop and implement an evaluation system to determine acceptable risk of ground shaking in terms of economic and social costs, environmental impact, risk to life and property, and government responsibility.



11. Evaluate disaster plan demands and potential effectiveness in terms of various earthquake intensities. Create County-wide systematic review by Emergency Preparedness Organizations and Police Departments on contingency disaster plans and programs.
12. Refine information and criteria at the micro-scale to mitigate ground shaking effects: land use compatibility, building location, evacuation routes, circulation, utility location, fire prevention, and emergency communications systems.
13. Require evaluation of the mounting and restraint of equipment and appliances in critical buildings such as hospitals, schools and power plants, and in buildings used as places of public assembly, with particular emphasis on equipment to be used in emergencies.



# SAFETY

FLOODING



FLOODING SECTION - IV-1 thru IV-10

The pages listed below have not been changed.

IV-2

IV-4

IV-5

# GENERAL DISCUSSION

## GENERAL DESCRIPTION

A flood may be defined as a "temporary rise in stream flow or stage that results in water overtopping its banks and inundating areas adjacent to the channel." (Kusler, p. 54). The area subject to inundation is generally referred to as the flood plain. The size and frequency of occurrence of a flood depends on a complex combination of conditions, including the amount, intensity, and distribution of rainfall, previous moisture conditions, and drainage patterns. (As long as the rise in water level is contained in the channel, no flooding exists.)

OK

The magnitude of a flood is measured in terms of its peak discharge, which is the maximum volume of water (in cubic feet per second) passing a point along a channel. However, floods are usually referred to in terms of their frequency of occurrence, which is related to discharge; for example, the 100-year flood for a particular channel is the size flood which has a probability of being equalled or exceeded once in 100 years. The magnitude of the flood selected by a governmental agency for planning purposes (usually 50-year or 100-year) is referred to as the selected or regulatory flood.

Flooding is a natural occurrence, with some long range beneficial aspects such as replenishment of sand to beaches and of nutrients to agricultural lands. It is a hazard only because people find flood plains a desirable place to live and use. Man's encroachment on flood plains can also increase the hazard: structures may obstruct the flood flow, thus increasing flood heights, and the covering of the ground with impervious surfaces (e.g. pavement) increases the rate and quantity of runoff.

COUNTY  
Paragraph  
Added

Some property damage occurs because of man's encroachment on the flood plain but much flood damage occurs because of a calculated risk. / ~~At some point it becomes uneconomical to design flood control facilities to protect property subject to flood damage.~~ As a result, it is inevitable that flood damage will occur and it should be acceptable. Man's encroachment on flood plains may increase the hazard; however, if pursued with knowledge and reasonable caution, is not a subject for alarm.

New wording

## GENERAL EFFECT OF THE HAZARD

The primary effect of flooding is the threat to life and property. People and animals may drown; structures and their contents may be washed away or destroyed; roads, bridges, and railroad tracks may be washed out; and crops may be destroyed. The amount of damage caused by a flood depends on the depth of inundation, the velocity and duration of the flood, the debris production of the watershed, and the erodibility of the bed and banks of the watercourse.

Much of the property damage from floods is caused by



the severe erosion which results from fast-moving flood waters. Serious damage can also be caused by the floating debris and sediment carried by flood waters. Floating debris (including parts of buildings, trees, etc.) can obstruct the flood flow, resulting in increased flood heights and overflow areas. Debris can also damage structures and bridges, and can damage or plug flood control channels. Mineral and organic debris and sediment deposited on the land as the flood waters recede create a huge cleanup problem and health hazard and can destroy crops and croplands.

Floods may also create health hazards due to the discharge of raw sewage from damaged septic tank leach fields, sewer lines, and sewage treatment plants and due to flammable, explosive, or toxic materials carried off by flood waters. In addition, vital public services may be disrupted.

A major secondary effect of flooding is the cost to local and national taxpayers. Evacuation, relief, and floodfighting services, cleanup operations, and the repair of damaged public facilities are all paid for by the public. Taxpayers must also bear a share of the cost of federal loans for reconstruction of private property and of damage claims under federally subsidized flood insurance. Another large expense arises from the construction and maintenance of flood control facilities to protect development from future floods.

The duration and extent of the hazard depend on the specific physical characteristics and conditions of the watershed and the intensity and duration of the storm. Generally, in Ventura County a flood builds up to a peak and then begins to recede, with the entire process lasting from an hour to a week, depending largely upon the size and slope of the watershed.

#### GENERAL INVENTORY OF THE HAZARD

Damaging floods at some locations in the county were reported as early as 1862; other floods were reported in 1884, 1889, 1911, 1914 and 1916. Floods for which data was recorded occurred in 1932, 1933, 1934, 1938, 1941, 1944, 1946, 1950, 1952, 1958, 1962, 1965, 1966, 1967, January 1969 and February 1969.

The largest and most damaging recorded natural floods in the Calleguas Creek, Santa Clara, and Ventura watersheds occurred in 1969. ok

In 1969 the 50 and 100-year peak discharges were exceeded in many channels. The combined effects of the 1969 floods were disastrous: thirteen people lost their lives and property damage was estimated at 60 million dollars. ok

A break in the Santa Clara levee threatened the City of Oxnard. Much agricultural land, primarily citrus groves, was seriously damaged. All over the county transportation facilities, including roads, bridges, and railroad tracks, were damaged. There was several million dollars worth of damage at the Ventura Marina. *The Fillmore, Oak View, and Ventura sewage treatment plants were severely damaged, dumping raw sewage into the Santa Clara and Ventura Rivers and polluting beaches.*

COUNTY  
SENTENCE  
Added

#### DEFINITION OF THE HAZARD ZONE

The boundaries of the hazard zone depend on the magnitude of peak discharge chosen for the selected flood. The Ventura County Flood Control District and most of the cities in the county use a 50-year flood as the selected flood, while the National Flood Insurance Regulations and most flood plain management literature use a 100-year flood. The Corps of Engineers has delineated 100-year (intermediate regional) and standard project floods (the largest flood that can reasonably be expected to occur).<sup>\*</sup> For this study the Corps of Engineers 100-year flood plain is used as the hazard zone on the streams for which it has been mapped. (See Hazard Plate III)

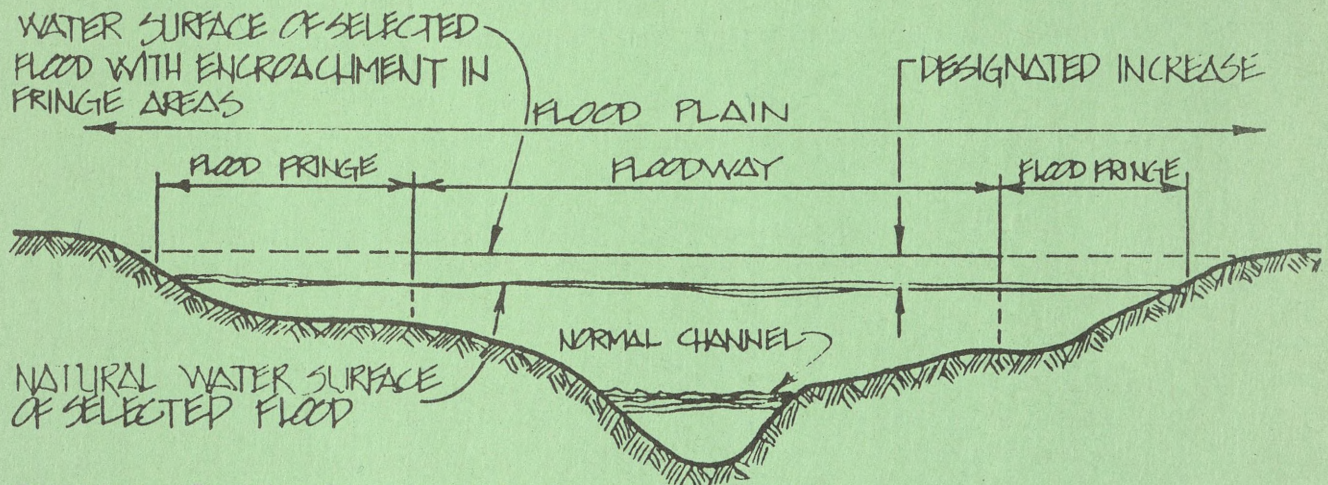
<sup>\*</sup> The Flood Control District and the Corps base their calculations on different assumptions of watershed development and therefore get different results for flood magnitudes and overflow areas. The District is presently conducting a study of the comparative magnitudes of the various floods to determine whether there is a significant difference between their 50-year flood and the Corps' 100-year flood.



All presently available information on the geometrics of flood plains in the county is shown on the Hazard Plate. The 100-year and standard project flood plains of the Santa Clara and Ventura Rivers, Calleguas Creek (including Arroyo Simi), and Santa Paula, Sespe, San Antonio, and Conejo Creeks have been mapped by the Corps of Engineers. The U. S. Soil Conservation Service has mapped the 50-year flood plains of Revolon Slough. Flood plain limits for the other tributary channels have not yet been mapped. Many of these tributaries have flood control improvements over at least part of their courses.

The flood plain may actually be divided into two hazard areas: (1) the floodway, which is the portion that carries the deep and fast-moving water (usually defined as the area needed to contain the flood, allowing for a designated increase in flood height); and (2) the flood fringe area, which is the remainder of the flood plain.

Illustration 4.1. Flood Plain



Source: County Department of Public Works

#### NATURE OF INFORMATION

Flood plain limits are calculated from the best topographical information and hydrologic and hydraulic data and assumptions available. These delineations reflect existing conditions and changes in topography or land uses could affect these limits. Although the flood plains of many of the watercourses in the county have not been mapped, the Flood Control District has the capability to calculate the overflow areas for specific locations.

Floodway limits, which are extremely important for flood plain planning, have not yet been delineated for any channels in the county. However, the Flood Control District has begun a 5-year program of mapping flood plains and will soon begin to compute floodway limits (referred to as "designated watercourses") for the rivers and major tributaries. The computation and designation of floodways for all channels under the District's jurisdiction will take many years.

## GENERAL MANAGEMENT RESPONSIBILITY

### INVESTIGATION

The Flood Control District has collected some data on flood discharges and topography and will soon begin delineating flood plains and floodways. At the request of the District, the Army Corps of Engineers has prepared Flood Plain Information Reports for eight major stream reaches in the county. These reports contain information on flood history and detailed maps and information on theoretical future flood profiles (heights) and corresponding overflow limits.

### REGULATION

The entities responsible for regulation in flood hazard areas are the local governments and the Ventura County Flood Control District. The Flood Control District, which is governed by the Board of Supervisors, has the authority to maintain and construct flood control facilities on the channels shown on Hazard Plate 3. Ordinance FC-18, adopted in 1972, requires that a permit from the Flood Control District be obtained for most activities in "designated watercourses". At present, "designated watercourses" refers only to the bed and banks of the channels but once the floodways are mapped and public hearings are held, a portion of the overflow area inundated by a selected flood will be controlled by the Ordinance.

Outside of the designated watercourses, the prime responsibility for regulating activities in flood hazard areas lies with local governments. By State law land use and building restrictions to protect life and property from floods may be included in zoning and subdivision ordinances and building and sanitation codes. State and federal legislation has sought to encourage local governments to establish regulations for flood plains.



The Colbey-Alquist Flood Plain Management Act requires regulation as a condition for state assistance on federally authorized flood control projects.

The regulations of the National Flood Insurance Program (administered by the Department of Housing and Urban Development) require that communities adopt land use restrictions for the 100 year flood plain, in order to qualify for federally subsidized flood insurance. The types of restrictions communities must adopt are listed in some detail in the regulations, and included is a requirement that residential structures be elevated above ~~the~~ the 100 year flood. Participation in the flood insurance is conditioned by a 1974 amendment making flood insurance (in identified "special flood hazard" areas) a prerequisite for receiving mortgages or construction loans from federally regulated lending institutions since practically all ~~for~~ federally regulated; participation in the program ~~lending~~ is mandatory. Ornard is now on the eligible list for Federal flood insurance at subsidized rates on an emergency basis. The City has submitted a list of land use and control measures and a Flood Hazard Boundary Map that is currently under review by the Federal Insurance Administrator. Once the Administrator completes this review and a rate making study now underway, Ornard will be converted to the permanent program.

City wording  
Deleted

institutions/  
are

#### WARNING

Flood warnings, issued by the U. S. Weather Bureau or the Flood Control District, are relayed to the public through the local news media and Sheriff's and Police departments.

#### ALLEVIATION

The flood hazard may be alleviated through a variety of measures, some corrective and some preventive. ok

Corrective measures include warning and relief programs, flood proofing of existing structures, and the construction of flood control works (channel improvements, levees, and dams). (Structural works are the ok traditional means of alleviating the hazard, but they are extremely costly and rarely able to keep up with development.)

Reinclude  
in Element

Preventive measures for alleviating the hazard include public acquisition of flood plain lands, public information program, development policies, and regulations. One of the most effective means of preventing flood damage appears to be the regulation of the types of activities permitted in flood hazard areas. This approach is generally referred to as flood plain management. Flood plain management addresses the problems encountered in the utilization of flood plains; given the possible future land uses, the total spectrum of possible solutions to problems is considered. Flood plain management however, cannot protect all existing development. Therefore, to provide for the maximum alleviation of the flood hazard, a combination of corrective and preventive measures is necessary.

COUNTY SENTENCE  
added



# LOCAL DISCUSSION

## LOCAL INVENTORY OF THE HAZARD

The Santa Clara River runs just north of Oxnard and the Revolon Slough is located to the east of the city. Most of Oxnard is protected from the Santa Clara River by a Corps of Engineers levee on its southbank. *Only the small City areas north of Gonzales Road and the area near Mandalay Generating Plant are in the hazard area.*

COUNTY SENTIN  
Added

The 50-year flood plain of Revolon Slough includes the incorporated areas roughly east of Rice Road. (See Hazard Plate III)

There is also a flood hazard along other major unimproved drainage channels. These drainage channels are included in the Flood Control District's *proposed* improvement program and are indicated on the hazard plate.

*Localized flooding in the developed areas is a problem due to inadequate drainage. These areas are being more thoroughly studied by the Army Corps of Engineers for the Federal Insurance Administration, but general areas have been identified for Oxnard. These are not related to natural flood situations but to urban drainage problems.*

GPSC  
Addition

## LOCAL RESOURCES AFFECTED BY THE HAZARD

Located in the Santa Clara 100-year flood plain are McGrath State Beach Park. Most of the area in the Revolon Slough flood plain is either in agriculture or undeveloped, though also included is a small industrial area, part of the freeway, and part of the Southern Pacific Railroad tracks. Many developed areas are subject to flooding from the major unimproved channels.

# FINDINGS

## PROBABILITY OF OCCURRENCE

Floods are natural occurrences whose frequency and magnitude depend on the rainfall and drainage patterns. It can be expected that the flood plain will probably be completely inundated on the average of once every 100 years.

## SEVERITY OF THE HAZARD

Much of Oxnard's potential flood hazard from the Santa Clara River has been alleviated through flood control works and planned channel improvements which would provide further protection to developed areas. This includes plans to construct a bridge on Victoria Avenue within the next year at which time improvements in the levee north of Gonzales Road will protect that area from the standard project flood on the Santa Clara River. Since the flood plain area north of Gonzales Road is adjacent to existing development, it could be subject to development pressures in the future and should be protected.

## RESOURCES AFFECTED

Located in the Santa Clara 100-year flood plain limits are undeveloped uses such as McGrath State Beach Park. The Revolon Slough area also includes a small industrial area.

## NATURE OF INFORMATION

Existing data is sufficient to calculate the overflow for specific areas. In addition, the Flood Control District has begun a 5-year study to map the flood plain limits (designated watercourses) of the rivers and major tributaries. In regard to the urban drainage problems, a master drainage plan study is needed to define local existing and future problem areas and recommend solutions.

*The pending revision of the National Flood Insurance Administration hazard map will update the Flood Hazard Zone.*

CITY  
Addition



## RECOMMENDED ACTIONS - FLOODING

*Further study*

1. Conduct a study to determine which areas of the City do not meet the requirements of the National Flood Insurance Program.
2. Designate all areas of the City that are subject to inundation from a 100-year flood as Flood Plain Zones.
3. Obtain the assistance of the Flood Control District to establish Flood Plain Zones in our growth areas.
4. Determine those improvements that are necessary to permit compliance with the National Flood Insurance Regulations.
5. Establish a City policy to comply with the National Flood Insurance Regulations to require protection for developed areas from a 100-year storm.
6. Establish a City policy of requiring new developments to:
  - a. Accept historical runoff from upstream.
  - b. Convey historical and newly created runoff safely downstream.
  - c. Contain a 10-year storm runoff within street area.
  - d. Protect all structures from a 100-year flood.
  - e. Eliminate localized street flooding and pooling during yearly storms.
7. Establish a program to eliminate localized street flooding and pooling during yearly storms, and so indicate problem areas on the City of Oxnard Hazard Plate III - Areas of Local Flooding.



# STABILITY

GISC  
Approved

LANDSLIDE/MUDSLIDE



LANDSLIDE/MUDSLIDE SECTION - V-1 thru V-13

The pages below have not been changed.

V-2

V-4

V-8

V-10

# GENERAL DISCUSSION

## GENERAL DESCRIPTION

All hills, mountains and other highlands are being worn down by various natural processes. The most spectacular of these is the landslide, along with the other related types of ground failure. These processes are referred to geologically as "mass wasting", defined as: "the en masse downslope movement of rock debris" (Physical Geology, p. 134) . There are numerous causes for mass wasting, including erosion, water, broken or weak bedrock, earthquakes, and engineering defects.

Stream erosion can undercut slopes thereby removing support and causing failure of slopes by landsliding.

Saturation of soil or bedrock on hillsides can reduce the strength of these materials under certain conditions to a point where downhill sliding can occur in response to gravity. Rainfall can also saturate and erode vast quantities of loose soil, especially after large fires denude slopes, washing it down slope as earth or mud flows.

Earthquakes can directly shake loose material to fall or slide downhill; it can also cause liquefaction of sub-surface materials, which also can lead to slides (see Liquefaction Hazard).

COUNTY SENTENCE  
Added

Finally, man-made cuts or excavations can undercut unstable slopes, thus causing landslides. In practice, most landslides are caused by a combination of two or more of these factors, and come in a number of forms.

First is the rockfall, which is simply the movement of all or part of a mass downslope without seriously disturbing the surface it moves over. This is most common on coastal or other types of bluffs in this area (Illustration 5.1).

More complicated are slides, which are a type of ground failure that affects both the soil and the subsoil surface. In a relatively homogeneous material the normal type of slide is a slump (Illustration 5.2). The plane of failure is usually curved and the two (the downhill end) flows out from under the surface as it rotates backwards as a unit. In a stratified, layered rock, the slide tends to be a block glide in which large masses of material move down an inclined surface maintaining their uniformity (Illustration 5.3). Both these types of slides can continue moving downslope after their



Illustration 5.1  
Example of a Rockfall

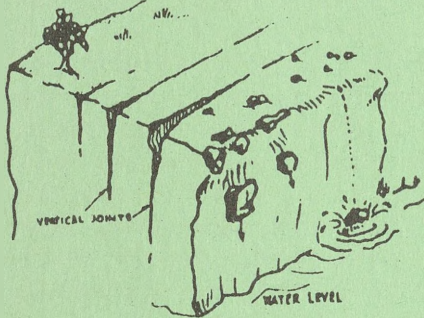


Illustration 5.2  
Slump in relatively uniform material.

Note curved slide surface.

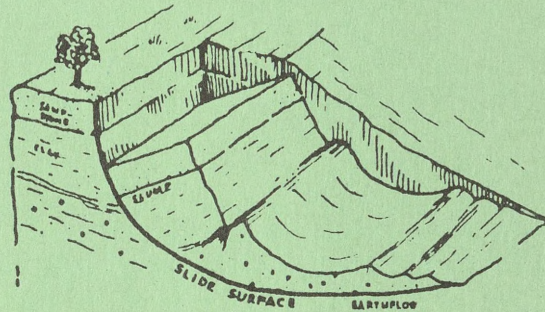


Illustration 5.3  
Block-Glide in layered rocks inclined down-slope.

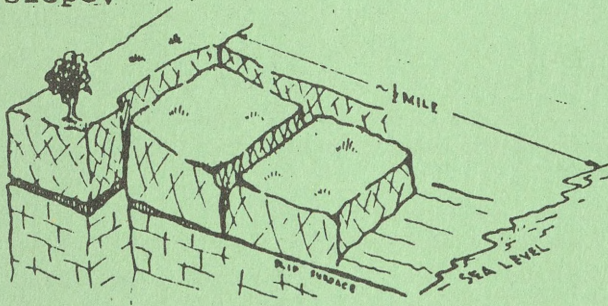
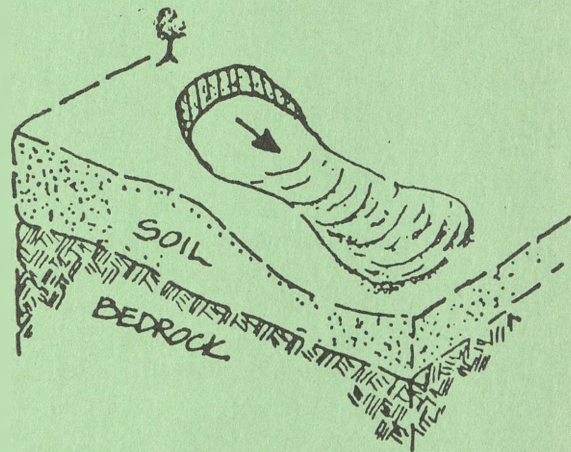


Illustration 5.4  
D. Earthflow



SOURCE: Coastal Landslides in Southern California, and Ventura County Public Works.

initial failure and be broken up by the down slope spreading movement. These can continue far beyond the area in which they began and, if the movement is rapid, can move up onto the opposite side of a narrow valley.

Fourth and last, a flow is a landslide in basically unconsolidated material (Illustration 5.4). Most flows consist of saturated or nearly saturated material that undergoes viscous flow, although some types of flows are dry. Their movement is characterized by plasticity, which permits them to spread outward over wide areas and to move greater distance than other types of landslides. They often involve greater masses of material and continue downhill far beyond the base of the slope from which they originated. Many of history's most destructive landslides have been flows. Mudflows are a type of flow that are particularly prevalent after brush fires.

The speed with which landslides occur can vary considerably from rapid downfalls to virtually imperceptable movements downslope under the pull of gravity. Soil creep is a very slow type of earthflow movement. It occurs mainly in soils containing clay.

In general, most landslides within the county are shallow, ranging up to perhaps 100 feet in depth and limited in extent, generally less than 100 acres. Most are not presently in motion (active) but that moved downslope to positions of stability. Generally, stability is achieved within several years after the initial failure under natural conditions. However, the margin of stability of most landslides is small and inadequate to safely place structures on their surfaces.

Many of the existing landslides can be reactivated and downslope movement renewed after exceptionally heavy rainfall periods or as a result of earthquake shaking. Most landslides are over 100 years old and can exist for thousands of years until all of the landslide material is removed from the hillside by erosion.

Generally, the renewed movement of old landslides is slow, perhaps only a few inches per day. However, the formation of a new landslide can be rapid with initial, often quite sudden movements of hundreds of feet within a few hours.



## GENERAL EFFECTS OF THE HAZARD

### PRIMARY

Slope instability that results in landslides has caused substantial damage to the works of man in the Southern California area since the 1950's, when significant amounts of urban development first spread to the hillside areas within the County of Los Angeles. As a result of the heavy rains of 1952 there was approximately 7.5 million dollars of damage in the City of Los Angeles alone, due to erosion, deposition and landsliding. Strong hillside grading and building codes were established within Los Angeles County to prevent such future losses.

Geologic conditions similar to those within Los Angeles County also exist within the hillside areas of Ventura County. Future landsliding within Ventura County could also affect developed areas unless landslide hazard areas are recognized and appropriate land uses are designated.

In general, landsliding and the differential subsidence of the surface of landslides as well as the lateral forces exerted by most landslides can destroy most engineering structures. Most structures cannot be economically designed to withstand the forces of landsliding. Mass grading techniques have proven to be the most effective means of stabilizing landslides and unstable hillsides. This grading technique basically involves leveling of hilltops or ridges and filling in of the valleys in between, resulting in a general reduction of the height and inclination of slopes within the area.

Primary effects of landsliding can include:

1. Abrupt depression and lateral displacement of hillside surfaces over distances of up to several hundreds of feet.
2. Disruption of surface drainage.
3. Blockage of channels and roadways.
4. Displacement and breakage of utility lines (pipe and power).
5. Displacement and destruction of any improvements such as roadways, buildings, oil and water wells, etc.

## SECONDARY

Secondary effects of landslides can include temporary impact on society such as displaced persons and families, and possible loss of life, damage of nearby property, etc. In addition, damage suits can be initiated against original developers of the property affected by landsliding, as well as the present owners and the government agency which may have reviewed the development, approved the plans and issued the grading and/or building permits.

Other effects could include:

1. Blockage of transportation routes.
2. Disruption of utility services.
3. Blockage of drainage.
4. Loss of usable land area, etc.

## GENERAL INVENTORY OF THE HAZARD

### LOCATION AND HISTORY

#### Southern Ventura County

Landslides and slope instability are widespread throughout the hillside areas and this includes the South Mountain portion of our growth area. In general, most existing landslides are within the Existing Landslide Areas shown on Hazard Plate IV; most are not of recent origin, having occurred over 100 years ago, and most are not actively moving.



#### DEFINITION OF THE HAZARD ZONE

Hazards Plate IV is a composite map showing landslide hazards within the southern county area. The Existing Landslide Areas designation includes area of major landslide features. The High Landslide/Mudslide Hazard zones indicate areas of marginal hillside stability which could be subject to major landslide occurrence. In general, the aforementioned categories are confined to areas containing ground surface slopes of 15% or more. Intermediate Hazard Zones are those

that could be subject to less severe landslides, but which have a definite risk slope, generally 10-15%. The Little or No Hazard Zone indicates areas which slope at less than 10% and not generally affected by landsliding. Active Beach Erosion is indicated for those areas which have, historically, been subject to severe wave erosion, which is considered a form of slope instability. Beach erosion per se, however, will be treated as a separate study within this Seismic/Safety Element.

COUNTY ADDITION

(Source - California Division of Mines and Geology. Analysis of Mudslide Risk in Southern Ventura County. Prepared for the United States Department of Housing and Urban Development, 1971.)

REFERENCE  
Added

The Hazard Zone boundaries were primarily determined based on information provided by two recent studies of landslide conditions in southern Ventura County (conducted by the State Division of Mines and Geology for the Federal Department of Housing and Urban Development (HUD) and for the County of Ventura under a cooperative agreement). The product of the latter study was the report entitled "Geology and Mineral Resources Study of Southern Ventura County" (1973), Preliminary Report 14.

#### NATURE OF INFORMATION

The potential landslide areas within the county were determined mainly by aerial photographic interpretation. The information is considered good, and fairly accurate. Knowledge of many locales, especially within or adjacent to areas of urban development was gained through experience in the particular area and field checking of some areas.

The current cooperative GEOLOGIC HAZARDS INVESTIGATION being conducted by the State Division of Mines and Geology for the Ventura County area will provide additional necessary information on landslide hazards in regard to: (1) those portions of the north half of the county in which development could possibly take place and (2) areas of the southern half of the county which could be susceptible to low-angle or lateral spreading during earthquake shaking. Except for the information necessary under Item 2 above, the present information is the best form available and is considered adequate for general planning purposes. It will, however, need to be supplemented with more detailed mapping or studies for any specific proposed development.



## GENERAL MANAGEMENT RESPONSIBILITY

### INVESTIGATION

The State Division of Mines and Geology is currently investigating geologic conditions as part of the cooperative Geologic Hazards Investigation, in those portions of the county in which development could possibly take place. The study will be completed in 1975 and will consider landslide hazards in portions of the north half, as well as the potential hazard of landsliding resulting from liquefaction of water saturated sediments during earthquake shaking in portions of the south half of the county.

Additional investigation is being conducted on a continuing basis by:

1. Private Geologic Consultants who provide original information during investigations for private developments.
2. Ventura County Department of Public Works which:
  - a) Provides review and evaluation of Geologic and Soils and Foundation Engineering reports prepared for private projects within the unincorporated area and for the Cities of Camarillo, Simi Valley and Santa Paula.
  - b) Performs Geologic and Soils Engineering investigations for County projects such as roads and flood control facilities.
  - c) Coordinates, evaluates, and compiles geologic information derived from public and private investigations within the unincorporated area and for the Cities of Camarillo, Simi Valley and Santa Paula.

### WARNING

The potential for landsliding can be detected with relative certainty before any structures or facilities are placed in jeopardy. However, the problem is more difficult to handle in those hillside areas where development has already occurred in possibly dangerous

locations. In cases where structures have been constructed, regional studies can, in many places, delineate potential problem areas before damaging movement occurs. These studies can be conducted by local agencies and/or by cooperation between the property owners affected.

Presently, little is known of the potential for low-angle landsliding resulting from liquefaction of sediments during earthquake shaking or of areas in which this hazard exists. As previously indicated, this hazard is being evaluated under the Cooperative Geologic Hazards Investigation being conducted by the State Division of Mines and Geology.

#### ALLEVIATION

Regulation of public and private land development within both incorporated and unincorporated areas is administered by:

City and County Departments of  
Planning, Public Works, and Building  
and Safety

City Councils and the Board of  
Supervisors

Enforcement of the Uniform Building Code and City and County regulations and policies can be effected by the above agencies by requiring the review of land use proposals and the evaluation of engineering studies for private development and public projects. Such reviews and evaluations can be performed by qualified engineering geologic and soils engineering staff or by retention of consultants.

Since alleviation of the hazard can be affected, in part, through land use controls, the agencies, departments and legislative bodies making land use decisions have the primary responsibility for alleviating the hazard. City and County Planning Departments can utilize available hazard information to avoid improper land use. Decisions concerning adoption of these recommendations rests ultimately with the Planning Commissions, City Councils and the Board of Supervisors. Other bodies making land use decisions include Port Districts and redevelopment agencies.

Present County Subdivision, Grading and Building Ordinances which are considered as strong or stronger than any in the Southern California, are adequate to insure that areas of landsliding or hillside areas



are adequately investigated and that any development incorporates appropriate design provisions to prevent landsliding. The Departments of Public Works and Building and Safety of both the County and Cities have the responsibility of adequately enforcing these or equivalent ordinances.

## LOCAL DISCUSSION

### LOCAL INVENTORY OF THE HAZARD

The City of Oxnard has no hillside areas within its boundary and most of the area is designated under the Little or No Hazard Area category on Hazards Plate IV ~~with-the-exception-of-South-Mountain, which-lies-in our-growth-area.~~ However, the immediate area of the beaches and marina is classified as a High Hazard Area, due mainly to the potential of wave erosion and partly due to the potential of low-angle landsliding or bank failures caused by soil liquefaction during earthquake shaking.

COUNTY  
SENTENCE

### LOCAL RESOURCES AFFECTED BY THE HAZARD

~~There-are-no-landslide-or-mudslide-hazards-in-the-City of-Oxnard, therefore, no-local-resources-are-affected.~~

Comparison of Hazard Plate IV with present land use areas within the City indicates that primarily residential and some commercial structures and utilities along the beach and harbor areas lie within the hazard zone, including the Southern California Edison Mandalay Generating Plant. The hazard zone along the beach is based (primarily on the potential of slumping caused by undercutting of the beach by wave action. The occurrence of lateral movement or low-angle landsliding is also potentially possible within this zone during earthquake shaking.) The hazard in harbor areas is mainly due to sliding of embankments and adjacent areas as a result of possible liquefaction. However, wave erosion and channel damage has also occurred.

COUNTY  
SENTENCE

Geologist  
wording

COUNTY  
SENTENCE

These areas were included in the landslide/mudslide hazard zone because they are so identified in the Analysis of Mudslide Risk in Southern Ventura County, California, 1971 and Landslide Risk Prediction, 1971 prepared by the California Division of Mines and Geology for the Department of Housing and Urban Development.



# FINDINGS

## PROBABILITY OF OCCURRENCE

Harbor areas, sea level channels, and perhaps some beach areas may be susceptible to sleughing-or-bank-failure; however, ~~this is not considered either landslides or mudslides. Any landslide or mudslide that might occur in the South Mountain area would be the result of inadequate engineering of the development.~~ low-angle landsliding or bank failure caused by soil liquefaction during earthquake shaking.

County  
Geologist  
wording

The beach areas are subject to erosion as a result of high wave action during the more severe storms, especially when such storms occur during periods of high tides. Resultant wave erosion, undercutting and slumping of beach can extend into the backshore and damage improved areas along the coast line.

## SEVERITY OF THE HAZARD

Oxnard does not have any hillside areas within its boundary and is designated in the little or no hazard zone, except for the beach areas which are in the high hazard zone. Additional information concerning the form and extent of low-angle landsliding, which might occur along beaches and channel and harbor banks during earthquake shaking, would be beneficial in evaluating the level of hazard.

## RESOURCES AFFECTED

Primarily, residential and some commercial structures and utilities along the beach and harbor are within the high hazard zone.

## NATURE OF THE INFORMATION

The present information is the best available and is considered adequate for general planning purposes. It will, however, need to be supplemented with more detailed mapping or studies for any specified proposed development.

## RECOMMENDED ACTIONS - LANDSLIDE/MUDSLIDE

1. Require that any proposed development within the Existing Landslide Areas or areas of High or Intermediate Hazard indicated on Hazards Plate IV be evaluated by qualified personnel retained by the local agency to determine if engineering, geologic, or soils engineering feasibility studies are necessary prior to approval of proposed land uses and require such a report where necessary.
2. Require each proposal for land development to be reviewed by qualified personnel registered by the State, such as professional engineers or geologists, and include a recommendation to the City as to the safety of the proposed development.
3. Achieve adequate enforcement through establishing qualified staff or retaining private consultants.







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# BEACH EROSION



BEACH EROSION - VI-1 thru VI-26

The pages listed below have not been changed.

VI-2

VI-4

VI-6

VI-7

VI-8

VI-9

VI-10

VI-11

VI-12

VI-13

VI-14

VI-15

VI-16

VI-17

VI-18

VI-19

VI-22

## GENERAL DESCRIPTION

The erosion of coastal beaches is a very complex and multi-faceted problem. It arises from many factors comprising the coastal ecosystem. Simplistic and short-sighted solutions are inadequate to deal with the beach erosion problem because it is such an intricate and dynamic phenomenon. Only long-range, comprehensive, technically informed approaches can effectuate a complete and long lasting solution.

## PHYSICAL PROPERTIES

The beach is an ever changing entity. It is in a perpetual state of dynamic disequilibrium, adjusting to changes in waves, currents, tides and sediment deposition. These agents create a flow of sand along the coastline known as the littoral drift. Beaches remain stable only when the amount of sand deposited is equal to the amount of sand taken away, both of which are determined primarily by the littoral drift. Since these two factors only rarely negate each other exactly, beaches are usually either receding or advancing at any one point in time.

Sandy beaches are formed largely by the weathering of inland rocks and riverine transport to the sea. The sand which maintains Ventura County beaches travels with the littoral drift from north to south, originating almost entirely from the Santa Clara River when in flood (70%) the Ventura River (10%) and from beaches up coast of the Ventura River (20%), totaling a movement on the average of 1.2 million cubic yards of sand per year between the Santa Clara River and Port Hueneme (Southern California Coastal Water Research Project, March, 1973). This sand is part of the Santa Barbara littoral cell. A littoral cell is a closed system of shoreline in which sand undergoes a complete transport cycle. It begins typically with a stretch of rocky coast where the sand supply is extremely limited. Downcoast, in the direction of the littoral drift, sand supplies become more abundant and the beaches become straighter and wider. The cell is terminated by submarine canyons or other "sand sinks" which capture sand and halt its movement, thus causing another littoral cell to begin with rocky coasts devoid of beaches (California Coastal Zone Conservation Commission, April, 1974). In the Santa Barbara cell most of the sand movement is interrupted by the Mugu and Hueneme submarine canyons and the remainder migrates southerly on the narrow coastal bench. The man-made interferences to this migration, such as the harbor entrances and breakwaters, require the pumping of sand around the obstructions.

New Wording

ok



The force which moves sand along the shoreline, creating the phenomenon known as the littoral drift, is provided by waves breaking at an angle along the beaches. Since a component of the wave energy imparted to the beach is along the shoreline, and consistently in the same direction, the net effect of many such waves is to push sand steadily alongshore. In Ventura County, waves moving in the direction of prevailing westerly wind generally do meet the beaches head on, because of the shoreline's orientation from northwest to southeast. The resultant effect is a net movement of sand over time from north to south along the beaches.

In addition to the littoral drift, there is an onshore-offshore movement of sand. Waves which are small or spaced far apart tend to move sand from the ocean bottom towards the beach, building it out. Large, closely spaced waves tend to cut back the beach and move the eroded sand seaward, forming sand bars in shallow water. In the absence of littoral drift, beach motion is merely an exchange of sand moving back and forth between beach and bar in response to changing weather patterns. (Bascom, 1964).

## ORIGINS

Natural Processes - As mentioned above, large, closely spaced waves tend to move sand from onshore to offshore. Also, large waves move sand at a faster rate alongshore than small waves (Bascom, 1964). Therefore, during periods of increased wave activity, the waves pounding the beaches can cause the coastline to dramatically recede, since more sand is taken away than is deposited. Major storms have caused erosion up to 100 feet on many U.S. beaches (Perm. Int. Asso. of Nav. Cong., 1973). Such recession is even greater when storms are combined with periods of high tides. This effect greatly elevates the ocean level since storms themselves cause the tide to elevate (a phenomenon called "storm surge").

Sandy beaches, formed largely by the weathering of inland rocks and riverine transport to the sea, often serve as a natural buffer between the sea and the easily erodible upland. A highly eroded beach loses some of its protective capability. A wide flat beach just above the waterline permits many of the oncoming waves to dissipate without damage, when the same waves would produce intensive damage in a region fronted by a narrow, eroding beach. A continuous dune line can likewise limit the area of wave damage to the ocean front by providing another line of defense against damaging waves; but the beaches and dunes are both subject to erosion by prolonged wave attack and areas that appeared safe at the beginning of a storm may be in danger if the storm surge persists through two or more high tides (U.S. Water Res. Council, August, 1971).

Southern California's coastline experiences relatively high levels of both wave activity and coastal sedimentation. Therefore, large changes in either factor relative to the other can result in rapid changes in coastal profile, since beach stability is dependent primarily upon a balance between these two factors (So. Calif. Assoc. of Govts., February, 1972). In fact, large changes in both do occur due to Southern California's highly variable weather. The sediment which is produced from storm related floods may take months, or even years, to find its way to the beaches and undo the immediate damage of the storm activity. Despite rapid changes, continuance of the beach over a long period of time is assured with an adequate supply of replenishing sand.

Coastal erosion in Southern California has seasonal trends and other natural cycles in addition to the dramatic fluctuations which occur from heavy storms. The beaches can change from month to month in response to tidal fluctuations, and generally advance in the summer months, which have moderate wave activity, and recede during the rest of the year in response to increased wave activity (So. Calif. Assoc. of Govts., March, 1973). Some beaches have, in addition, even longer cycles of beach erosion. California's weather runs wet and dry in cycles of about 25 years, corresponding roughly to the double sunspot cycle that affects all of earth's weather. In a dry cycle, relatively little sediment gets washed into the sea (Soucie, June, 1973). Therefore, in the interim dry periods between large storms, a net erosion trend should be anticipated. This erosion trend would be especially pronounced after a number of dry years.

Illustration 6.1 depicts seasonal rainfall fluctuations at Santa Paula from 1769 to 1965, dividing the trends into wet and dry periods. Since there were six cycles during this period, the cycles run roughly 32 years, somewhat longer than the stated 25 year cycle. Nevertheless, it substantiates the existence of a long term cyclical pattern of rainfall to which a pattern of erosion should generally correspond. The relationship between rainfall and coastal deposition of sediment was elucidated by an Army Corps study in Santa Barbara Harbor, which showed that a graph of rainfall plotted by 2-year totals had a striking similarity to a graph of accretion of 2-year intervals when the time factors were adjusted to show accretion lagging 3-1/2 years behind rainfall (U.S. Congress, December, 1948).

It is possible that superimposed on natural cycles of erosion, where they occur, are very long-term trends of net shoreline change stemming also from natural processes. General states of shoreline progradation (built out) or



# Illustration 6.1

Estimated Seasonal Rainfall at Santa Paula 1769-70 to 1871-72  
 Measured Seasonal Rainfall at Santa Paula 1872-73 to 1964-65  
196 Year Average 16.55"

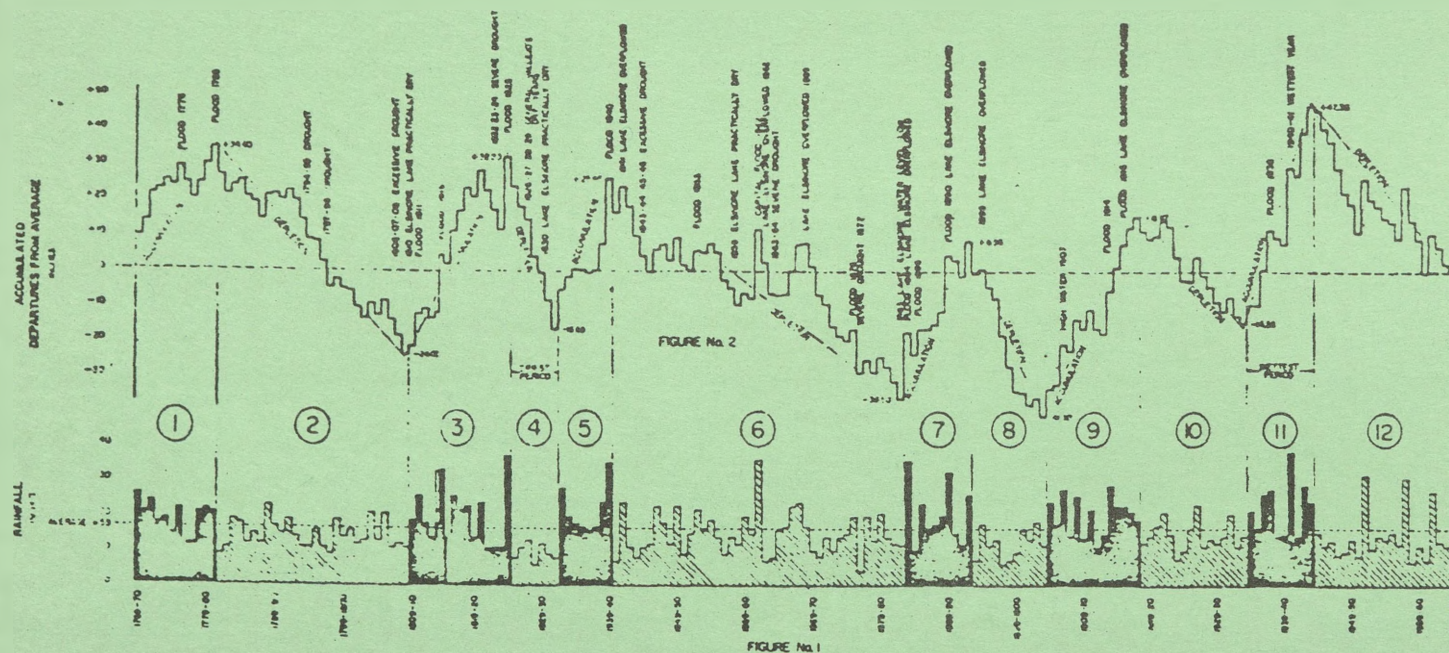


FIGURE No. 2

FIGURE No. 1

retrogradation (erosion) could be caused by such agents as geologic uplift or subsidence, climatic shifts, and a fluctuating sea level (some authorities believe the sea level has been rising 1 to 2 feet every century) (Perm. Int. Assoc. of Nav. Cong., 1973). Long-term trends which are more localized can be caused by river migration, near-shore wave energy alteration, and the presence of headlands.

The wave energy which actually reaches the shoreline at various points is influenced by nearshore wave refraction and ocean bottom configuration. These factors have the ability to influence the erosive capability of waves reaching the beach, and hence create a alternating erosion and accretion zones (Munk, January, 1947). Headlands which jut out into the water also act as groins. Hence, the bare rock of headlands on their down current sides often erodes away continually because the flow of sediment is captured by the headlands on their updrift sides.

Man-Induced Processes - Like nature, man has the ability to alter the configuration of the shoreline by inducing long-term or short-term erosion. His method is to interfere with natural processes, and his motivation is usually to prevent or impede natural fluctuations in the shoreline. However, sometimes his works are meant to correct problems of his own doing. These problems may stem from short term solutions to other erosion problems, or from projects ostensibly unrelated to the beach.

The construction of groins, jetties, seawalls, and breakwaters are the primary structural measures used to impede beach erosion. Each is at best a partial, short-term solution to erosion problems. Groins, for example, can trap littoral sand and build beaches out over a certain area, but by doing so they reduce for a time the amount of sand that flows to downcurrent beaches and, therefore, may relocate the original problem by causing erosion in other areas. Breakwaters and jetties (which are typically employed to protect harbors from wave activity) have similar down-current effects on the littoral drift of sand, although the mechanics are different. Since jetties are longer than groins, they interfere with sand flow to a greater degree, and sand bypassing is usually required to replenish down-current beaches. Seawalls can provide a "line of defense" for homes against the onslaught of waves, but tend to reflect the energy of the waves backward, which gouges out sand seaward of the wall during high swells. While property is protected, the beach between the property and the sea is more quickly reduced and public recreational area is diminished (U.S. Army, August, 1971).



Any structure protruding into the ocean can act as a groin. Landfills built to support highways swinging out into the ocean can have downcurrent groin-like effects.

Localized erosion problems can also ensue from the removal and/or alteration of sand dunes by making the beach more susceptible to erosion. Dunes protect the land behind the beach from erosion and flooding and serve to hold and extend the beach itself (Oxnard Planning Dept., September, 1972). Merely the pedestrian use of dunes can weaken surface vegetation and destabilize them to a point where they become less able to contain storm waves.

For Southern California in general, it has been stated that the coastline is presently in a state of retrogradation, as evidenced by its straight alluvial coasts and the absence of beaches along rocky coasts, indicating a general dominance of wave activity over stream deposition of sediments (So. Calif. Assoc. of Govts., February, 1972). This may be supported by the fact that 87% of the coastline of Southern California is erosional, as opposed to depositional (So. Calif. Water Research Project, March, 1973). It has also been stated that "There is evidence that the artificial drainage systems developed in Southern California coastal watershed have created a general condition of retrogradation. This may be one of the greatest impacts that man has made upon the natural environment to date." (So. Calif. Assoc. of Govts., February, 1972). The same source states further that, "The fact that the sands will eventually be depleted from our shores in significant amounts is especially disturbing because it might occur catastrophically rather than gradually. On an annual basis stream energy distributions are erratic while wave energy distributions are relatively constant. We know, for example, that most of the 7 million cubic yards of sand transported to the shore by the Santa Clara River during 1933-1938 was delivered in a flood during a 4-day period of February - March, 1938. This volume represents about a 7 - 10 year supply for the waves along the Ventura-Oxnard coast where water-impounding dams and flood control now greatly restricts the input of sediments into the ocean."

On the West Coast, where rivers and streams are by far the major source of sea sediment, flood control measures to protect development in flood plains and water supply dams are estimated to trap 50% of the sediment that once replenished the beaches (Soucie, June, 1973). Over 50% of Southern California's watershed is behind dams (36.5% for Ventura County). The National Academy of Sciences - Committee on Oceanography recently noted that runoff control in Southern California has severely cut the supply of sand, and without some intervention, the beaches may seriously deteriorate within the next two decades (Orange County Planning Dept., November, 1971).

It should be kept in mind that sand supplies in Ventura County have not been cut off as much as it has in Southern California as a whole, and may have unique circumstances involved in terms of topography, etc. This makes it all the more urgent to examine what might be the potential outcome of the trends which have been set in motion .

While the immediate results of flood control improvements include both increased safety for those living along the inland flood plains as well as the creation of more developable land, the flood control facilities often channel to the ocean water containing far fewer sandy particles than are necessary to even hold the line on threatened beaches (Orange County Planning Dept., November, 1971). Channeling of stream beds and dam construction for soil erosion prevention or flood control have reduced beach sand supply and changed prograding river deltas into tidal inlets, consequently including beach erosion (So. Calif. Assoc. of Govts., February, 1972). When river deltas and adjacent feeder beach areas are reducing by withholding sand supplies, in the face of persistent longshore currents, the result is a gradual recession along all of the shoreline that is dependent on the tributary drainage area as a source of replenishment (U.S. Army, May, 1972).

Such effects in adjacent counties have been documented via analysis of Southern California watersheds. Little beach building material is derived from the Malibu Creek watershed except during large storm runoff because of five reservoirs on Malibu Creek watershed built between 1881 and 1925. The accumulation of debris by these reservoir developments has reduced the passage of potential littoral materials to the coastline (U.S. Army, August, 1972). The Santa Maria River in Santa Barbara County has more than 75% of its sediment cut off by the Twitchell Dam (Calif. Dept. Water Res., July, 1969).

For Ventura County, in 1961 the Army Corps of Engineers asserted that prior to 1948 there were no restricting structures on any of the streams making up the Santa Clara and Ventura River basins. However, since 1948 the total drainage areas of the streams have been reduced by about 1/3 by the construction of the Matilija, Casitas and Santa Felicia Reservoirs (U.S. Army, April, 1961). In 1962, the Army Corps further asserted that construction of these reservoirs and the relatively dry years after 1948 were estimated to have decreased sand supplies by at least 1/2. This reduction in material supply, part of which is permanent, had caused substantial recession of the shoreline (U.S. Congress, May, 1962). The erosion between the Ventura and Santa Clara Rivers was expected to continue, in view of the prevailing dry years and the resultant lack of flood



runoff from the streams which had previously supplied littoral material to the area. It was estimated that due to the construction of reservoirs on Matilija and Coyote Creeks since 1948, sediment contribution to the ocean from the Ventura River has been reduced by 50% (U.S. Army, April, 1961). Another study of the Ventura and Santa Clara Rivers showed that prior to 1948 these rivers contributed approximately 1,702,000 cubic yards of sediment annually to the littoral zone. By 1963, controls and a series of dry years had reduced the quantity of sediments to the coast to an average of about 716,000 cubic yards per year. Sediment contributions from these streams was expected to be further decreased in the future (Watts, 1963).

Still another study calculated that dams in the Santa Clara and Ventura Rivers reduced in those rivers the annual average production of sediment, considering only those grain sizes suitable for beach nourishment, from 1,230,000 to 700,000 cubic yards. The calculations incorporated 50 year averages of rainfall, so that the effects of the dams were isolated from that of fluctuating rainfall in the short term (Calif. Dept. of Water Res., July, 1969).

It should be noted that the 1969 floods of January and February, because of the unusually heavy rains of that period, deposited about 13 million cubic yards of sediment at the mouth of the Santa Clara River. This could have a significant effect on some of the earlier estimates of annual sand supply, if taken into account.

Dams for water retention have the ability to contribute to beach erosion in several ways. Because they trap practically all of the sediment in the stream, they reduce the watershed area capable of supplying sand to the beach (See Illustration 6.2). The watershed area which they block off is usually in the upper reaches of the tributaries, where stream velocity and rainfall is greatest and most of the sediment is generated. For example, it has been observed that the Ventura River currently carries only a small fraction of the former volume of sediment because of the construction of the Matiliga Dam, and the Matiliga Dam controls only 24.3 percent of the drainage basin (Norris, 1964). They also lower peak flood velocities by controlling the amount of water released, which reduces the ability of streams to carry sediments, especially the larger particles. The large grained sediments are important to the beach because they are not easily erodable and help to hold the beach together (Drelicharz, 1974). They also "bounce" along stream bottoms during floods and create additional sediments (Norris, 1964).

The "clean" water which flows downstream from dams has the capacity to pick up sand up to its carrying capacity if sand is available and the slope is steep. However, by doing so the water erodes downward, which can reduce the gradient of some portions of the stream and thereby decrease stream velocity, which in turn diminishes the ability of the water to carry sediments over the long run (Drelicharz, July, 1974). Also, at some point in time, stream flow will winnow from the channel bedload below controlled portions of the watershed the smaller sand grains which are easily transportable, after which the amount of sand transported will be sharply decreased, and shores will deplete rapidly and waves will attack the shores directly (So. Calif. Assoc. of Govts., February, 1972). This point in time may be far off into the future in Ventura County watersheds because of the sharp gradient and the abundance of sand in the stream channels below dams. However, no one can predict when it might occur, without a program of continual monitoring and measuring of sand supply movements.

The existence of dams in Ventura and Santa Clara River waters was singled out by the Army Corps in 1961 as an important determinant of current and continuing beach erosion in Ventura County and was used as one of the justifications for the groins at Pierpont. The recent construction of the Castaic Dam has cut off more of the sediment-generating watershed in the Santa Clara. The construction of more water-impounding dams could further the impact. For instance, the Department of Water Resources had predicted that sediment production in the Santa Clara Watershed would be further decreased from an average of 600,000 cubic yards annually to 250,000 cubic yards annually with the future construction of dams on Castaic Creek (completed) and on Topa Topa and Cold Springs (since abandoned) (Calif. Dept. of Water Res., July, 1964).

The Army Corps of Engineers, in their Environmental Impact Statement for the Ventura Marina, stated that "Future reductions in the rate of supply of sand from river sources to the beaches downcoast from Ventura Marina, occasioned by the construction of upstream reservoirs, may cause long-term erosion in this area unless measures (such as groin construction) are taken to protect the beaches from erosion" (U.S. Army, Sept., 1970).

Flood control projects such as debris basins also catch sand and prevent its movement down to the beaches. For example, after the 1969 floods, 12 of the 26 debris basins in the county were cleared or about 400,000 cubic yards of sediment (Ventura County Department of Public Works, June, 1972). (The 1969 floods, estimated as a 1%



frequency of occurrence for the Santa Clara River and 2% for the Ventura River, deposited more than 13 million cubic yards of sediment at the mouth of the Santa Clara, an enormous amount despite the retention by dams and flood control projects, because of the unusually heavy rains.) Debris basins tend to settle out the larger particles of sand which are more important to the beach. Unless the basins are very large they have relatively little effect on peak flood flows. The facilities are designed to trap debris and sediment and pass flood flow over the spillway as cleaner water which picks up material from the downstream channel. The possible long term effect of releasing this "clean" water has already been mentioned.

One should be reminded that there are large public benefits associated with dam and flood control operations, such as the protection of life and property, water conservation, recreation and the opening of land to development and agriculture. It is probable that some of these benefits are of greater public importance than the preservation of our beaches. However, property loss can also ensue from beach erosion, and the beaches themselves constitute a resource of great economic and aesthetic value. Difficult either/or decisions are not always necessary, because remedial measures often can be incorporated into stream development structures. At least a modification of present thinking by including regular consideration of beach sand supply in all new stream development programs could be taken.

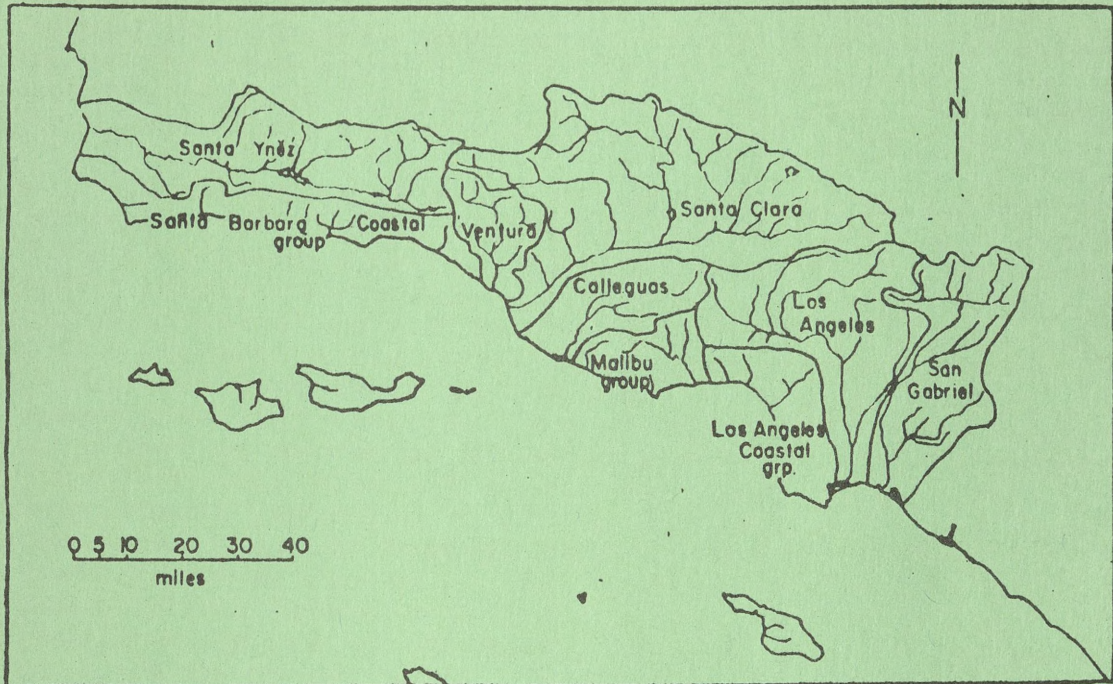
As stream development proceeds and the amount of sand which floods would normally carry to the beaches is critically reduced, we may expect in Southern California a slow but continuous shrinkage of our beaches, and we may have about 20 to 40 years to institute remedial measures (Norris, 1964).

In addition to flood control projects and damming operations which provide sources of water and flood protection, river bottom gravel operations which "mine" river sediments for use in constructions can remove beach-destined sand supplies to a significant degree. For instance, one such operation, the Southern Pacific Milling Co. on the Ventura River, alone removes more than 5% of the remaining sands moving downcoast of the Santa Clara River (based on annual average), and more than 14% of the sand flowing between the Ventura and Santa Clara Rivers (Ventura County Planning Dept., July, 1974). As well as extracting sand which might have replenished beaches, mining operations create open pits which act as sand traps and prevent the trapped sand from moving further downcoast (Calif. Coastal Zone Comm., April, 1974).

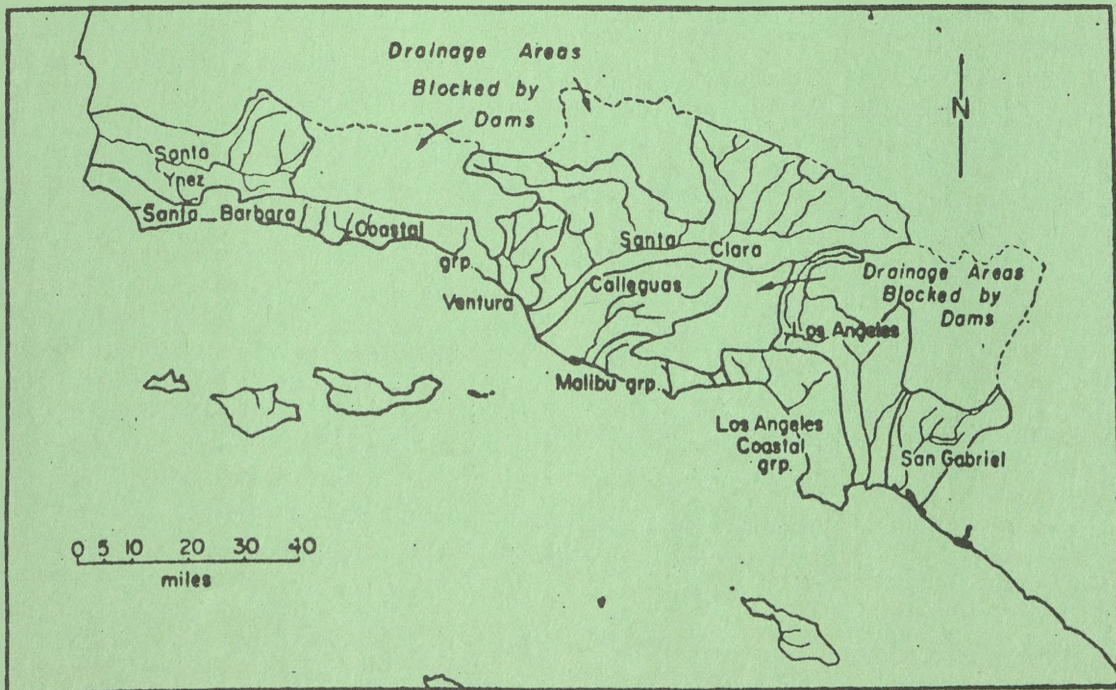
Although development contributes an initial surge of sediments to streams, as urbanization encroaching



Illustration 6.2



*Generalized coastal drainage basins in the northwestern half of southern California*



*Dams and Beach-Sand Supply in Southern California  
Undammed or unobstructed portions of coastal drainage basins  
in the northwestern half of southern California  
(As of 1964, does not include Castaic Dam)*



upon flood plains becomes established, erosion is reduced because of the storm drains which immediately catch water and the grasses, paving and buildings which replace exposed soil. Bernard W. Piphen, a USC geologist, has stated in a general sense that: "What few studies have been conducted suggest that sediment delivered to the beaches will be decreased by 30% by the year 2000, even if no more dams are constructed (Soucie, June, 1973).

Urbanization of areas adjacent to the stream sources of beach replenishing sediments can therefore be a major factor in beach erosion, apart from the flood control and water supply construction it demands. In Orange County, rapid urbanization and channelization of watersheds for flood protection has necessitated the construction of groins and sand dredging and pumping in Seal Beach, Sunset-Surfside Beaches, Newport Beach and Doheny Beach at a cost in excess of \$7 million over the last 5 years (Orange County Planning Dept., November, 1971). The significant reduction in sediment material derived from the Santa Ana, Los Angeles and San Gabriel tributary drainage areas caused by the intense encroachment of Southern California urbanization and other land use developments has necessitated artificial fill programs at Surfside-Sunset Beach. Without these beach fill programs, the shoreline at Surfside-Sunset would be under continuous recession (U.S. Army, May, 1972).

Since the floodplains of Ventura County are still relatively undeveloped these effects of urbanization on beach sand supplies in Ventura County are far from their potential. However, in light of this fact it must alternatively be recognized that most of the sediment producing watershed in Ventura County is located in mountainous terrain unsuitable for urbanization.

It has been estimated that the Santa Paula Creek flood control project might reduce sand in the littoral drift circulation by less than 2%. Its effects might be diminished by the fact that given the tremendous amount of sand in the Santa Clara River and its steep inclination, the amount of water flowing in the river is really what determines the amount of sand carried to the beach (Ventura County Beach Erosion Study, July 1973). However, one must assess the cumulative effects of many such projects, as well as damming operations which withhold water and the total effects of urbanization, in order to predict the irreversible impacts of inland development on beach sand supplies over a long period of time.

It may be said then, that long-term, continuing, general states of net beach erosion (which subsume short-term cycles) can have natural or man-induced origins.

We are probably in a general state of erosion at present in Ventura County, and human activities likely are a major contributing factor. The man-made impacts on beach sand supplies are for all practical purposes irreversible, and in the absence of remedial measures could continue at an increasing rate into the foreseeable future as the county becomes more urbanized in the flood plains, and particularly if more water impounding dams are built. The current extent of these human impacts in Ventura County can only be determined by new studies which are based on updated information reflecting more recent conditions, such as the construction of the Castaic Dam and the advent of the 1969 floods.

## DETECTION

It is evident that beach erosion is a dynamic, ongoing process. It can have short-term, dramatic effects as well as long-term, more subtle effects. It can go through cycles of varying lengths of time, and can be part of a general trend over a very long period of time.

How you detect beach erosion, then, depends on exactly which aspects of it you wish to see. Shoreline recession from intense storms at sea can be estimated by the casual on-site observer, as long as he has a good idea of how far the beach extended before the storm. The elucidation of long-term changes or trends, including erosion cycles, require more continuous observation. Old aerial photographs, Army Corps studies, and even mission records can help trace historical changes to see what has happened in the past and what is likely to happen in the future, by establishing a zone of shoreline fluctuations. This type of data usually isn't complete enough to trace exactly what trends have been dominant through time. However, it can help determine what areas have been most susceptible to erosion at various points in time, relative to the whole coast, and how much the width of these areas is capable of fluctuating.

Erosion susceptibility can also be estimated through the use of wave refraction studies, in conjunction with analysis of beach slope and grain size. A combined effort such as this would establish the relative magnitude of wave energy reaching various portions of the beach, and the resistance of these areas to the force of waves. Computer models simulating stream sediment transport and the littoral drift can help predict the effects of inland sand retention on the sand budgets of littoral cells, and the complete downcoast effects of protruding oceanic structures on the littoral flow.



Shoreline changes can be monitored exactly through a continuous program of aerial photography and measurement of onshore elevations and offshore depth contours. Small changes in the present could then be detected, and a baseline of data for uncovering long-term trends would be supplied for future reference.

## GENERAL EFFECTS OF THE HAZARD

### PRIMARY EFFECTS

People have shown a natural affinity for the coastline. They locate their structures in close proximity to the ocean for purposes of easy accessibility to and close association with the marine environment, often removing natural protective barriers in the process. They are unlikely to be appreciative of the hazards to life and property involved with their decision to build on changing, impermanent land, if they haven't observed the beach over a long period of time. Man, in his eagerness to be close to the water, loses sight of the fact that land comes and goes, and that land which nature provides in a given period may later be reclaimed by the sea (U.S. Army, May, 1964). The end result is the direct destruction of homes and property as foundations are undermined by the advancing sea and the structures themselves are attacked by waves whose force is no longer dissipated by wide beaches.

The millions of dollars of damage caused by coastal erosion is borne not only by private individuals. The public sector suffers damages to streets and utilities which are supportive of beach development subject to erosion hazards.

### SECONDARY EFFECTS

Since erosion reduces the protective capability of the beach against waves, it can increase the flooding hazard of areas of low land profile during storm activity. This is especially true where other protective barriers such as dunes have been removed. Flooding can imperil life as well as inflict property damage.

In certain cases, erosion can unearth septic tanks and cause effluent to run onto the beach and flush directly into the ocean, creating a public health hazard and a threat to marine biota as well.

Beach erosion can reduce the amount of recreational beach available to the public, particularly when sea walls are used to impede it. However, this is a lasting

effect only under conditions of general, long-term erosion, since the amount of beach available for recreation has always fluctuated. During periods of acute erosion, the land itself can be eroded away, permanently losing its soil to the ocean.

The cost to taxpayers is another secondary effect. The public must pay for street and utility damage, and funds rescue and clean-up operations. Low interest disaster loans continue the relief effort. Public agencies are afterwards called upon to spend large sums on erosion protection measures to avert further disaster and protect large investments which have encroached upon the beaches. In some cases, governing bodies are sued by homeowners for allowing development to have commenced in the first place in areas subject to erosion hazard.

#### DURATION AND EXTENT

The duration of hazard from beach erosion depends on a host of meteorologic and geologic factors. Most of the immediate hazard comes from storms, which can last several days or more, and cause severe erosion, flooding, and structural damage. However, a net erosion factor can prevail over several months or even many years, which in turn leaves the shoreline more susceptible to erosion and flooding and structures more vulnerable to wave damage. Continuing, long-term erosion can stem directly and indirectly from the urbanization of watersheds. The effects of urbanization on sand supplies is for all practical purposes irreversible, and in absence of remedial action could continue at an accelerating rate into the foreseeable future as flood plains become more urbanized.

The extent of hazard can be confined to several hundred feet inland from the mean high tide line, except for coastal flooding that is made possible by extensive erosion, which may spread over a considerable area in the coastal zone once the waves overtop physical barriers.

#### GENERAL INVENTORY OF THE HAZARD

##### LOCATION OF THE HAZARD

All beaches in Ventura County are subject to erosion to a certain degree. Even beaches stabilized by groins can erode, only at a slower pace. Erosion will accelerate in the future at all beaches if sand supplies to the coast are further decreased.

Areas which have in the last few years undergone



severe beach erosion are shown in Plate IV. This was taken from an inventory of beach erosion damage in Ventura County completed by the Department of Public Works in 1972.

#### HISTORY OF THE HAZARD

The history of beach erosion in Ventura County is sketchy, due to a lack of documentation. Unfortunately, there has been no ongoing shoreline monitoring program in the past, and the information has been evolved piecemeal. Some of what is available indicates that the shoreline does indeed come and go, and property has been damaged by beach erosion in Ventura County.

Records indicate, for instance, that the area between the Santa Clara River and Port Hueneme, which includes the Oxnard Shores area, advanced roughly 500 feet from 1856 to 1938 (U.S. Army, April, 1961), and more from 1938 to 1959. Consistent advance of this shoreline indicated that available sand supply had exceeded the transport capacity of littoral forces (U.S. Army, October, 1948). This trend towards shoreline advancement was reversed in 1959 at Oxnard Shores. The area was at its most seaward position from about 1955 to 1959, due to the 1938 and 1943 floods. From 1959 to 1972, the shoreline moved landward about 140 feet, and should continue to move landward at this rate (11 ft./yr.) for the next three years, until that time when the 1969 flood sands are expected to reach the area in large quantities (Moffat & Nichols, August, 1972). Subdivision activity began in 1959, and since then homes have been destroyed and utilities endangered (Oxnard Planning Dept., 1972). In February of 1973, Governor Reagan declared Oxnard Shores a flooding disaster area. Apparently, storms have caused millions of dollars worth of damage here.

Pierpont Beach similarly advanced 1,000 feet from 1856 to 1948 (Ventura Port District, August, 1953), reversing this trend by eroding 300 feet from 1948 to 1961, until stabilized by a series of seven groins constructed between the Ventura Pier and the Ventura Marina shortly thereafter. The entire area between the Ventura and Santa Clara Rivers lost approximately six million cubic yards of sand from 1938 to 1959 (U.S. Army, April, 1961). Still, this amount of recession didn't bring the beach back to the limit of the extremely narrow 1855 shoreline, and wouldn't have up to now even without the stabilizing groins (it was predicted in 1961 that Pierpont would reach the 1855 line at the then current rate of erosion by 1986). Construction was discouraged by erosion damage caused by storms in 1936 and 1938 (over \$1,000,000 of damage was incurred at Pierpont in 1938), but the area has grown rapidly since 1950, giving rise to many homes which would have been under water in 1855 (See Illustration

6.3) (U.S. Army, April, 1961).

The lack of data before 1855 and between 1855 and 1938 on shoreline changes (a partial survey was made in 1869; other data may yet lie uncovered), leaves questions about the validity of these apparent trends. 1855 conditions may have resulted from a period of acute erosion following severe storm activity and may not be indicative of this time period. Whether or not the trends at Pierpont over the last century are indicative of the whole Ventura County coastline is questionable. More than a century ago the Santa Clara River migrated northward, causing convexity at its mouth, and acted as a groin, which may explain why Pierpont advanced steadily from 1855 (Ventura Port District, August, 1953). The width of the shoreline there is, therefore, very dependent upon the size of the adjacent Santa Clara River delta. In light of these facts, it is interesting to postulate that the Santa Clara is due for a shift to the south due to the continuing subsidence of consolidating sediments on the Oxnard Plain, but this is not likely to happen due to the construction of levees.

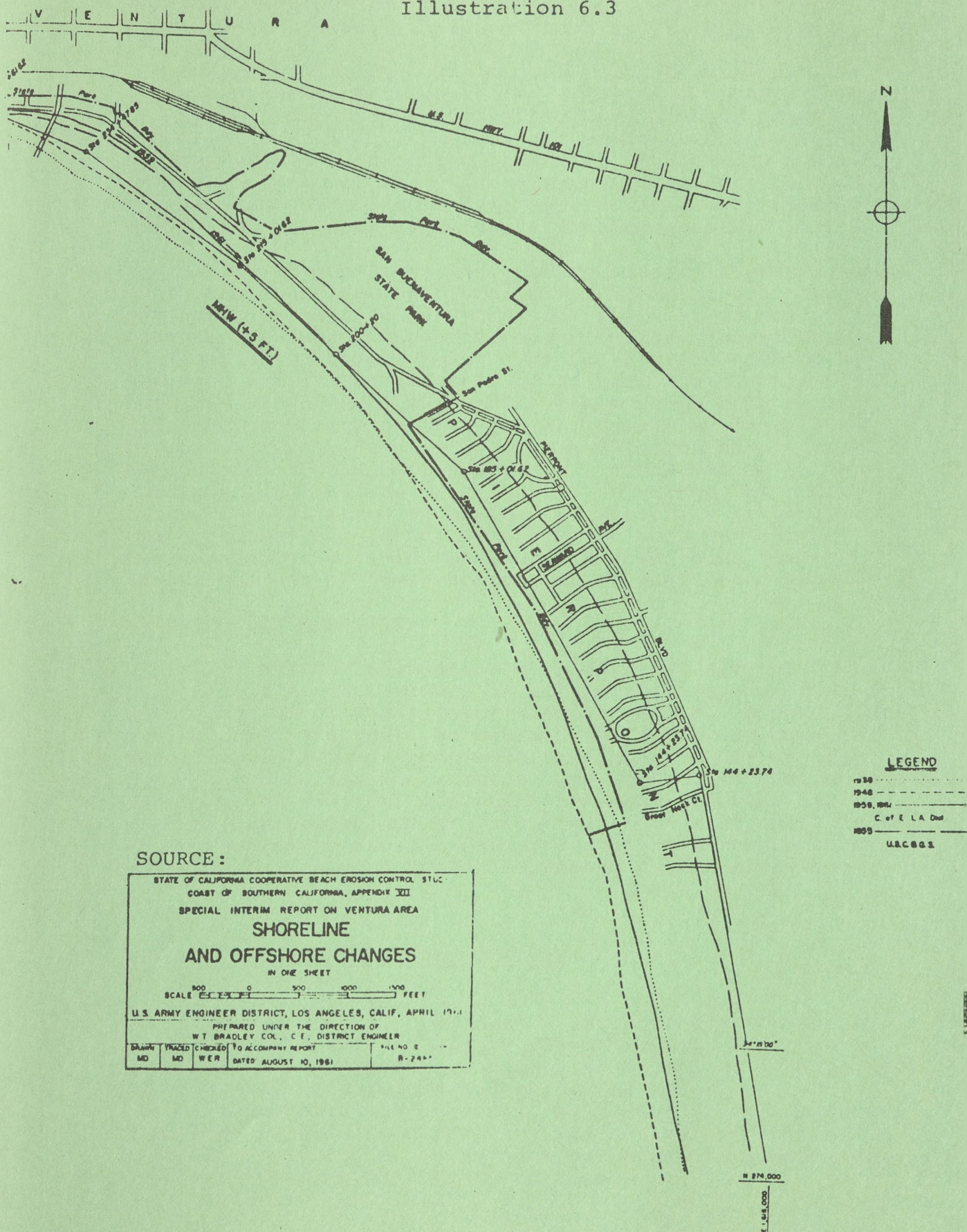
The historical occurrence of erosion induced by man-made structures has been documented as well. Subsequent to the construction of jetties at the entrance to Port Hueneme in 1938, the shoreline directly upcoast advanced 600 feet by 1948. During the same period the shoreline four to five miles upcoast receded 400 feet (Ventura Port District, August, 1953), and the shoreline directly downcoast from a seawall built adjacent to the east jetty receded 700 feet, the recession tapering to zero six miles downcoast. Prior to this construction, the beaches from Port Hueneme to Point Mugu receded and advanced an average of about 200 feet, with no apparent trend since 1855 (U.S. Army, October, 1948).

#### DEFINITION OF HAZARD ZONE

The beach erosion hazard zone will be defined as areas along the Ventura County coast which encompass beaches extending parallel to the shoreline along the areas designated in this report as being subject to severe beach erosion, and which extend from the mean high tide line of these beaches (Summer, 1974) 500 feet inland or to a distance where a rise of 15 feet in sustained elevation over the mean high tide line is first reached, whichever comes first. The 15 foot figure was chosen because it represents the verticle elevation susceptible to wave damage from maximum storm surge in combination with maximum wave height (8 feet and 7 feet). The 500 foot figure was chosen because while some broad, low-lying beaches may be protected from immediate wave damage several hundred feet inland, they nevertheless may erode many feet over a long period of time. Since Oxnard



Illustration 6.3



Shoreline Changes at Pierpont from 1855 - 1936



Shores is approximately 500 feet seaward from where it was in 1856, this indicates the erosion potential for this type of broad, low-lying beach in Ventura County.

Sites within the hazard zone might be suitable for certain structures if protected by a sizable barrier such as several rows of previously existing houses, or an extensive dune line. These sites would probably still be susceptible to flooding, however. A location set back well on a shelf of land of resistant rock under 15 feet of elevation and fronted by a very narrow sandy beach would also probably be suitable for development.

It is obvious that the erosion hazard increases along any shoreline with proximity to the ocean. It also must be kept in mind that all portions of sandy beaches are subject to erosion and can be classified in at least a low hazard zone. The beaches are created by the sea, and it has the ability to undo what it has done. Even groins which "stabilize" a beach serve only as a delaying mechanism against erosion caused by relentless processes (Orme, July, 1974). The 500 foot horizontal delineation should be regarded as conservative in the long run, in the face of a lack of knowledge which documents the full range of historical shoreline fluctuations, the continual alteration of shoreline configuration by man-made structures in the ocean, and the ever increasing adverse effect of human activities on beach sand supplies.

#### NATURE OF INFORMATION

The lack of information on historical erosion trends and current erosion susceptibility prohibits the detailed determination of local beach erosion hazard. A more fine-grained analysis would be enabled by filling in gaps in the historical data, from such possible sources as Army Corps records, mission records, and old aerial photographs. The location of areas currently undergoing severe beach erosion, as determined by Public Works in 1972, will have to be updated as erosion patterns change in response to changing natural and human influences on the shoreline.

#### GENERAL MANAGEMENT RESPONSIBILITY

The Army Corps of Engineers is currently conducting a study on the Ventura County littoral drift and related problems. Their report is due by 1978, and will inventory current erosion problems and recommend solutions. For planning purposes, it hopefully will also provide a certain amount of predictive capability for estimating future shoreline conditions, by projecting natural and man-made processes which effect beach changes.



Major flood control and erosion correcting measures are almost always undertaken by the Army Corps of Engineers. As a prerequisite, the County must first request assistance from the Corps, after which the Corps then seeks approval from Congress for federal funding, which covers construction costs on the order of 50% of beach erosion projects, and up to 100% for flood control projects of regional significance. Local and state agencies pay for right-of-way and utility relocations. The County Public Works Agency lends coordinative and technical assistance to the Corps for major projects, and also undertakes flood control projects of a lesser significance. It is now County Policy that the County Parks and Recreation Department manage the use of beach erosion corrective measures for County property, such as Mandalay Beach Park. ~~The State will also construct structures to protect against erosion, as funds are available, such as the rip rap wall at Seacliff.~~ The State may under certain circumstances participate in construction of structures to protect against erosion, such as the rip rap wall at Seacliff.

The County Flood Control District is the agency which has assumed responsibility for cooperating with other agencies in studying and monitoring sediment production and transport as it may affect sand supply for beach building purposes. Cooperative studies with the U. S. Geological Survey are being conducted to better define the problems and develop proposed solutions.

County working  
The District has also become the responsible agency for conducting all investigations pertaining to beach erosion. Section 7 of the Ventura County Flood Control Act was recently amended to include the power to cooperate and act in conjunction with or to contribute funds to other agencies for the purpose of protecting and restoring beaches and shorelines. The District staff will be working closely with the Corps of Engineers in their beach erosion investigation and also plan to conduct periodic bathymetric surveys to determine changes in the beach profiles in various areas along the County shoreline. The District staff should be consulted in developing regulations for land use and reviewing plans for protection in areas subject to beach erosion, and when providing information on shoreline conditions and plans for a comprehensive beach management program.

Local government agencies charged with land use regulation are responsible for managing the placement of structures and facilities in undeveloped areas subject to beach erosion. Their actions ultimately determine whether or not there is going to be an erosion problem, whether or not measures will be necessary to protect endangered property from erosion. Additional incompatible land uses can be kept out of erosion hazard zones through the various land use regulatory devices at the disposal of local governments, supplemented by the environmental impact review process.

The Flood Control Department of the County Public Works Agency also has limited responsibility for flood plain management in the County. The cities do as well, when flood plains come under their jurisdiction. By regulating urbanization in the flood plains, there could be less of a need to protect development from floods through flood control structures, and the effects of urbanization on sediment production in the flood plain could be lessened.

# LOCAL DISCUSSION

## LOCAL INVENTORY OF THE HAZARD

The hazard zone is located along McGrath State Beach, the Oxnard Shores area, and Ormond Beach. It extends the full 500 feet inland at both McGrath and Oxnard Shores (except where it converges with McGrath Lake).

## LOCAL RESOURCES AFFECTED BY THE HAZARD

At McGrath Beach, there are no resources in the hazard zone which would suffer lasting damage from beach erosion, assuming that natural processes retain the capacity to build the beach back out. At Ormond, the permanent loss of soil would ensue at some locations if all of the sandy beach eroded within the zone. The most resources possibly affected by far are located at Oxnard Shores. Here, many houses and apartments are contained within the zone, some situated as close as 100 feet from the mean high water mark. Supportive utilities and streets are similarly threatened. Some oil facilities in the zone may possibly be affected. Mobile homes in the zone are assumed to have the ability to avoid the hazard due to the slow progression of the hazard, even in its most violent form.

At all of the beaches, continuing erosion can decrease the available amount of recreational beach over time. Any man-made structure built to decrease beach erosion, unless properly designed, can effect beaches' down the coast line.

*New Wording*



# FINDINGS

## PROBABILITY OF OCCURRENCE

Beach erosion occurs over varying time spans with varying rates of incidence. Some erosion is correlated with changes in the weather and other natural phenomena. There can be short-term, rapid erosion from storms, seasonal and tidal fluctuations, and cycles which cover 25 years or so and are correlated with sunspot activity. Short-term erosion can also be man-induced, as from groins and jetties. There are also long-term, continuing trends of erosion which can have natural and/or human origins. Shoreline fluctuations which occur over the shorter time periods are much easier to predict than the longer trends because they occur more often, and more is known about them. However, a continuing, long-term, general state of erosion at County beaches may become dominant in the future if the increasing urbanization of the County subtracts further from the amount of debris-producing areas in the flood plains of the County, and leads to additional stream development and, most importantly, water-impounding dams. This would be particularly true if the human impacts on beach sand supplies are not offset in the future by the occurrence of major flood flows, such as the 1969 floods.

## SEVERITY OF THE HAZARD

Beach erosion occurs with varying degrees of severity. Tidal fluctuations cause little change in beach profile, while major storms, particularly when at high tide, can cause the coast to rapidly recede. Long-term trends may be undiscernible to the casual observer, but may have catastrophic effects when they result in the erosion of many feet of beach over a long period of time. Erosion severity can change from place to place along the coast at any one point in time in response to changing wave patterns and geomorphological features.

Based upon past history of other areas of Southern California, it can be said that as the urbanization of the County increases in the future, the general severity of incidences of beach erosion will also increase. However, remedial measures taken by proper management of water resources and sand supply, and the future occurrence of major flood flows, could reduce the hazard.

## RESOURCES AFFECTED

Erosion can undermine the structural foundation of buildings within the hazard zone, and allow waves to damage the structures themselves. Supportive facilities

can also be damaged or destroyed. Good soils from the land itself can be permanently eroded away if all of the sandy beach with its protective capability is removed. Seawalls installed to protect structures have the effect of decreasing recreational beach seaward of the wall. Normally, natural features such as beaches and sand dunes affected by beach erosion free from human origins are usually restored by natural processes over time. The total amount of recreational beach available over time can be reduced by those human activities which induce general, continuing states of beach erosion.

#### NATURE OF INFORMATION

The information used in this report, namely current inventories, research papers, and historical studies, was adequate to establish a general erosion hazard zone and predict a possible worsening of future conditions. More detailed information is needed to establish more fine-grained hazard zones sensitive to local conditions, and anticipate future erosion with more accuracy. Hopefully, the Army Corps study due in 1978 will be informative in this way.

#### OTHER FINDINGS

Many of the protective sand dunes at Oxnard's beaches have already been removed to accommodate development. Also, sand dunes and their stabilizing vegetation in some instances have been bulldozed in order to provide a better ocean view for residents of Oxnard Shores. These sand dunes serve not only to hold back the waves, but they serve to contain sand blown inland by the wind channeled to the area by Channel Islands (which also increases wave activity, and, therefore, erosion in the area). When these dunes are removed, sand blown from the beach to replace them (which usually winds up in residents' backyards) is lost from the beach. It is imperative to preserve the dunes on the Oxnard beaches, unless they have been blown to far inland to be of use. Sand from dunes blown inland can possibly be brought back to the beach to replenish it (such as the ones across Harbor Boulevard).

COUNTY SENTENCE  
Added

According to the report done for the Oxnard Shores Community Association, the beaches in the area will be replenished by 1969 flood sand within the next few years. Until then, continued erosion can be expected.

COUNTY SENTENCE  
Added

Although sand bypassing operations mitigate the presence of the Ventura Marina on downcoast sand drift, long-term erosion to downcoast areas will probably result, unless protective measures such as groin construction are taken (U.S. Army, September, 1970). The width of the beach at Ormond is directly related to the

COUNTY PARAGRAPH  
Added



amount of sand bypassed by dredging at Port Hueneme Harbor (U.S. Army, December, 1970).

The Oxnard Plain is of a very low land profile, and is, therefore, subject to coastal flooding as well as erosion under certain conditions of severe storm action and/or high tides beach erosion may increase the hazard. Coastal flood hazard can be expected to increase with increasing beach erosion.

Geologist  
wording

## RECOMMENDED ACTIONS - BEACH EROSION

1. Establish a procedure for City review of any proposals for direct alteration of shoreline configuration, or structures which protrude into the ocean, to insure that the detrimental effects to natural processes, which includes increased erosion of downcurrent beaches, are avoided. This should be completed before substantial financial commitments are made.
2. Utilize structures which impede beach erosion and/or wave activity, such as groins, jetties, and seawalls, only where property is clearly in danger of being destroyed or eliminated, or where overriding public benefit clearly demonstrates the need for additional marine installations. These structures should be designed in such a way as to minimize erosion seaward of the structures and at adjacent points along the shore.
3. Establish a working relationship with the proper County agency to monitor sediment production, including river-bed mining operations, as to their effects upon sediment transport. Establish criteria for the amount of mining permitted and the amount of sediment for stream transport.
4. Investigate the feasibility of preserving existing sand dunes to serve as protective barriers against erosion and tidal flooding. Stabilize existing dunes via surface vegetation and construct artificial dunes where appropriate.
5. Keep land uses which are subject to serious property damage from beach erosion out of beach erosion hazard zones. Control the siting and design of uses in erosion hazard zones to minimize the danger of property damage from erosion, such as requiring deep pilings for houses.
6. Until the adoption of regulations controlling land use specifically in the beach erosion hazard zone, afford owners of hazard zone property all available information which serves to warn them of the threat of hazard within the zone.



# SEISMIC SAFETY

LIQUEFACTION



LIQUIFACTION SECTION - VIII-1 thru VIII-12

The pages listed below have not been changed.

VIII-6

VIII-7

VIII-8



## GENERAL DISCUSSION

### GENERAL DESCRIPTION

By far the greatest threat from an earthquake is the ground shaking that is produced and the resulting direct and indirect effects on manmade structures. In some earthquakes ground shaking results in ground failure, which can have catastrophic effects on structures. ~~Most of the damage caused by liquefaction and can occur on relatively level ground although it is generally associated with landslides in hilly areas.~~ Ground failure is most often caused by liquefaction and can occur on relatively level ground.

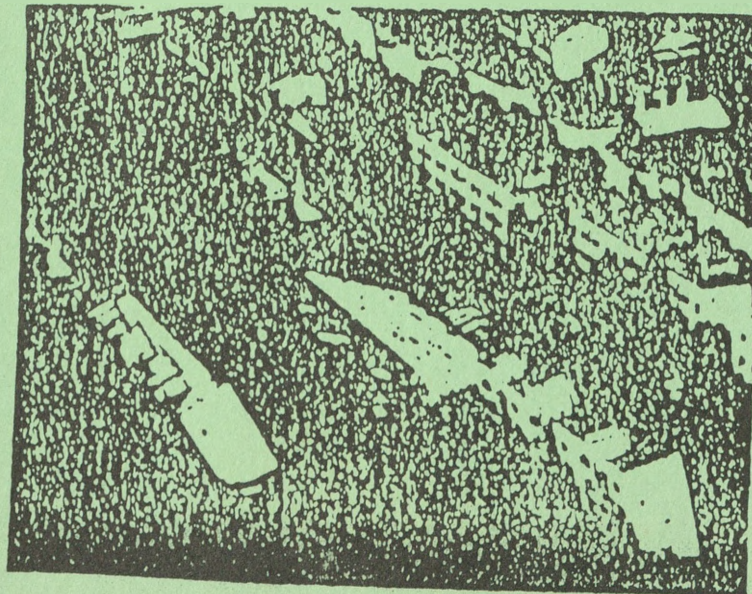
COUNTY  
Sentence

(Liquefaction can occur when loose cohesionless, uniform soils saturated with water are subjected to ground shaking of ~~the very~~ high enough intensity, ~~duration and frequency.~~ and long enough duration. Liquefaction

is generally manifested either by the formation of sand boils and mudspouts at the ground surface and the seepage of water through ground cracks or, in some cases, by the development of quicksand-like conditions over substantial areas. When the quicksand-like conditions occur, buildings may sink substantially or tilt into the ground (See Illustration 8.1) and light-weight buried facilities may float to the surface. (Seed, 1969) Other manifestations are landslides in hillside areas which can move hundreds of feet and lateral earth spreading of tens of feet.

#### Illustration 8.1

Tilting of apartment buildings, Niigata, Japan (1964)



COUNTY  
wording

A number of conditions are necessary to produce liquefaction. These include low density of the soil, uniformity of grain size, confining pressure, saturation of the soil materials with water, the intensity of the shaking and the duration of the shaking. In terms of density of soil, loose soil materials are most subject to liquefaction. Uniformity of grain size, such as a deposit of only sand, causes materials to be more susceptible to liquefaction than well graded materials. The deeper the soil zone, which is susceptible to liquefaction, the higher the confining pressure will be and, consequently, the potential for liquefaction is reduced. The soil must be saturated with water for liquefaction to occur.

COUNTY  
wording

Depending upon the confining pressure and the specific soil conditions, a certain intensity of shaking is required to trigger liquefaction. Intensity depends on the magnitude of the earthquake and the amplification of the ground shaking. Finally, the duration of the shaking is also important, as it takes a certain number of cycles of ground shaking for liquefaction to occur. The landslides of the 1964 Alaskan Earthquake did not occur until 90 seconds after the shaking started (Seed and Indriss, 1972). As compared to the 1971 San Fernando Valley Earthquake, where landslides were triggered after only 30 seconds of shaking.

Technically speaking, when a saturated sand is subjected to the necessary amount of ground shaking, it tends to compact and decrease in volume; if drainage cannot occur, the decrease in volume increases the pressure of the contained water. If the pressure reaches a point equal to the overburden pressure, the sand loses strength completely, and develops into a liquefied state (Seed, 1969).

Liquefaction can occur at any level of a deposit but usually occurs within the first 40-50 feet. The potential for liquefaction exists wherever there are saturated loose sand deposits, especially if they are near the surface.

It should be pointed out again that it takes a combination of several conditions happening at the same time to have liquefaction occur. The probability of these conditions occurring together is very small.



## PRIMARY EFFECTS

There are two major kinds of liquefaction. The first is where surface or near-surface liquefaction of soils occurs. Structures whose foundations are within such a liquefaction zone lose support under part or all of their foundations, which causes them to tilt or settle into the ground surface. If a building is not designed to account for this, the entire building may collapse. ~~(Although many designs are generally designed to take into account all relevant soil strength, liquefaction is not designed for because of the inability to predict occurrences and the slight probability of occurrence.)~~ A partially liquefied layer can also flow out from under the weight of the foundation with similar settling effects. As a general rule, for structures not designed against liquefaction, the larger the structure the greater its potential for settling through liquefaction during an earthquake. Thus, while differential settling may affect almost any structure, smaller buildings such as single family frame homes are not likely to suffer major damage except in situations where the water table is less than fifteen feet from the surface. Larger buildings not designed against liquefaction, however, can be severely affected at almost any level down to about forty to fifty feet below the surface, as loss of frictional support of deep pile foundations can occur. In addition, light sub-surface structures such as pipelines and storage tanks can float to the surface during the ground shaking, causing further damage and potentially widespread dislocation of services.

The second type of liquefaction occurs when the soil layer that liquefies is below the surface. As the soil compacts under the ground shaking of the earthquake, the hydrostatic pressure increases. This pressure is usually relieved by the flow of water and soil to the ground surface. If the flow is small and the areas localized, the effect on the surface is that of sand boils and mud-spouts which can last for a number of hours after the earthquake. However, if the flow is large and general, it will induce a "quick" or liquefied condition at the surface, with the same results as surface liquefaction. If the subsurface liquefaction occurs on a slope, the liquefied layer can act as a lubricated plane for the layer above it to respond to gravity and move downhill. The effect is even more pronounced if the water cannot escape vertically and is forced horizontally along a contact surface. This type of liquefaction is a common cause of earthquake-induced landslides. Structures built across the edges of the slide

are torn apart in much the same manner as if they were located on a fault (See Illustration 8.2, Page VIII-6); a good examples of this occurred in the 1971 San Fernando earthquake where the Juvenile Hall slide was caused by liquefaction of a subsurface layer. An area of almost 163 acres moved down a 2.5% slope causing damage of over \$30 million. Movement down a slope with such a low gradient had not previously been recorded, but such effects must be considered in future earthquakes.

The liquefaction also often causes settlement of the soil. In Niigata, Japan, after the 1964 earthquake, settlement of over 3 feet was common. In Alaska, the ground around one wellhead settled 4.5 feet.

## SECONDARY EFFECTS

Liquefaction could destroy or disrupt much of the infrastructure (i.e., gas lines, water, sewer, roads, etc.) in an area. Pipelines could be broken either by being floated to the surface or by landslide displacement. Bridge abutments could suffer differential settlement, cutting off roads. The settlement of large areas of land could drop some areas below sea level and produce a new shoreline, or at least require reconstruction to re-establish continuity of roads, etc. (see subsidence hazard). These secondary effects of course would only occur under the most extreme case of liquefaction.

## GENERAL INVENTORY OF THE HAZARD

### LOCATION OF THE HAZARD

The hazard exists wherever there are certain soils, particularly loose sand soils, that are constantly or seasonally saturated with water. This might include most of the river valleys and the low lying plains areas that have poor drainage (Hazard Plate V). Since subsurface soil properties are not precisely known, it is necessary to assume that all alluvial areas having high groundwater may be subject to liquefaction during strong earthquake shaking.

Most of the Oxnard Plain and Pleasant Valley have these characteristics and therefore, must be considered to have a liquefaction potential. Virtually all of the low lying areas in the Ventura River drainage appear to have these characteristics as does most of the Santa Clara River.



Most of the beach areas of the county including the entire coastline from Point Mugu to and including the Ventura River delta are probably underlain by loose water-saturated sands and other alluvial deposits which could be subject to liquefaction during strong earthquake shaking. Low-angle landsliding or lateral spreading along the beach areas could occur as a result of liquefaction of these deposits. In addition, landsliding could occur within and adjacent to the submarine canyon areas (see Hazard Plate V).

### HISTORY OF THE HAZARD

Liquefaction has not yet been a damaging hazard in Ventura County, but along with its attendant ground shaking, it is ~~a major~~ *possibly the biggest seismic threat in the County.*

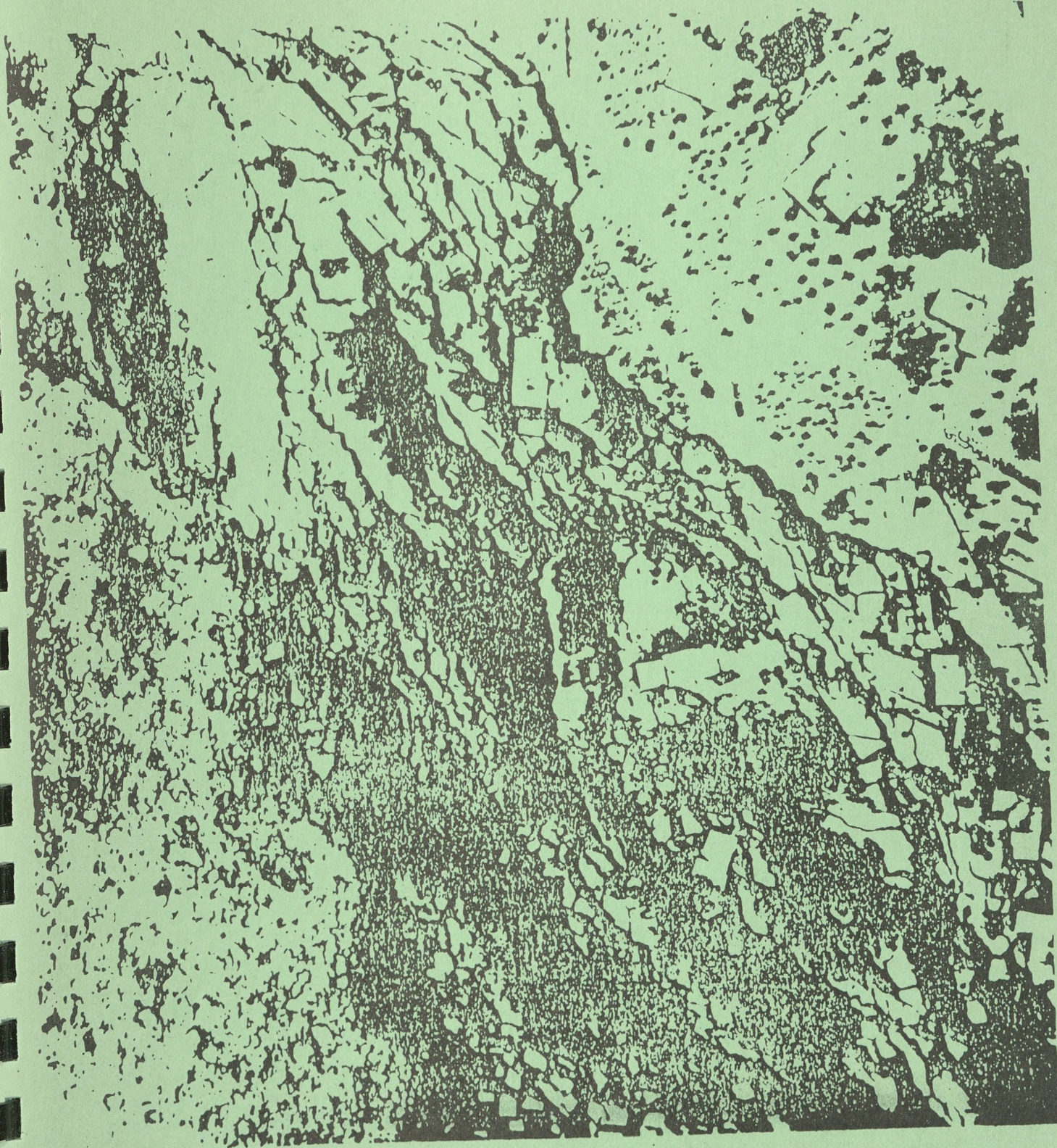
Some experience from other areas will possibly provide an insight into the potential effects of liquefaction on Ventura County. The effects of liquefaction was well illustrated by the Niigata earthquake of 1964 (See illustration 8.1). The structural damage was severe and there were numerous other damaging effects such as sand eruptions, water flows, landslides and settling of the ground surface.

In the Alaskan earthquake of 1964, there were numerous bridge foundation settlements, but the most severe damage was from the Turnagain Landslide, which was caused by liquefaction (See Illustration 8.2). The most startling discovery of the 1971 San Fernando earthquake in regard to liquefaction was that major slides could occur on slopes with an inclination as low as 2.5%.

Locally, liquefaction occurred in Calleguas Creek, Mugu Lagoon and the lower Santa Clara River during the February 21, 1973, Point Mugu Earthquake. The effects were mainly the development of minor ephemeral features such as shallow cracks and sand boils, but as Morton and Campbell point out in their report (California Geol., Dec. 1973) if the "shaking had been more severe, such effects might well have been widespread and could have resulted in significant agricultural crop losses". Also, *the effects on structures could have been significant.*



Eastern Portion of Turnagain Slide



SOURCE: U.S. Army photograph



Illustration 8.3

Turnagain Heights, Anchorage



This photo well illustrates the spectacular slide damage caused by the March 27, 1964, earthquake to the roadway and homes in this suburban development.



Eyewitness reports of the effects of the 1857 Fort Tejon Earthquake (magnitude + 8.0) on the San Andreas Fault suggest general liquefaction occurred along the Santa Clara River, along with other damage.

#### DEFINITION OF THE HAZARD ZONE

Since soil properties are not precisely known, all alluvial deposits must be considered to be subject to liquefaction until investigation proves otherwise. Consequently, areas which are designated as within the high hazard zone are alluvial areas which have had water table levels within 15 feet of the ground surface at some time in the last fifty years or since well records have been kept. The moderate hazard is defined as including alluvial areas which have had water between 15 and 40 feet of the surface.

Large areas of the county have a surface layer of unconsolidated sand deeper than 40 feet and the entire county is susceptible to possibly severe earthquake shaking. Therefore, the primary variable factor for liquefaction in the County is the depth of the water table. The water level varies, but to be conservative, the highest level was selected. This is reasonable in urbanized areas where the water table is usually rising due to a number of factors including; curtailment of pumping; importation of increased amounts of water; reduced evaporation due to paving; heavy irrigation from watering of yards; percolation of sewage, etc.

The threat posed by this hazard varies depending upon the seasonal water level in some areas. The hazard zones designated assume that water levels are at their highest.

The significance of the water level being less than 15 feet from the surface is that in this range even small structures such as single family residences could be affected by liquefaction. This is the level at which the most severe liquefaction damage occurred in the 1964 Niigata, Japan earthquake. The 40-foot level corresponds to approximately the deepest level at which liquefaction most commonly can occur and is the level above which most building foundations are constructed, except for important structures.



## NATURE OF THE INFORMATION

Data on the water surface level was taken from the extensive well records maintained by the Hydrology Section of the Ventura County Department of Public Works. These well records include up to 50 years of actual measurements at approximately one-month intervals.

Certain areas did not have usable well records. For these areas, either other special reports were used or actual field data was collected. One of the areas so field checked was Pleasant Valley. Alluvial areas are shown on Plate I of the State Division of Mines & Geology report entitled: Geology and Mineral Resources Study of Southern Ventura County (1973).

## GENERAL MANAGEMENT RESPONSIBILITY

### INVESTIGATIVE

(The Public Works Department and Building and Safety Division have primary responsibility for further investigation of the liquefaction hazard in Oxnard.) The California Division of Mines and Geology in their cooperative study during 1975 will investigate the hazard further. The California Department of Water Resources and the U. S. Geological Survey have ongoing projects to study groundwater and water table levels that affect liquefaction potential. Further research by federal and state agencies should be undertaken to more precisely determine the location and magnitude of the hazard as well as possible methods to counteract it. ok

### ALLEVIATION

There is little that can feasibly be done to reduce the hazard. Important or critical structures can utilize special designs to alleviate the effects of the hazard. Land use controls are the only other methods available to reduce the threat to life and property. Whether or not land use controls are instituted by the Planning Commissions and City Councils or the Board of Supervisors depends upon these entity's perception of the probability of the hazard occurring, the costs of restricting land uses and their concept of acceptable risk. ok

COUNTY SENTENCE  
Added

Present Subdivision, Grading and Building Ordinances require geologic and soils hazards, such as liquefaction, to be considered in the design of land developments and construction of important or critical structures as well as single family homes where necessary.

# LOCAL DISCUSSION

## LOCAL INVENTORY OF THE HAZARD

The entire City of Oxnard is located in one or the other of the hazard zones, as designated on Hazard Plate V. There is an area of moderate hazard in the El Rio area extending north almost to the Camarillo Hills. The high hazard zone covers the remainder of the City. The term "high hazard" should not be used out of context and is not intended to be compared to other seismic safety considerations. "High hazard" is a relative term applied only to the comparison of liquefaction areas.

## LOCAL RESOURCES AFFECTED BY THE HAZARD

The information used to define the zones (on Hazard Plate V) was the best available but does not allow precise delineation of the hazard areas. Also the boundary lines represent a transition zone which fluctuates seasonally and with changes in water supply.

The areas designated on Hazard Plate V encompass the entire City of Oxnard.



# FINDINGS

## PROBABILITY OF OCCURRENCE

There appears to have been general liquefaction in the Santa Clara River Valley during the Fort Tejon Earthquake along the San Andreas Fault in 1857. Localized liquefaction occurred in the area during the 1973 Point Mugu Earthquake. Liquefaction, therefore, could be expected to occur again whenever an earthquake with a high enough intensity, ~~duration and frequency occurs when the necessary other physical conditions are present.~~ An earthquake generating fairly intense groundshaking is predicted by many experts within the next fifty years from the San Andreas or some other nearby fault.

COUNTY  
SENTENCE  
added

## SEVERITY OF THE HAZARD

There may be no practical means of reducing the overall hazard due to the City's high groundwater levels which are influenced by surrounding agricultural irrigation and close proximity to the ocean and the Santa Clara River.

COUNTY  
Paragraph  
added

The severity of the effects depend upon the soil properties, and intensity and duration of the shaking, and the resultant type of ground failure.

## NATURE OF INFORMATION

The water table levels in alluvial areas were arrived at by taking the highest figure measured from the extensive records of the Hydrology section of the County Department of Public Works. The boundaries of the hazard zones are only approximations and are not accurate enough upon which to base any building code requirements. In addition, the estimated effects of liquefaction may vary greatly within a given one during a given earthquake. Any specific conclusions should be reached on the basis of detailed site-by-site soils and geologic studies (and upon the information received in the future from Federal and State studies. )

OK

## OTHER FINDINGS

Future development plans within the City should be carefully evaluated due to the hazard imposed by the potential of soil liquefaction. Unless structures are adequately designed to resist the potential effects of the hazard, structural damage resulting from the effects of liquefaction could occur to public and

COUNTY  
Paragraph  
added

County  
Paragraph  
added

private structures and vital utilities within the City in the event of a severe earthquake. In general, single story buildings have significantly lower risk than multi-story structures.



## RECOMMENDED ACTIONS - LIQUEFACTION

1. Encourage performance of regional studies by qualified Federal and State agencies such as the U. S. Geological Survey and the State Division of Mines and Geology, or private research firms, in order to more accurately determine areas of potential soil liquefaction hazards and the probability of occurrence.
2. Encourage and participate in cooperative studies with the above agencies.
3. Encourage State or Federal agencies and universities, as well as private groups such as the Structural Engineers Association and the American Society of Civil Engineers, to undertake or sponsor research in design and construction to develop methods of providing greater resistance of structures to withstand the effects of soil liquefaction.
4. Utilize the latest uniform codes accepted by the State in the design of buildings and structures to resist liquefaction damage.
5. Evaluate water management plans and programs as to their effect on perched water tables as a factor of liquefaction. Make recommendations to appropriate agencies in areas where problems are identified to minimize liquefaction.



# SAFE

TSUNAMI



TSUNAMI SECTION - IX-1 thru IX-12

The pages listed below have not been changed.

IX-1

IX-2

IX-3

IX-7

IX-8

IX-11

The following pages have been changed.

# GENERAL DISCUSSION

## GENERAL DESCRIPTION

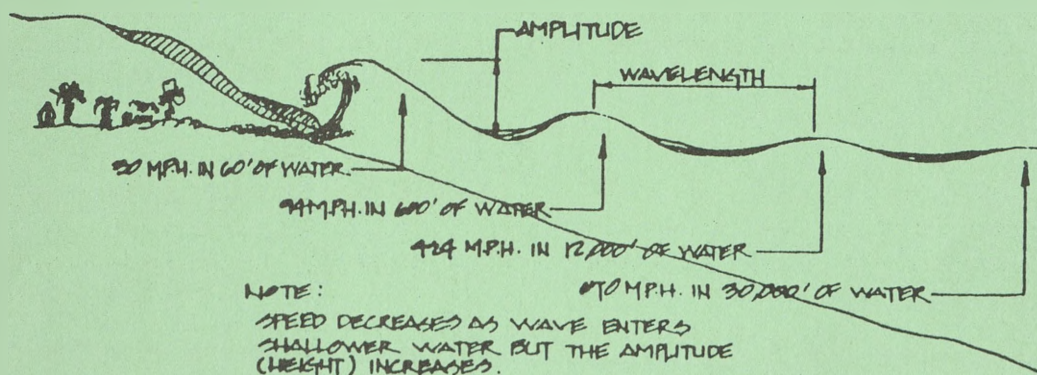
### PHYSICAL PROPERTIES

Tsunamis (pronounced soo-nom-ee) are large ocean waves that are generated by submarine landslides, volcanic eruptions or earthquakes in or near ocean basins. These waves are commonly referred to by the general public as tidal waves.

The term "seismic sea wave" applies to a tsunami caused by an earthquake. These waves have a long wavelength (distance from the crest of one wave to the crest of the succeeding wave), normally over 100 miles and a very low amplitude (height from crest to trough).

As these waves approach shallow water, the speed decreases from a deep water speed of over 600 m.p.h. to less than 30 m.p.h. as they move across the beach. The energy however, is transferred from wave speed (velocity) to wave height (amplitude) and waves as high as 100 feet can be formed.

Illustration 9.1  
Characteristics of a Tsunami or Seismic Sea Wave





The waves can arrive on shore in intervals of up to an hour and since there are usually a number of waves in a set (rather than just one) the threat usually exists for as long as 10 to 12 hours. Tsunamis are sometimes preceded by a trough which frequently brings the curious down to the shore to examine what appears to be an extremely low tide. The wave itself, may follow the trough by 15 to 45 minutes. Tsunamis can also travel considerable distances inland on waterways, particularly those with shallow gradients.

## DETECTION

The Seismic Sea Wave Warning System (SSWWS), directed by the Coast and Geodetic Survey, is the primary source of tsunami detection. This system has been in operation since 1948. The SSWWS and cooperating foreign countries operate a system of seismographs and tide stations. This system includes automatic seismic alarms that are triggered whenever an earthquake of sufficient magnitude to generate a tsunami is recorded, since earthquakes produce the vast majority of tsunamis. The SSWWS Honolulu Observatory determines the location of the quake by using the local arrival time of different earthquake waves. If the quake is in or near the Pacific Basin a Sea Wave Advisory is issued, along with estimated times of arrival of tsunamis. (See illustration 9.2)

Although the arrival time of waves can be predicted, the intensity of the wave when it reaches shore cannot be predicted. Until the 1960 Chile tsunami, which caused hundreds of deaths in Japan, it was not known that a tsunami of such distant origin (10,000 miles) could produce such devastating effects in Japan. In other instances, extensive damage can occur in one area while causing negligible damage in adjacent areas.

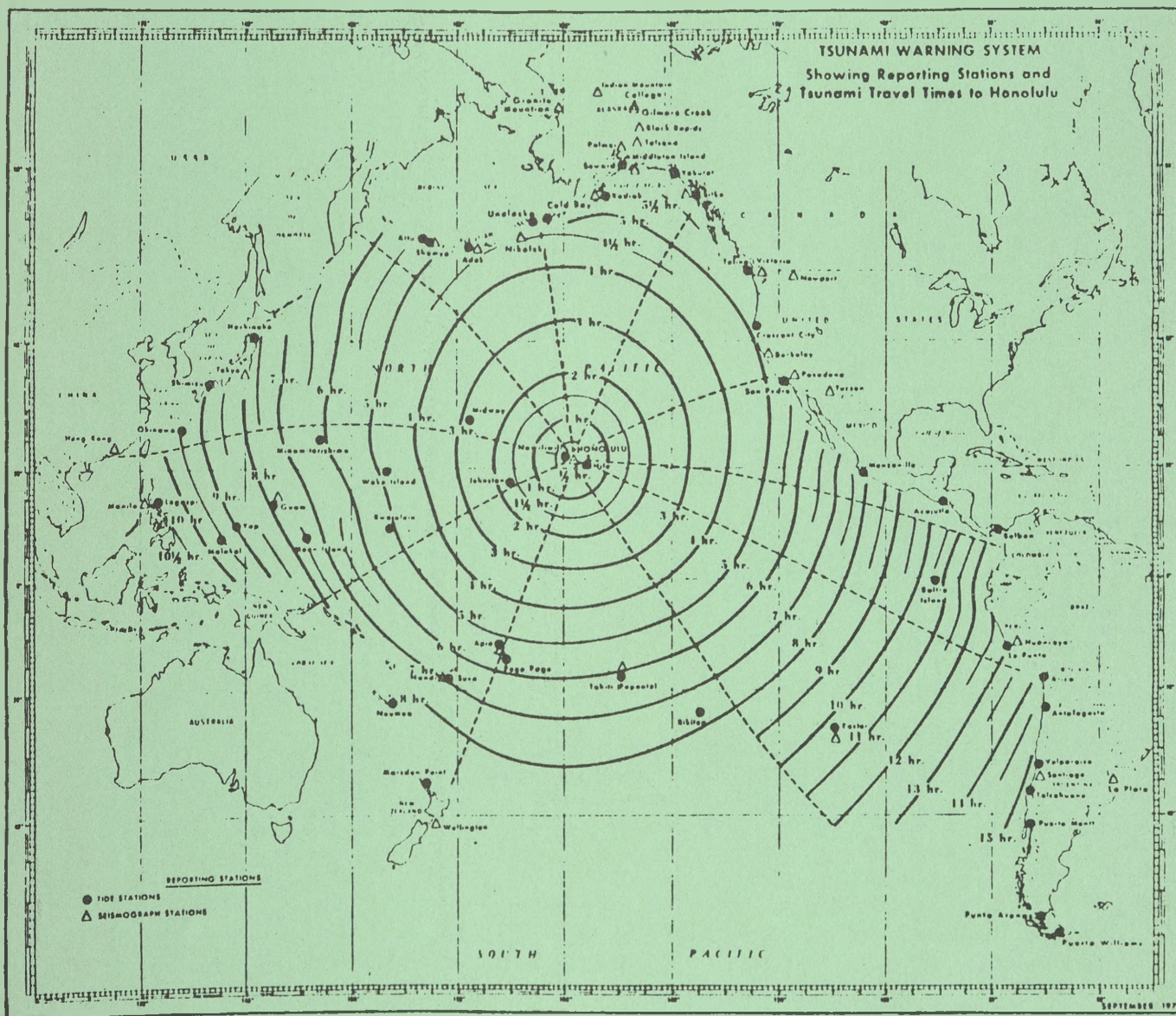
## GENERAL EFFECTS OF THE HAZARD

### PRIMARY EFFECTS

Tsunamis are a threat not because they are so extensive or frequent, but because the destruction they cause can be devastating. The danger is also compounded by the fact that the intensity of the wave is unpredictable and the threat is intermittent over many hours.

The tsunami threat is mainly confined to the immediate beach areas, except in river channels. Beach areas have been affected up to a mile or more inland in very flat areas.

Illustration 9.2  
Tsunami Warning System Map, showing reporting  
stations and Tsunami travel times to Honolulu  
from possible distant origins of such waves.



Source: National Oceanic and Atmospheric Administration - NOAA.



Tsunamis can also proceed up flowing rivers for many miles if the gradient of the river is shallow. The effects of the waves are most noticeable on man-made features and these effects are usually temporary. But the waves can also change river channels and modify coastal landforms and these effects are noticeable for many years. There is no way to avoid the damage to features in the path of a tsunami, but when there is enough time for a warning to be issued, there should be no loss of life if the necessary precautions are taken. These waves are not common in California and, therefore, the recurrence interval seems to be large; however, the historical record is not extensive enough to develop predictions.

## SECONDARY EFFECTS

The immediate or primary effects of a tsunami are easily visualized but the secondary effects can be unanticipated. Water systems can be contaminated, power disrupted, transportation systems blocked or dislocated, increased occurrence of fires from broken oil and gas tanks or lines, flooding from blocked rivers, etc.

## DURATION

The assault on the shoreline from a tsunami is relatively shortlived, but because the waves come in succession over a period of up to 10 to 12 hours the duration of the threat is quite long.

## GENERAL INVENTORY OF THE HAZARD

### LOCATION OF THE HAZARD

All of the coastal areas in Ventura County are susceptible to tsunamis to some degree. A tsunami from the north Pacific could move down the Santa Barbara Channel and affect the northerly coastal areas; a seismic sea wave from the South Pacific or from South America could strike the County coastal areas from the south to southwest; and a tsunami generated along one of the faults within the Santa Barbara Channel could affect much of the County coastal areas. The Channel Islands do not provide adequate protection for the County coastal areas.

COUNTY PARKING  
Added

### HISTORY OF THE HAZARD

The worst recorded tsunami to hit California was in 1812. An earthquake occurred in the Santa Barbara Channel, and the resulting waves are reported by some disputed sources to have been up to 50 feet above sea level at Gaviota (Richter, Pg. 113).

COUNTY PARKING  
Added

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COUNTY PARKING  
Added



at least 15 feet above sea level at Ventura. Crescent City has been the scene of numerous recorded seismic sea wave incidents. Widespread damage and some loss of life occurred in 1964 following the Alaskan earthquake.

Tsunamis from the 1964 Alaskan earthquake destroyed a number of towns in Alaska and cause over one-third million dollars of damage to the Los Angeles-Long Beach harbors and approximately thirty-five thousand dollars of damage to the marinas in this County. The marina damage in Ventura County, which was mainly to the channel banks, was caused by the rapid and extreme changes in sea level.

*Reinclude County Paragraphs*

The historic record indicates that there is a small probability of occurrence of a major tsunami in Ventura County. Statistically it has been over 160 years since the last major tsunami; but many smaller, unrecorded tsunamis may have occurred.

#### DEFINITION OF THE VARIABLE HAZARD ZONE

The uncertainty of local effects makes the definition of the hazard zone difficult, but the east-west trending faults in the Santa Barbara Channel area seem to intensify the hazard parallel to them, thus increasing the possibility of high waves in the north and south coast areas.

*New wording*  
Hazard Plate V delineates the hazard zone in 5' increments up to 25 feet above sea level. The basis for the location of the hazard zone on the Oxnard Plain is the estimated 15-foot-high wave of 1812. As an added safety factor, the hazard zone in this region is extended up to 25 feet in elevation. This estimated level will allow for the probable subsidence of the plains area as well as a possible rise in sea level since 1812. It is possible that waves larger than those ever recorded could occur, but there is no way to predict what level they would reach.

The recommended areas of evacuation in the event of a tsunami are all areas below the aforementioned elevations of within a mile of shore (whichever is of the greatest inland extent), and two miles inland on the Santa Clara River, Ventura River, and Calleguas Creek. The reason for extension of the zone two miles upstream from the mouths of these watercourses is that a tsunami can generate a bore (a wave moving upstream) in flowing water and travel farther inland.

(See Plate V)

## NATURE OF INFORMATION

Information on the tsunami of 1812 is from mission records at Santa Ynez, Santa Barbara, and San Buenaventura. The most recent information seems to discredit much of the information from Santa Ynez and Santa Barbara since it was from witnesses whose remembrances were recorded many years after the event. However, the records from Ventura were recorded at the time of the event and are believed much more accurate. The historic data on tsunamis in Ventura County, while limited, is generally accepted as accurate.

## GENERAL MANAGEMENT RESPONSIBILITY

There is no known way to end or even to feasibly mitigate the tsunami hazard. Since the occurrence of tsunamis are very infrequent and many of them can be predicted hours ahead of time, a warning system seems to be the best method of alleviating the hazard.

## INVESTIGATION

Research on tsunami hazards is continuing on virtually all levels of government. UNESCO's International Oceanographic Commission (IOC) has established an International Tsunami Information Center in Honolulu, to promote further research and exchange of information concerning tsunamis. The National Ocean Survey (NOS) and U.S. Coast and Geodetic Survey (USCGS) of the National Oceanic and Atmospheric Administration (NOAA) are the primary investigators of tsunamis in the U.S. The U.S. Geologic Survey (USGS) is also assisting in the basic research of processes involved in the generation of tsunamis. The California Division of Mines and Geology is investigating the extent of hazard to California. The Division will generally investigate the threat to Ventura County as part of the special geological investigation they will undertake in Ventura during the latter part of 1974.

## WARNING

Warnings of impending tsunamis are generated by the USCGS Seismic Sea Wave Warning System (SSWWS) and the Alaskan Regional Tsunami System. They issue both Seismic Sea Wave Advisories, when an earthquake of significant magnitude has occurred in an area susceptible to tsunami generation, and Seismic Sea Wave Warnings, when tide stations confirm the generation of a tsunami (See illustration 9.2).



These Advisories and Warnings are transmitted by NOAA Satellite to the California Office of Emergency Services (OES). These warnings are evaluated by the Warning Control Officer and Director of OES and if necessary a statewide warning is issued to the local Sheriff, along with the estimated time of arrival of the wave. (See illustrations 9.2 & 9.3). Ultimately, the Sheriff has complete responsibility whether to alert the coastal areas. If it is decided that an evacuation is necessary, the Sheriff will call the Police Departments of Oxnard, Ventura and Port Hueneme, the Highway Patrol, Fire Department, and the Director of Disaster Services. After this is accomplished, appropriate jurisdictions and departments are alerted. It is the responsibility of each jurisdiction to decide whether or not their population will be alerted. Ultimately, the evacuation of the coastal areas (See Plate V) is voluntary on the part of the residents. The alerting agencies can only warn people of the hazard--they cannot force evacuation. However, they can control re-entry into a hazard area.

Unfortunately, neither the Seismic Sea Wave Warning System nor any other known means of monitoring can provide sufficient warning time to allow for evacuation of coastal areas should a tsunami be generated along one of the faults within the Santa Barbara Channel. The arrival time for such a wave at any point on the coast would only be a matter of minutes. The only warning prior to arrival of a possible tsunami would be the ground shaking experienced from the earthquake. Such shaking would be felt in advance of the tsunami arrival and, if heeded, could allow sufficient time for people to move to higher ground.

#### ALLEVIATION

The threat to human life can be nearly eliminated by an effective warning system when advance notice is available. The county territory as well as the cities of Oxnard and Port Hueneme have an efficient warning system in effect which can alert the entire affected population, if enough warning time is available (refer to Warning section). Because advance notice may not always be possible (such as in the case of a tsunami originating in the channel), and because warning systems cannot alleviate the threat to property, various jurisdictions may wish to evaluate land uses as a means of insuring minimal loss of life and property. As indicated earlier, there is a small probability of the occurrence of a tsunami in Ventura County. Therefore, the most practical means of alleviation is an effective warning system. Whether or not land use controls are employed by the various jurisdictions depends upon its perception of the probability of the hazard occurring and the costs of restricting certain land uses.



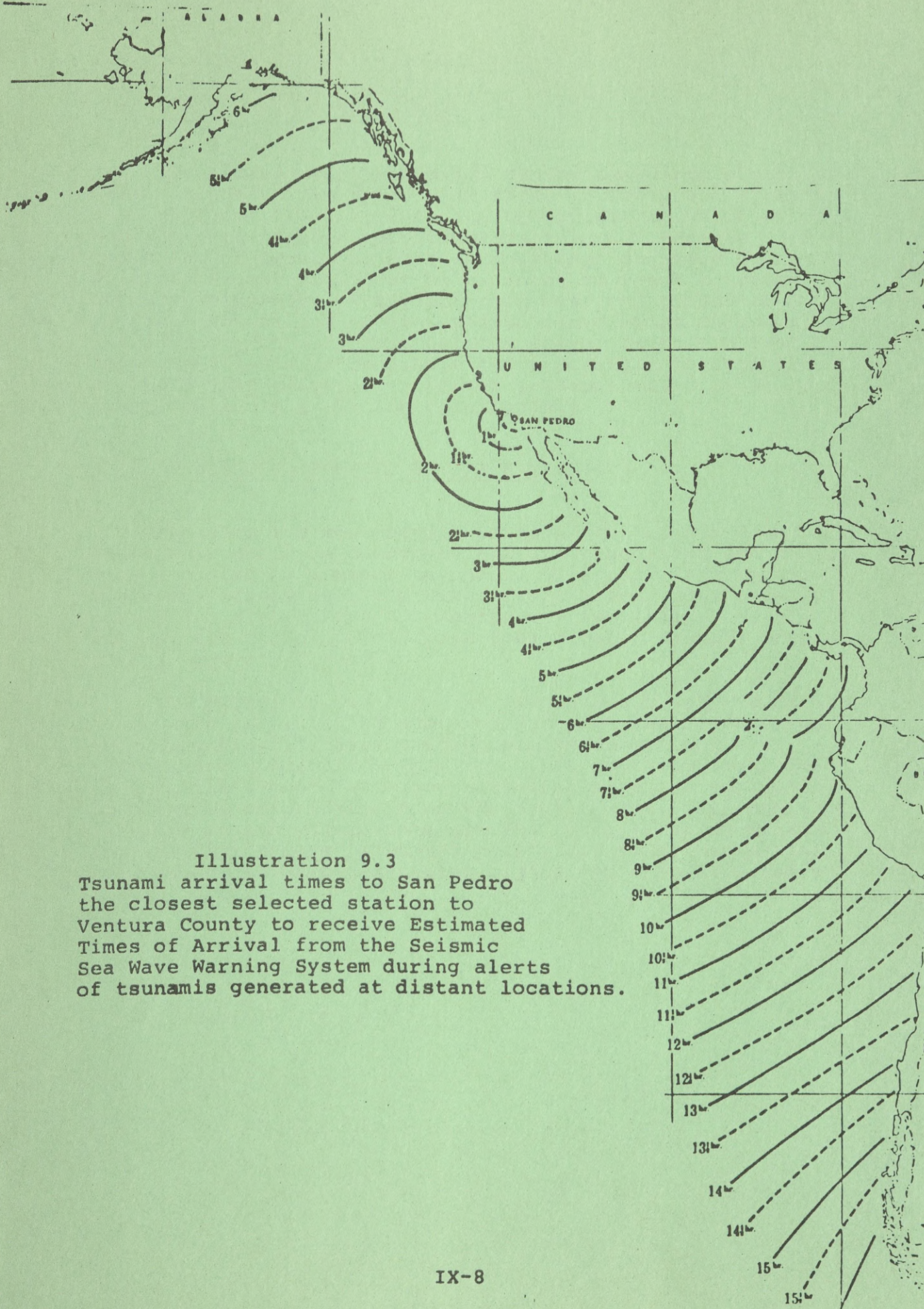


Illustration 9.3  
Tsunami arrival times to San Pedro  
the closest selected station to  
Ventura County to receive Estimated  
Times of Arrival from the Seismic  
Sea Wave Warning System during alerts  
of tsunamis generated at distant locations.



## LOCAL INVENTORY OF THE HAZARD

The hazard zone is limited to the immediate shoreline area. Plate VA has 5 foot, 10 foot, 15 foot, and 20 foot contour lines drawn to indicate the extent to which an unusually large tsunami might extend inland. Because of intervening obstructions such as buildings and sand dunes, a large tsunami would not be expected to reach a certain contour uniformly. A tsunami that wets the ground at a 20 foot contour can be expected to cause minor damage at the 15 foot contour, more serious damage at the 10 foot level, and cause major damage and a possible loss of life at the 5 foot elevation. Lesser tsunamis would cause reduced damage in a similar relationship.

## LOCAL RESOURCES AFFECTED BY THE HAZARD

Based on the most severe hazard, the McGrath Beach State Park could be disrupted and its vegetation and facilities impacted by a major tsunami. This park, the Harbor Boulevard bridge over the Santa Clara River, the Mandalay generating station and the nearby oil facilities are all susceptible to possible damage from a major tsunami originating from any direction.

The Oxnard Shores area, Hollywood Beach and the Marina area, with its existing and proposed high density development, are slightly less susceptible to damage but the effects are difficult to predict. The southern area, including the Ormond Beach generating station, is susceptible to tsunamis originating from the south. The vital public services in the hazard zone are the two generating plants and the City sewage treatment plant. It is probable that only one of the two generating plants would be affected at a time.

# FINDINGS

## PROBABILITY OF OCCURRENCE

A tsunami threat exists to the entire coastline of the city. Based upon historic record, the possibility of a major tsunami hitting the area seems remote, but due to the unpredictable nature of geologic movements, could be generated at any time. The probability of a tsunami from the west is slightly higher than one from the south. The last major wave struck from the Santa Barbara Channel in 1812 but minor tsunamis have been recorded as recently as 1964.

## SEVERITY OF THE HAZARD

Historic records in Ventura County (and throughout the world) reveal that the severity of tsunamis vary greatly, but a major tsunami could cause extensive damage within the designated hazard zone and possible loss of life if the warning system is inadequate.

COUNTY  
SENTENCE  
Added

## RESOURCES AFFECTED

In the event of a major tsunami, loss of life and property damage could occur within the hazard zone. There are numerous residential and recreational areas in the hazard zone as well as some vital public services that could be affected.

## NATURE OF INFORMATION

The validity of conclusions arrived at in this study of tsunamis is a function of the information from which they were derived. It should be noted therefore that while local data is limited, it does provide a basis for making general indications of the areas that could be affected by a major tsunami and that damage could occur.

## OTHER FINDINGS--

Since tsunamis themselves cannot be eliminated, the alternative means of reducing the hazard would be through the protection of people and property. Unless a tsunami originated from within the channel or other source close to the city, there would generally be adequate time to warn people and thus prevent any loss of life. While warning systems, however, do not prevent property losses, they can alleviate the loss of life. Land use controls within the hazard zone are another method of alleviating the possibility



of damage to property, or loss of life when there is not time for a general warning. However, the entity determining land use controls, must take into consideration the infrequency of recent occurrence, the lack of detailed information from the historic record, and the appropriateness of the controls.

## RECOMMENDED ACTIONS - TSUNAMI

1. Develop a contingency plan for tsunami and update if necessary. Include consideration of areas to be warned and evacuated under the Tsunami Warning Plan and contingency plans for alerting boat owners so that boats can be moved to the open sea.
2. Investigate the feasibility of a program to protect existing sand dunes as possible barriers to tsunami inundation.
3. Insure that the existing jetties and breakwaters adjacent to Channel Islands Harbor are maintained at the minimum of the existing levels, or improve based on changes in the state of the art.



# SAFE MRC

# SAFETY

SEICWHE



SEICHE SECTION - X-1 thru X-5

The page listed below has not been changed.

X-1

The pages following have been changed.



# GENERAL DISCUSSION

## GENERAL DESCRIPTION

A seiche (pronounced sash) is a wave or series of waves or oscillators, set up in an enclosed or partially enclosed body of water by wind, earthquake or landslide. In a large body of water, wind can set up an oscillation that will send waves above the normal water line. These oscillations can be visualized by imagining a pan of water that is gradually tilted until waves start to slosh out. This type of seiche usually occurs only when the body of water is located in an unusual position in relation to local wind patterns.

The most common seiches are set up in lakes and bays, either directly or indirectly by earthquakes. The shaking of an earthquake can set up large and destructive oscillations that can send waves tens of feet above normal lake level. In harbors and bays, these waves can destroy harbor and shore facilities. Indirectly, tsunamis, by causing a rapid change in sea level or more commonly by the wave itself, can set up smaller internal oscillations in bays and harbors. These seiches are very similar to tsunamis, but the waves are smaller and of lower energy. Fault displacement under a reservoir can either displace a quantity of water or tilt the lake bed suddenly, producing waves by either effect. Earthquakes can also trigger landslides and these, whether triggered seismically or in some other manner can be by far the most destructive type of seiche (see Landslide/Mudslide Hazard). A landslide into an enclosed body of water can produce massive waves, especially on the shore opposite the slide.

Although it is possible to measure the slow ground surface movement that sometimes precedes a landslide, in general, methods for the detection of landslides and other seiche-producing agents are still under study.

## GENERAL EFFECTS OF THE HAZARD

### PRIMARY THREAT

The primary threat from a seiche is to structures and facilities in or very near a lake, harbor or bay. Boats and their wharfage can be heavily damaged by seiches, and buildings and campgrounds can be inundated. Only in the case of an extremely severe seiche, a rather rare occurrence, would loss of life be likely from the seiche itself. This is not the case, however, with the secondary effects.

## SECONDARY THREAT

The secondary effects of a seiche can often produce more damage than the seiche itself. Large seiches can overtop the dams of man-made lakes and reservoirs, causing flooding in the areas downstream. This overtopping can also wash out earth-fill dams, causing their complete collapse.

The extent of most seiches is small, usually no more than ten to twenty feet above water level, and the duration is short, usually only a few minutes. However, a landslide can displace a wave that could travel hundreds of feet up the opposite shore of a body of water. Also, tsunami-caused seiches can last for many hours due to the possible rejuvenation of the seiche by each passing tsunami crest; however, each seiche would last only a few minutes and be of decreasing severity.

It appears that the actual threat that is posed by seiches is small, and it is probably the most remote of the hazards studied, although it may not be the least severe.

## GENERAL INVENTORY OF THE HAZARD

### LOCATION OF THE HAZARD

The hazard exists in all the lakes in the county, the two marinas and the harbor. The lakes that are impounded by earth-fill dams could have the greatest hazard potential. These lakes are Lake Bard (Wood Ranch Reservoir), Lake Piru and Lake Casitas. The Santa Clara River Valley could also be affected should a seiche-caused dam failure occur on Castaic Reservoir or Pyramid Reservoir. (See Plate V)

COUNTY  
SENTENCE  
Added

### HISTORY OF THE HAZARD

No recorded seiche has ever occurred in Ventura County, but the damage to the marinas from a seiche could possibly be similar to that caused by the tsunami of 1964 (see Tsunami Hazard).

In Italy, in 1963, a landslide into Vajont Reservoir caused a seiche that traveled up 800 feet on the opposite bank of the lake and swept over both abutments of the dam (the world's highest thin arch concrete dam) to a height of 328 feet. The water completely destroyed the town of Longarone below the dam, with a loss of over 2,000 lives. After all this, the dam itself was still standing.



## DEFINITION OF THE HAZARD ZONE

The hazard zone surrounds all of the existing reservoirs and lakes, the harbor and the two marinas, up to an elevation of 10 feet above the water level. The ten foot figure is an estimate due to lack of information about the hazard.

COUNTY PARAGRAPH  
added

## DEFINITION OF THE HAZARD ZONE

There is very little information available on seiches. There is no historic record of seiches occurring in Ventura County. Due to the indefinite nature of the triggering mechanisms, it seems doubtful that enough information will ever be known for general prediction of the hazard for planning purposes.

## GENERAL MANAGEMENT RESPONSIBILITY

There is no way to alleviate the effects of possible seiches except by prohibiting construction within the hazard area. The State Division of Mines and Geology will in a general way, examine the hazard further within the next year.

## RESOURCES AFFECTED BY THE HAZARD

~~These are the local resources affected by the hazard~~

COUNTY SENTENCE  
added

The homes, boat docks and boats at the marina could be affected, as could the wharfage and facilities at Port Hueneme. In the case of a seiche-caused dam failure, all the areas below that dam could be affected.

## FINDINGS

A hazard from seiches does exist in the County, but the threat is considered extremely remote especially in the inland water way. Only facilities in, or very near, enclosed bodies of water could be immediately affected.



## RECOMMENDED ACTION - SEICHE

1. Insure that the existing jetties and breakwaters adjacent to Channel Islands Harbor are maintained at the minimum of the existing levels, or improve based on changes in the state of the art.





SAFE

SUBSIDENCE



SUBSIDENCE SECTION - XI-1 thru XI-10

Each page in this section has been changed.

# GENERAL DISCUSSION

## GENERAL DESCRIPTION

Subsidence, or the sinking of the land surface, is a worldwide problem. In Japan, nearly three million people in Tokyo and Osaka now live in areas below the high tide level. (California Geology, p. 149). Mexico City has subsided twenty five feet. (Geology, Seismicity and Environmental Impact, 1973). Numerous other examples exist which can be related to human activities.

In California, four types of subsidence caused by human activity, have been identified (in addition to those forms of the hazard which occur naturally). Named according to the action which causes the subsidence, these four are: Groundwater Withdrawal Subsidence, Oil or Gas Withdrawal Subsidence, hydrocompaction Subsidence and Peat Oxidation Subsidence. Of all of these types, Groundwater Withdrawal Subsidence, which generally occurs in valley areas underlain by alluvium, is the most extensive and the impacts most costly. (Urban Geology, p. 43).

Basically, the process by which this first and most important type of subsidence occurs involves the extraction of a large quantity of water from an unconsolidated aquifer. As this water is removed from the aquifer, the total weight of the overburden which the water used to help to support, is placed on the alluvial structure. Where this is unconsolidated, it can be compressed.

If fine-grained silts and clays make up portions of the aquifer, the additional load can squeeze the water out of these layers and into the coarser grained portions of the aquifer. *All of This* compaction produces a net loss in volume *of sediment* and hence a depression in the land surface. A *very somewhat* similar sequence of events *sometimes can* lead to subsidence with oil and gas withdrawals (California Geology, p. 148).

Current studies of

*groundwater subsidence show six major factors that influence the degree of subsidence. These are:* degrees of groundwater confinement, thickness of aquifer systems, individual and total thickness of fine-grained beds, compressibility of the fine-grained layers, probable future depth of wells, and probable future decline in groundwater levels. All of these have a direct bearing on the subsidence,

*Substantial or initial (first-time) reductions in the water levels often have a greater effect than subsequent losses.* The two other forms of subsidence, peat oxidation and hydrocompaction, are rather localized and no evidence exists which indicates their occurrence in Ventura County (Urban Geology, p. 47).



Though the focus of this discussion has been on that subsidence which is caused by human activities, it is important to understand that subsidence can and does occur as a natural process. Surface deformation can be the result of the natural compaction of loosely consolidated alluvium or tectonics. Subsidence has been traced to the settling of geologically new sediments and to downwarping which accompanies crustal folding.

Subsidence can also be caused by several kinds of natural processes. Perhaps the most hazardous for Ventura County is that which might be caused by seismic shaking in the area of the Oxnard Plain. That area is known to be subsiding, thus exhibiting an intrinsic instability. The addition of strong ground motion from an earthquake could result in the liquefaction of fine-grained materials. This would cause a loss of ground support and the land surface could settle (Seismic Hazards, 1974). Unlike other forms of subsidence, this one could occur in a short period of time.)

NOTES: The subsidence is caused by several kinds of natural processes. Perhaps the most hazardous for Ventura County is that which might be caused by seismic shaking in the area of the Oxnard Plain. That area is known to be subsiding, thus exhibiting an intrinsic instability. The addition of strong ground motion from an earthquake could result in the liquefaction of fine-grained materials. This would cause a loss of ground support and the land surface could settle (Seismic Hazards, 1974). Unlike other forms of subsidence, this one could occur in a short period of time.)

In terms of controlling subsidence, it is important to recognize that combinations of the above types may cause the change in level in a specific area. Before any steps in controlling subsidence can be attempted, a comprehensive investigation into what the cause or causes are, will be necessary. If human activity, such as extraction of fluids, is determined to be the key then regulatory action could halt the subsidence. However, if natural processes are responsible, control is much less easily exercised assuming it is even possible.

## PHYSICAL PROPERTIES

The surface deformation resulting from oil extraction has been described as "... differential subsidence of lands centering on the fields, inwardly directed horizontal displacement and faulting." Urban Geology, p. 46). The first of these, differential subsidence, is both the most common and the most widespread surface manifestation of subsidence. A large bowl shape, extending beyond the production area is commonly identifiable.

Extensive oil field subsidence is a relatively rare phenomena known to occur only in a limited number of fields, namely: Wilmington and Inglewood Oil Fields in Los Angeles County, Lake Maracaibo in Venezuela, a small field in Texas (Goose Creek) and a gas field in Japan (Niigata). Relatively small amounts of subsidence have occurred in many other oil fields. Detailed analytical data is generally

\*Dr. Mayuga is the Chief Geologist for the City of Long Beach.

*lacking since the rates and extent of sinkage have not been serious enough to cause damage. Also, at least portions of the subsidence often might be attributable to groundwater withdrawal rather than oil production operations.*

Oil extraction has resulted in the greatest *vertical* subsidence on record (elsewhere, not in Ventura County). In the Wilmington Oil Field, near Long Beach, a drop of 29 feet was recorded in the period 1928 to 1972. In 1966, a program of repressurization in conjunction with the secondary recovery of oil commenced which successfully halted the subsidence by 1972 (Urban Geology, p. 46).

A subsidence of similar magnitude *has occurred* in the San Joaquin Valley. This was recorded in 1969. A key difference between this case and the previous one, however, was that here the cause has been determined to be the extraction of groundwater (Urban Geology, p. 46). *Worldwide, land subsidence due to groundwater extraction is widespread, often measuring up to six feet or more and covering thousands of square miles.*

## MEASUREMENT AND DETECTION

Forecasting the extent, rate and magnitude of subsidence is difficult. A series of benchmarks must be established to measure any vertical change. This will, over time, provide information regarding the location of subsiding land and show that area which is subsiding fastest. From this point, core samples of the area would have to be compaction tested to determine *possible* ranges of future consolidation. Combining this information with fluid withdrawal rates (if any extraction is occurring)

*sometimes enable reasonable forecast to be made.* From this point, the desirability of either planning for the subsidence in terms of regulated land use or counter-measures to halt the subsidence could be assessed.

A successful attempt to reduce the amount of subsidence has been made in the Santa Clara Valley, south of San Francisco starting in 1964. While still sinking, a reduction in the rate of subsidence by about 95% was achieved when large amounts of imported surfact water allowed a reduction in the tapping of the valley's underground sources. The water level subsequently rose about 60 feet. In a study of this process, a research hydrologist has concluded that a complete halt can be put to Santa Clara's subsidence and possibly a reversal can be achieved, if the water table is raised sufficiently. (California Geology, p. 148).

Another source lists the possible means by which withdrawal caused subsidence can be curbed. Prefacing



these methods with the statement that any attempt to stop subsidence is a major undertaking, this article states that the technique employed depends on the structure of the aquifer. In areas of unconfined aquifers, reduced withdrawal or increased recharge through water-spreading is necessary. Confined aquifers or oil bearing zones must be repressured by injection wells in order to stop subsidence. This

method has been used in only one instance in the *Wilmington Oilfield* for the primary purpose of arresting subsidence. However, oilfield repressuring and pressure maintenance by water and/or gas injection has frequently been used to increase oil production.

## GENERAL EFFECTS OF THE HAZARD

As with the destruction which is caused by expansive soils, that caused by subsidence is generally not of an immediate or violent nature. Except when prompted by seismic shaking, the compaction of alluvium and settling of the land surface is a process which consumes years. Undoubtedly, since most subsidence damage occurs very slowly over a long period of time, it is assigned an unwarranted lack of attention. Much money is lost through either premature abandonment or repair costs. It now appears that at least in the case of withdrawal subsidence, proper management could prevent continuing damage.

## PRIMARY EFFECTS

Subsidence which results from groundwater withdrawal can be responsible for numerous structural effects. Most seriously affected are long surface infrastructure facilities which are sensitive to slight changes in gradient. Within this group, wells, canals, sewers and drains especially have experienced functioning and structural failure. In a 1970 projection, losses to the year 2000 were estimated to reach about \$26,000,000 for subsidence in California. Water withdrawal subsidence accounts for a large part of this. (Urban Geology, p. 11).

Subsidence caused by oil and gas extraction is similar in effect to that caused by water extraction. In one example, oil extraction was responsible for \$100,000,000 in damages to various facilities and structures in the Long Beach and Los Angeles Harbors and adjacent areas overlying the Wilmington Oilfield.

Hydrocompaction can also create subsidence conditions as can peat oxidation.

(Urban Geology, p. 48). Both of these, however, are common only in areas outside of Ventura County so they are of minor or no consequence here.

## SECONDARY EFFECTS

Inundation must be viewed as a potentially serious secondary effect of subsidence in Ventura County. Both the ocean and the Santa Clara River could flood into depressed areas of the Oxnard Plain. If a naturally low area is further depressed by the action of subsidence, it is reasonable to assume that the damage will be more severe than if the subsidence had not occurred. In the case of the coastal portion of the Oxnard Plain, beach erosion could extend further inland due to the additional loss of elevation caused by subsidence.

The Santa Clara River poses another problem. It is building up sediments within its present course while no longer adding deposits to the remainder of the Oxnard Plain. If the old deposition sites have had an opportunity to consolidate and establish a gradient difference between themselves and the present river course, a flood could change the river course and thus inundate the lower land. Extraction of oil and/or water could increase the potential for such an occurrence and increase the area affected if they added to the subsidence.

Numerous other secondary effects can be identified. Most of these are related to the disruption of services provided by various structures which might be damaged by subsidence. Those facilities most commonly affected are canals, wells, pipelines, drains, and related facilities.

## GENERAL INVENTORY OF THE HAZARD

### LOCATION OF THE HAZARD

A very significant area in Ventura County, the Oxnard Plain, is experiencing subsidence. This area has been monitored by the U. S. Coast and Geodetic Survey since the 1930's. Up to 1965, one large area was subject to subsidence of between 0.04 and 0.05 feet per year. (Coastal Geology, p. 5). A single point located at Hueneme Road and Highway 1 has dropped 1-1/2 feet in just twenty-one years. Records to 1968 show a dozen benchmarks that have settled a foot in a fifteen to twenty year period.

Hazards Plate VI of the Seismic and Safety Elements shows three subsidence zones. These zones are: probable subsidence that is on the order of 0.05 feet/year; probable subsidence of less than 0.05 feet/year; and the estimated limit of areas presently affected by subsidence. The first and most severe of these categories reaches roughly from Pierpont in the north to the Mugu Lagoon in the south and extends east on the Oxnard Plain to the junction of Highways 1 and 101 (Public Works). The last two categories extend inland from the more severe subsidence on the Oxnard Plain



ultimately up through the Santa Clara River Valley to a point just east of Piru.

#### NATURE OF INFORMATION

Definite and detailed establishment of the rate and/or cause of subsidence in Ventura County has not been made. Public Works information indicates four possible causes: natural consolidation of alluvium, tectonic deformation, water extraction, and/or oil and gas extraction.

*The specific cause or causes of Ventura County subsidence can be reasonably determined. The current Water Resources Management Study being conducted by the State Department of Water Resources is anticipated to provide detail information concerning groundwater withdrawals, water table drop and results of such replenishment operations as have been conducted to date. Extensive data concerning oil and gas withdrawals and geological detail on oil and gas fields are available through State Division of oil and gas, petroleum geological studies and information from oil producing firms. If, as a result of thorough analysis of these data, it is found that human activities were responsible for the subsidence then measures could be taken to halt or even reverse the process.*

*Current data indicates that groundwater has been extracted from the aquifers underlying the Oxnard Plain at a rate that exceeds the rate of replenishment. Overdraft of water for agricultural, domestic and industrial uses has increased from about 32,000 acre feet per year in 1959 to about 44,000 acre feet per year. The water table has dropped in some areas as much as 55 feet below sea level as a result of this continuous overdraft. (Water Quality Control Plan, p. 27).*

*If the subsidence is widespread, slow in rate, spatially and temporarily related to water extraction, then this (water extraction) must be assumed to be the primary cause.*

As part of a regional effort extending from Santa Barbara to Los Angeles, some 500 to 600 benchmarks are being monitored in Ventura County by a federal agency to determine the extent of subsidence. Readings were taken in 1970 and a second series, five years later, should result in a report on areas of significant change.

While not aimed at identifying causes, this report coming out next year, will at least establish locations and amounts of subsidence (Powell).

The County Surveyor is participating in this program which is being conducted by the National Ocean Survey, formerly the U. S. Coast and Geodetic Survey. Preliminary data, does indicate that subsidence is occurring on the Oxnard Plain. Secure figures on rate, amount and extent of the subsidence here and elsewhere, will have to wait until the publication of the 5-year report (Powell). Areas requiring more detailed studies could be determined based upon the information in the report.

*The amount of elevation survey data is somewhat limited prior to 1969. In 1969 to 1971 many additional benchmarks have been placed by the County Surveyor throughout Oxnard and vicinity. It will, therefore, be possible in future years to determine with some precision the exact limits and rates of subsidence throughout the Oxnard area. Elevation data from the 1975 surveys can be compared to the 1969 and 70 readings. These data will be available by fall of 1975.*

*If the 1975 survey reports indicate continuation or any significant increases in rates of land sinkage, it will be worthwhile to undertake detailed studies to correlate water management data and changes in water tables in order to determine the probable influence of groundwater withdrawals on surface subsidence. It will also be desirable to undertake detailed review of oil and gas extraction operations and geological structures to determine whether these operations might be a significant contributing cause to past and possible future land subsidence. A system of shallow compaction recorders could be installed that would accurately locate compacting zones if extraction of ground water is the primary cause of subsidence.*

#### GENERAL MANAGEMENT RESPONSIBILITY

Studies of water withdrawal subsidence have been conducted by the U. S. Geologic Survey and the California Department of Water Resources. Adverse effects are moderated to some degree by State and Federal projects which provide surface water to areas with dropping groundwater tables. In areas where such assistance is not available or where a project does not make up all of the difference, then control of the problem is responsibility of local



water conservation districts.

*In Ventura County replenishment operations are being operated by United Water Conservation District.*

Subsidence resulting from oil and gas extraction has been investigated by the U. S. Geologic Survey, California Department of Water Resources and the California Division of Oil and Gas.

*The Division of Oil and Gas has responsibility for maintaining a monitoring and, if necessary, regulatory program to control oil and gas extraction operations which are determined to cause damaging subsidence. The Division, under some circumstances, can require oil producers to institute repressuring operations. Coordination with local agencies and expansion of the program to areas of need are the only changes the State has identified as necessary for proper control of this hazard. (Urban Geology, p. 11).*

As stated previously, several agencies are involved in the control of this hazard in Ventura County. The first step in this direction, the inventory and investigation of subsidence, is being undertaken. When this effort is completed, a better understanding of the nature of the problem should afford the concerned agencies an opportunity to determine the need for special monitoring and, ultimately, to control and/or plan for it.

# FINDINGS

## FINDINGS

### PROBABILITY OF OCCURRENCE

There is minimal land subsidence occurring in Oxnard and vicinity. It will probably continue and could increase if extraction of fluids from this area is increased without offsetting replenishment.

### SEVERITY OF THE HAZARD

Measurements to date indicate that a maximum drop on the order of 1.5 (.025 average rate per year) feet has occurred over the past 30 years at one measurement point on the Oxnard Plain near City limits of Oxnard. The area has generally subsided 0.04 to 0.05 feet per year. The sinkage identified to date does not indicate a significant present hazard. Further surveying is continuing and should better define the magnitude of this problem and possibility of serious future hazard potential.

### RESOURCES AFFECTED

Property damage due to subsidence can and does occur over a long period of time, particularly where marked differentials in rate occur within a relatively small area and/or where flooding hazards also exist. Loss of life would probably occur only as a secondary effect of subsidence, such as the result of flooding. Drainage courses, wells, utility lines and large area structures are potentially the most vulnerable to damage.

### NATURE OF INFORMATION

A possibility exists that such potential subsidence damage, as is caused by human activity, can be controlled. Until information is fully developed, little can be done to plan for or respond to this potential hazard. Further information on extent and rate of subsidence will be available from the scheduled 1975 Bench Mark Surveys conducted by the Ventura County Surveyor. The current Water Resources Management Study being conducted by the State Department of Water Resources in cooperation with the County of Ventura and due to be completed in December, 1975, will provide additional information in regard to groundwater management. The water studies are expected to include detailed information on groundwater withdrawals, present and proposed replenishment operations, well water levels, etc. These data will make possible reasonable determination of probable contribution of groundwater withdrawals as a total or partial cause of subsidence. Extensive data on oil field geology and oil, water and gas withdrawals by oil production operations is also obtainable and can be used to judge possibility that these operations could contribute to subsidence problems.



## RECOMMENDED ACTIONS - SUBSIDENCE

1. In cooperation with the County Surveyor and National Ocean Survey, develop a program to fully monitor subsidence activity in Oxnard and its immediately adjacent areas.
2. Maintain a full, up-to-date library of data concerning the geology of the Oxnard Plain, particularly those portions lying within the Oxnard sphere of influence. This data should include all available information derived from past oil and water well drilling activities.
3. Assemble and analyze such information concerning groundwater management and oil production operations in Oxnard and its vicinity as available from past completed studies. Obtain and regularly review all related future studies. Regularly secure current data on;
  - a. Water well levels and water management, and,
  - b. Petroleum production operations.
4. Take such actions that may be appropriate to insure that the necessity of control of land sinkage is an important consideration in water management recommendations that are included in the current study being conducted by the California Department of Water Resources. Support implementation of the water management program recommended as a result of this study to insure that water replenishment measures are sufficient to substantially restore and maintain water tables in the southwestern area of the Oxnard Plain, and monitor results from the standpoint of control of land subsidence.
5. If analysis of oil production operations indicates any significant potential cause of past and future subsidence, restoration and maintenance of oil reservoir pressures will be required.



# SEISMIC SAFETY

EXPANSIVE SOILS



EXPANSIVE SOILS - XII-1 thru XII-9

The pages listed below have not been changed.

XII-4

# GENERAL DISCUSSION

## GENERAL DESCRIPTION

Expansive soils (which are identical to soils referred to elsewhere as having a shrink-swell potential) are those which are generally clayey, expand or swell when wetted and contract or shrink when dried. Wetting can occur naturally in a number of ways, i.e. absorption from the air, groundwater fluctuations, as well as from other sources, i.e., lawn watering, broken water or sewer lines.

In the 1960's, expansive soils caused severe damage to many housing developments in the Thousand Oaks and Los Posas areas. While significant construction deficiencies were noted, more conservative engineering design provisions and regulations were initiated which effectively eliminated the hazard to future construction. Subsequent engineering studies have resulted in tests and design procedures which provide safe and economical design for expansive soils. Local building ordinances have incorporated these concepts in recent years.

The only area relating to expansive soils, which must continue to receive special attention, is downslope soil creep in hillside areas. As an expansive soil expands and contracts it tends to move downslope in response to gravity. Recognition of this condition by all parties should not be overlooked. This condition may require flatter slopes, soil removal and special landscaping and irrigation treatment.

The tremendous force exerted by the expansion of soils is generally not understood by the average person and quite often results in requests for waiver of the soil test as "unnecessary." Such a complacent attitude is unjustified. In no way should the ability to provide designs for expansive soils give one the feeling that expansive soils are no longer a factor to be considered.

## GENERAL EFFECTS

Fully 20% of this nation's land area will be affected by expansive soil movements during the period of the average person's lifetime. Typically, expansive soils are located in areas of moderate slope which are coincidentally the areas generally most attractive for intense, urban type uses. The movement of expansive soil may be slow, progressing over a period of years. Commonly, this movement is associated with seasonal or even longer wet/dry cycles. (Civil Engineering, 1973, p. 49).



## PRIMARY EFFECTS

These soil movements can cause structural damage to houses, pavement and utilities in two ways. First, the expansion of the soil can cause it to heave and thus place direct pressure on a structure. Alternately, soil expansion can lead to the loss of support under part of a structure. This can occur during swell conditions if the saturated soil shifts due to the weight of the structure, or in dry conditions if the soil shrinks and support is withdrawn.

Damage can range from the impaired functioning of doors and windows through plaster and foundation cracks to total destruction in extreme cases. Often water from a leaking sewer line is responsible for causing the soil expansion which damages a home. Annually, some 250,000 homes are built on expansive soils in the United States and 10% of these will experience "significant damage." Nationally, at least \$2.3 billion is lost annually due to damage to houses, buildings, roads and pipelines. Records exist of expansive soils causing damage to highways, buildings, reservoirs, swimming pools, canals and utilities of all types. (Civil Engineering, 1973, p. 49).

## SECONDARY EFFECTS

The main secondary effect of expansive soils to structures not designed against the condition is monetary loss.

## GENERAL INVENTORY

### LOCATION

Three expansive soil zones have been mapped; and they appear on Hazards Plate VI. Derived from the Soil Conservation Service's 1970 Soil Survey, this map designates high, moderate and low expansive zones. This is a generalized version of individual soils maps. It generally indicates those areas where expansive soils are present. (See Soil Survey in Ventura Area, 1970). The classification of soils as shown on Hazards Plate VI is a condensation of eight soil classes established by the "Soil Conservation Service". The extent of linear expansion can be precisely determined; however, it may vary at different depths and is easily altered by construction activity. As a result, the low, moderate and high designation used on Plate VI is purely a judgement statement and should not be construed to indicate the degree of hazard.

The classification in this report differs from that shown in the Uniform Building Code. Since the U.B.C. is, at present, more precise and is required by law, it will continued to be used by Oxnard as a protection against expansive soil hazards. The difference between the two is not great enough to cause concern.

<u>UNIFORM BUILDING CODE</u>		<u>PLATE VI</u>	
<u>INDEX</u>	<u>CLASS</u>	<u>INDEX</u>	<u>CLASS</u>
0 - 20	Very low	0 - 30	Low
21 - 50	Low	31 - 60	Moderate
51 - 90	Medium	Above 60	High
91 - 130	High		
Above 130	Very High		

A more specific map was prepared for each entity, and the degree of expansiveness may not conform precisely to Plate VI even though both utilize identical categories of expansive soils. The reason for this is that the local maps were taken from the non-generalized maps developed by the Soil Conservation Service and thus display a greater level of detail.



While the general and specific maps are quite useful for locating large areas of potential hazard, it must be stated that they cannot be used in lieu of site inspection when construction is considered. Experience in the Building and Safety Department indicates that a soils test at the specific site is necessary because this hazard is so localized in nature.

## HISTORY

In the early 1960's numerous homes were lost and many more were severely damaged in the Shadow Oaks Tract. Adjacent to the City of Thousand Oaks, this area experienced soil expansion which cracked many 2-inch thick slabs. Other areas of the county have also experienced problems due to soil expansion, specifically the Camarillo Heights Area. However, here the damage has not been as great because many lessons were learned in the Shadow Oaks case.

As the damage started to appear in the new homes of this tract, many of them were vacated. Still others remained occupied but some people stopped making their payments. Many houses were rented, a transient group of people occupied these and the neighborhood generally declined.

In time, repairs saved some homes while others were replaced using more cautious construction techniques. The slabs were increased in thickness up to 9 inches. In time, this requirement was refined and relaxed in cases where soils tests revealed minimal shrink-swell potential. The Shadow Oaks case was primarily responsible for the establishment of more stringent building code requirements which have effectively eliminated the expansive soils problem in Ventura County.

## NATURE OF INFORMATION

General information concerning the shrink-swell potential of the county's soils has been provided in the Soils Survey by the Soil Conservation Service. This information is useful but its limits must be recognized.

Expansive soil is so localized in occurrence that it is necessary to test each site and gauge construction to the specific soil conditions. A range of design requirements and construction techniques must be met according to the expansive quality of the soil. It appears that no further information is needed about the general occurrence of expansive soil in the county. However, investigation is needed for each site and this is being accomplished as specific proposals for development are made.

It is generally accepted that the expertise exists to both identify the problem and provide solutions. Soils engineers can locate problem areas and foundation engineers can design counter measures. The ability to control and minimize damage from expansive soils is such that the State in its Urban Geology Master Plan sees no need to either institute new or change existing programs. Merely implementing existing programs to their full extent is the recommendation of this State report.

#### GENERAL MANAGEMENT RESPONSIBILITY

#### REGULATION

Numerous agencies have established standards to eliminate the potential for structural damage due to expansive soils. Both HUD and FHA have codes to be followed if expansive soils are present. The United States Department of Agriculture in conjunction with the University of California Agricultural Extension Station have recommendations based on their Soil Survey of Ventura County. In addition, the State Subdivision Map Act and the Uniform Building Code, which are legal requirements imposed on development, provide the necessary controls to mitigate any hazard.

In the case of the construction of buildings, the Department of Building and Safety requires a soils test.



## ALLEVIATION

Steps would have to be taken in the grading and construction phases of a subdivision in order to assure protection against this hazard. Among the corrective measures which might be employed are various foundation construction techniques including proper drainage. The degree of expansiveness, as revealed in the expansion test, dictates the type of foundation design. If the expansiveness of a soil exceed a set limit, then a special engineering design is required for that site and building (Uniform Building Code). Responsibility for enforcement of City ordinances for grading rests with the Department of Public Works, for public rights-of-way and public projects, and with the Department of Building and Safety for buildings (structures).

# LOCAL DISCUSSION

## LOCAL INVENTORY OF THE HAZARD

In the vicinity of the intersection of Santa Clara Avenue and Highway 118 is a high shrink-swell potential. This is the only part of the city so designated. Moderately expansive soil exists in the remainder of Oxnard's jurisdiction.

## LOCAL RESOURCES AFFECTED BY THE HAZARD

No significant or large scale structural damage has been recorded which is directly attributable to expansive soils.

No threat of the magnitude of that in the Shadow Oaks area, exists in Oxnard.

## LOCAL MANAGEMENT RESPONSIBILITY

The City's current program is adequate due to the more silty and sandy nature of Oxnard's soil and its lower clay content.

A soils test must accompany the materials filed with the Public Works Department for a tract approval. This information, along with soils test data for street construction is forwarded to the Building and Safety Department. When construction commences, this soils information is referred to and corrective measures are taken as needed. Individual sites are not tested for shrink-swell potential.



## FINDINGS

It appears that existing controls and restrictions are satisfactory from the City's viewpoint. Should damage from expansive soils develop, more stringent testing procedures might be instituted.

## RECOMMENDED ACTION - EXPANSIVE SOILS

1. Within Oxnard, the control procedures should continue to be maintained at present levels. Projecting this performance into the future indicates adequate protection will be provided by this level of service.



# SEISMIC SAFETY

DAM INUNDATION



Since potential dam failures affect the safety of many communities, inundation maps for all major dams are being prepared by the dam operators pursuant to section 8589.5 of the Government Code of California. These maps will become a mandatory consideration in the Safety and Seismic Safety Elements when the maps have been approved by the State Office of Emergency Services.

Preliminary maps are available for some of the dams affecting the county. Lake Casitas, the largest dam in the county is controlled by the Federal Bureau of Reclamation and they cannot be compelled to do the inundation maps. However, they have indicated that they will prepare one next year. Castaic and Pyramid Dams, in Los Angeles County but upstream in the Santa Clara River drainage system, are operated by the California Department of Water Resources as part of the California Water Projects. These maps are in preparation but the State refuses to release the preliminary maps.

The maps for the three largest dams that effect the county are not available and all the rest are only preliminary and subject to change. Since they are not yet required and the information is preliminary, it was decided to delay the inclusion of this hazard section until the final maps are received, probably sometime in 1975.

This hazard has more relevance to Ventura County than almost any other area of the State because of the 1928 failure of the St. Francis Dam which caused massive destruction in the Santa Clara River Valley. This dam failure was the second worst disaster, in terms of the number of lives lost, in California history; second only to the 1906 San Francisco earthquake. This section will be added to the Seismic and Safety Element as soon as the final maps are available. The State does not require this section as part of the element until the final maps are received.



# STAIRS SAFETY

FIRE HAZARD



## ABSTRACT

This document is prepared in cooperation with the Oxnard Fire Department and summarizes the fire safety situation in the City of Oxnard to provide background information for the City's Safety Element. It identifies existing and potential fire hazards, analyzes fire protection capabilities and evaluates the effectiveness of fire fighting forces to combat existing and potential fire problems. This document also suggests an action plan that will assist in the development of a fire protection system that offers a higher level of service at a reasonable cost.



## INTRODUCTION

Historically, many cities throughout the United States have neglected to identify fire hazard potentials and develop fire protection capabilities to effectively combat large loss fires. As a result, fire losses to property, loss of lives, and fire protection costs are excessive. Only through proper building and fire code adoption and enforcement, in conjunction with adequate personnel and equipment, can these losses be reduced. Nevertheless, some risks must be calculated into the Fire Safety Element. Fires will occur despite all reasonable precautions because of human negligence, incendiary acts and disasters. The realistic approach is to evaluate what there is to burn; apply reasonable code enforcement to prevent accidental or potential fires from occurring; provide educational programs to inform citizens on fire prevention; and develop methods and policies that give operational guidelines to other departments within the City that provide services in the area of fire protection. Consideration must also be given to the firefighting training and techniques, modern firefighting devices, an ongoing program of fire station location (to shorten response time), and the considerable resources available through our Automatic Aid and Mutual Aid agreements with neighboring jurisdictions.

## GENERAL DISCUSSION

### GENERAL DESCRIPTION

It is the objective of this Fire Safety Element Report to summarize the fire safety situation in Oxnard. Toward that end, this report will identify existing and potential fire hazards, analyze fire protection capabilities and evaluate the effectiveness of fire fighting forces to combat existing and potential fire problems.

To provide the reader with a general perspective of the potential for fire hazards, an article from "Fire Journal - September, 1974" has been included. This article discusses fires and fire losses for the total United States.



# FIRES AND FIRE LOSSES

## CLASSIFIED, 1973

THE NFPA MAKES ANNUAL ESTIMATES of the numbers of fires, fire deaths, fire injuries, and fire losses in the United States during the past year. The estimates for 1973 are summarized in the tables accompanying this article.

The important points are as follows:

- Fire deaths in 1973 declined to 11,700 from 1972's 11,900. This is encouraging, but certainly not a dramatic reduction — only 1.7 percent.
- Fire injuries increased to 117,000 from the 112,000 reported in 1972. As in previous years, more than half the injured were fire fighters.
- 82.1 percent of the fire deaths occurred in residential occupancies. Most of these, 55.5 percent, were in private dwellings and apartments.

• Incendiary fires — fires that were intentionally set — continue to increase at an alarming rate. The number of incendiary fires was up 12 percent over last year, and up 205 percent over 1963. Losses from such fires showed a similar increase.

• Large fires continued to cause a disproportionate share of losses. In 1973, there were several group fires and one large-scale urban conflagration. These were only 0.2 percent of all the fires — yet they caused nearly one-sixth of the estimated total loss.<sup>1</sup>

One hopes these estimates will aid all those who are interested in improving the nation's fire record.  
(Text continued on page 35)

<sup>1</sup> See "1973 Large-Loss Fires, United States and Canada," FIRE JOURNAL, Vol. 68, No. 4 (July 1974), p. 77.

Table 1. Estimated United States Building Fire Losses by Cause, 1973

*These estimated figures are intended to show the relative order of magnitude of fire losses by cause, and to indicate year-to-year trends. While they are reasonable approximations based on experience in typical states, they should not be taken as exact records for each class. The figures by themselves do not show the relative safety in use of various types of materials, devices, fuels, or services, and they should not be used for that purpose. Reproduction of this table, in whole or in part, is authorized only with written permission from the Association and with the following identification of figures: National Fire Protection Association estimates.*

Cause	No. of Fires	Estimated Loss
Heating and Cooking Equipment .....	165,800	\$ 189,700,000
Equipment defective or misused .....	97,500	\$126,800,000
Chimneys and flues .....	23,900	17,700,000
Hot ashes and coals .....	6,500	3,700,000
Combustibles near heaters and stoves .....	37,900	41,500,000
Smoking-Related .....	115,200	100,700,000
Electrical .....	170,700	331,500,000
Wiring and general equipment .....	106,700	213,300,000
Motors and appliances .....	64,000	118,200,000
Trash Burning .....	35,200	2,100,000
Flammable Liquids <sup>1</sup> .....	67,300	61,200,000
Open Flames and Sparks <sup>1</sup> .....	70,000	99,500,000
Sparks and embers .....	6,500	7,000,000
Welding and cutting .....	9,800	34,400,000
Friction, sparks from machinery .....	16,200	17,100,000
Thawing pipes .....	5,500	11,100,000
Other open flames .....	32,000	29,900,000
Lightning .....	21,600	41,900,000
Children and Fire .....	70,800	76,300,000
Exposure .....	25,200	23,200,000
Incendiary and Suspicious .....	94,300	320,000,000
Spontaneous Ignition .....	14,900	25,500,000
Gas Fires and Explosions <sup>1</sup> .....	9,600	23,100,000
Explosions from Fireworks, Explosives .....	4,300	5,200,000
Miscellaneous Known Causes .....	70,500	191,100,000
Unknown Causes .....	150,500	1,015,300,000
<b>TOTAL BUILDING FIRES .....</b>	<b>1,085,900</b>	<b>\$2,537,200,000</b>

<sup>1</sup> Does not include fires originating in heating and cooking equipment.

Table 2. Estimated United States Fire Losses by Occupancies, 1973

These estimated figures are intended to show the relative order of magnitude of fire losses by occupancies. While they are reasonable approximations based on experience in typical states, they should not be taken as exact records for each class. Any reproduction of these figures should be identified as follows: National Fire Protection Association estimates.

Occupancy	No. of Fires	Estimated Loss
<b>Public Assembly Occupancies</b> .....	<b>34,100</b>	<b>\$ 155,000,000</b>
Amusement centers, ballrooms .....	2,300	\$ 10,700,000
Auditoriums, exhibition halls .....	600	5,600,000
Bowling establishments .....	800	9,500,000
Churches .....	3,900	28,400,000
Clubs, private .....	3,000	14,500,000
Restaurants, taverns .....	19,500	54,900,000
Theaters, studios .....	1,100	13,500,000
Transportation terminals .....	500	2,600,000
Other public assembly occupancies .....	2,400	15,300,000
<b>Educational Occupancies</b> .....	<b>24,100</b>	<b>99,000,000</b>
Schools, through Twelfth Grade .....	18,900	81,900,000
Other schools .....	5,200	17,100,000
<b>Institutional Occupancies</b> .....	<b>21,600</b>	<b>23,000,000</b>
Rest and nursing homes .....	6,400	3,600,000
Hospitals .....	10,700	12,400,000
Mental institutions .....	800	1,500,000
Other institutions .....	3,700	6,400,000
<b>Residential Occupancies</b> .....	<b>705,800</b>	<b>\$1,103,400,000</b>
Apartments .....	138,000	265,300,000
Dwellings, one- and two-family .....	587,200	\$700,700,000
Hotels and motels .....	21,700	42,200,000
Mobile homes .....	25,100	57,800,000
Other residential occupancies .....	23,800	37,400,000
<b>Mercantile and Office Occupancies</b> .....	<b>76,100</b>	<b>306,700,000</b>
Appliance and furniture stores .....	4,100	27,500,000
Clothing stores .....	4,500	20,900,000
Department and variety stores .....	4,500	40,700,000
Drugstores .....	2,900	11,400,000
Grocery stores and supermarkets .....	6,900	35,900,000
Motor vehicle sales and repair facilities .....	9,600	34,100,000
Offices and banks .....	15,900	47,300,000
Service stations .....	5,300	11,100,000
Other mercantile occupancies .....	22,400	137,800,000
<b>Basic Industry, Defense and Utility Occupancies</b> ..	<b>6,900</b>	<b>76,300,000</b>
Electric power plants .....	3,000	22,900,000
Laboratories and data-processing centers .....	800	2,600,000
Mines and mineral product plants .....	1,600	41,400,000
Nucleonic facilities .....	100	1,500,000
Other basic industry occupancies .....	1,400	7,900,000
<b>Manufacturing Occupancies</b> .....	<b>40,400</b>	<b>\$ 364,400,000</b>
Beverage, tobacco, and essential oil plants .....	900	\$ 5,100,000
Drug, chemical, paint, and petroleum plants .....	3,600	89,000,000
Food product plants .....	3,600	39,600,000
Laundry and dry cleaning plants .....	3,300	9,200,000
Metal and metal product plants .....	4,000	51,700,000
Paper and paper product plants .....	3,100	11,000,000
Plastic and plastic product plants .....	1,900	16,700,000
Printing plants .....	1,600	6,100,000
Textile and textile product plants .....	3,500	15,700,000
Wood and wood product plants .....	3,100	43,600,000
Other manufacturing occupancies .....	11,800	76,700,000
<b>Storage Occupancies</b> .....	<b>57,300</b>	<b>\$ 300,000,000</b>
Barns and stables .....	14,800	74,400,000
Bulk plants and tank farms .....	1,100	9,300,000
Garages and residential parking .....	20,000	27,900,000
Grain elevators .....	1,800	39,300,000
Lumber and building materials storage .....	1,000	18,900,000
Sheds and farm storage buildings .....	10,800	27,600,000
Other storage buildings .....	7,800	102,600,000
<b>Other Buildings (not included above)</b> .....	<b>30,200</b>	<b>18,500,000</b>
<b>TOTAL BUILDING FIRES</b> .....	<b>1,085,900</b>	<b>\$2,537,200,000</b>



Table 2. (continued)

Occupancy	No. of Fires	Estimated Loss
<i>Nonbuilding Occupancies</i> .....		
Standing crops .....	21,000	\$ 32,000,000
Forests .....	119,000	126,000,000
Grass, brush, and rubbish .....	891,200	—
Motor vehicles .....	574,000	135,300,000
Ships .....	500	12,500,000
Railroad rolling stock .....	2,250	27,800,000
Aircraft, aerospace vehicles .....	250	150,000,000
<b>TOTAL NONBUILDING FIRES</b> .....	<u>1,608,200</u>	<u>\$ 483,600,000</u>
<b>TOTAL FIRES</b> .....	<u>2,694,100</u>	<u>\$3,020,800,000</u>

Table 3. Estimated Activities of Fire Departments in the United States, 1978

Legitimate fire calls .....	2,710,000
Malicious false alarms .....	820,000
Assistance to other fire departments .....	75,500
Other calls* .....	2,660,000

\* Includes rescue, medical assistance, public service and similar calls.

(Text continued from page 33)

Concerted action directed toward meaningful objectives can result in dramatic reductions in all the kinds of losses listed above.

Fires in buildings in 1973 increased by only 3.4 percent . . . whereas the number of fires in residential occupancies showed a sharp increase — nearly 8.2 percent. Principal categories in that larger residential total were private dwellings, apartments, hotels and motels. Fires in places of public assembly and storage occupancies showed apparently significant decreases of 10 percent or more. The reasons for these changes are not clear. In general, dollar losses followed the trends in numbers of fires, at least when compared on an occupancy-by-occupancy basis.

Another large decrease occurred in outside (i.e., nonbuilding) fires, which decreased by nearly 6 percent. The greatest reduction in this group was in rubbish and brush fires. Forest fires also decreased slightly. The number of motor vehicle fires and their losses increased substantially.

Overall, the total number of fires decreased by 5.9 percent and fire deaths decreased by 1.7 percent. Fire-related injuries increased by 4.5 percent, and dollar losses by 3.2 percent. The increase in dollar losses would diminish to nearly nothing if the effects of inflation were taken into account.

The data used in compiling this summary of fires and fire losses was obtained from a survey of 2,000 fire departments in the United States. The departments that responded protect populations ranging from 8,000,000 to 50,000 and are located in all 50 states. Additional information was obtained from the reports of state fire marshals and fire departments. The information obtained from these sources was extended by recognized statistical techniques, and allowances for unreported fires and losses were included.

The National Fire Protection Association wishes to thank all those who contributed the data that made these estimates possible. Their help is deeply appreciated. △

## LOCAL DISCUSSION

### LOCAL INVENTORY OF THE HAZARD

The fire loss per capita for 1974 was \$10.10 compared to \$4.46 for the same period in 1973, and the experience on a national basis of \$18.77. The average loss per building fire was \$3,943.68 as compared to \$1,803.84 in 1973.

Fire loss, in buildings wherein loss exceeded \$1,000, occurred in 69 alarm calls. The fire loss in these calls totaled \$840,617. The following list is a portion of these alarms wherein loss exceeded \$15,000:

19 January 1974 at 1855 Ferrera - Residence	\$ 18,378
15 April 1974 at 106 Driskill - Residence	\$ 26,075
24 August 1974 at 745 Columbia - Residence	\$ 17,000
31 December 1974 at 5200 S. J St. - Apts.	\$ 18,000
2 February 1974 at 3597 W. Wooley - Commercial	\$ 43,000
2 March 1974 at 535 S. C St. - Commercial	\$ 29,000
27 May 1974 at 1920 N. Ventura - Commercial	\$350,000
15 June 1974 at 323 S. E St. - Church	\$ 21,000
16 July 1974 at 804 Cooper - School	\$ 23,000
14 November 1974 at 5014 Saviers - Commercial	\$ 18,000
	<u>\$563,453</u>

The structures involved in these fires were valued at approximately \$20,000,000. With a potential direct loss of \$20,000,000 and indirect losses (i.e. loss of business, loss of jobs, loss of business goodwill, sales tax losses, etc.) estimated at four times the direct loss, the savings to our City totaled \$76,645,332. There was one (1) fire-related fatality in 1974.

The following table provides the reader with a comparison of years from 1970 to the present and the fire loss in dollars per capital.



The second table is a graphic representation of the 1,258 fire responses for 1974.

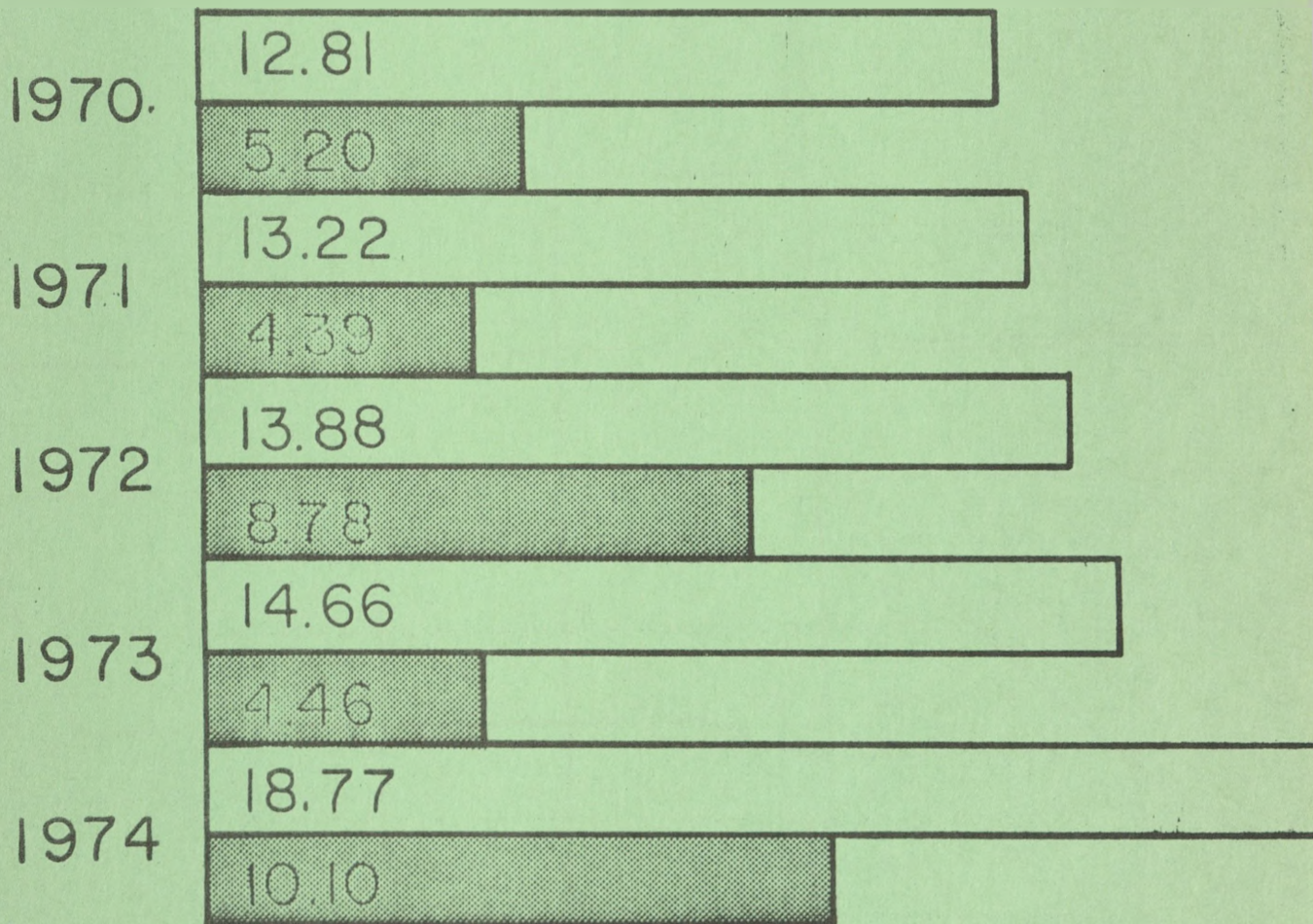
The third table represents, over a five-year period, the relationship of residential to commercial fire calls.

The fourth graph depicts the yearly fire incidence by type: Brush & rubbish; Vehicle; Residence; Commercial; and Dumpster for the City.

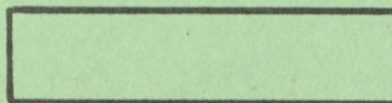
The fifth graph presents a five-year % breakdown for different types of fire causes.

The sixth and final graph provides a comparison between fire call and the number of rescues required each year for a five-year period.

# FIRE LOSS PER CAPITA (dollars)



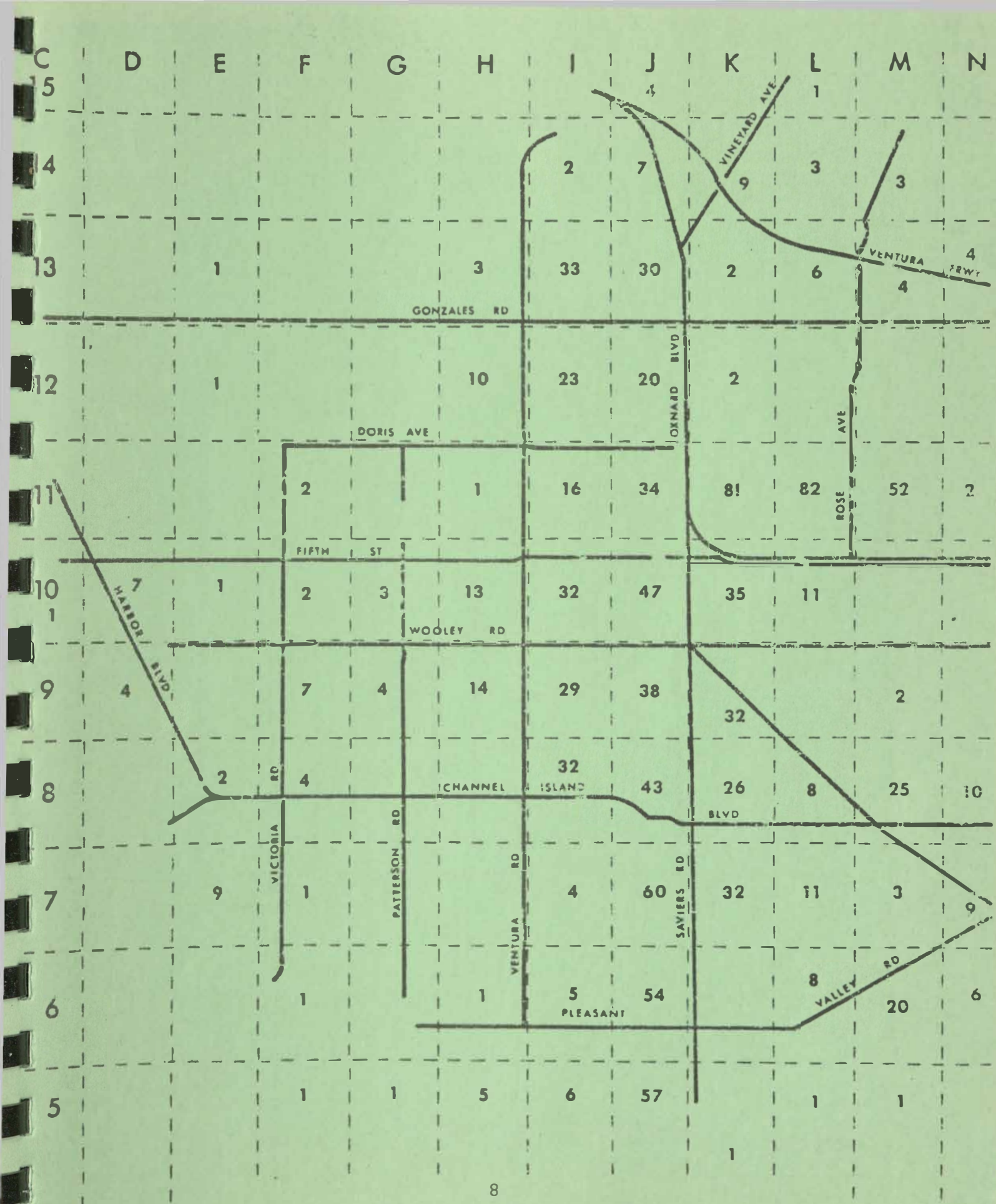
NATIONAL  
AVERAGE



CITY OF  
OXNARD

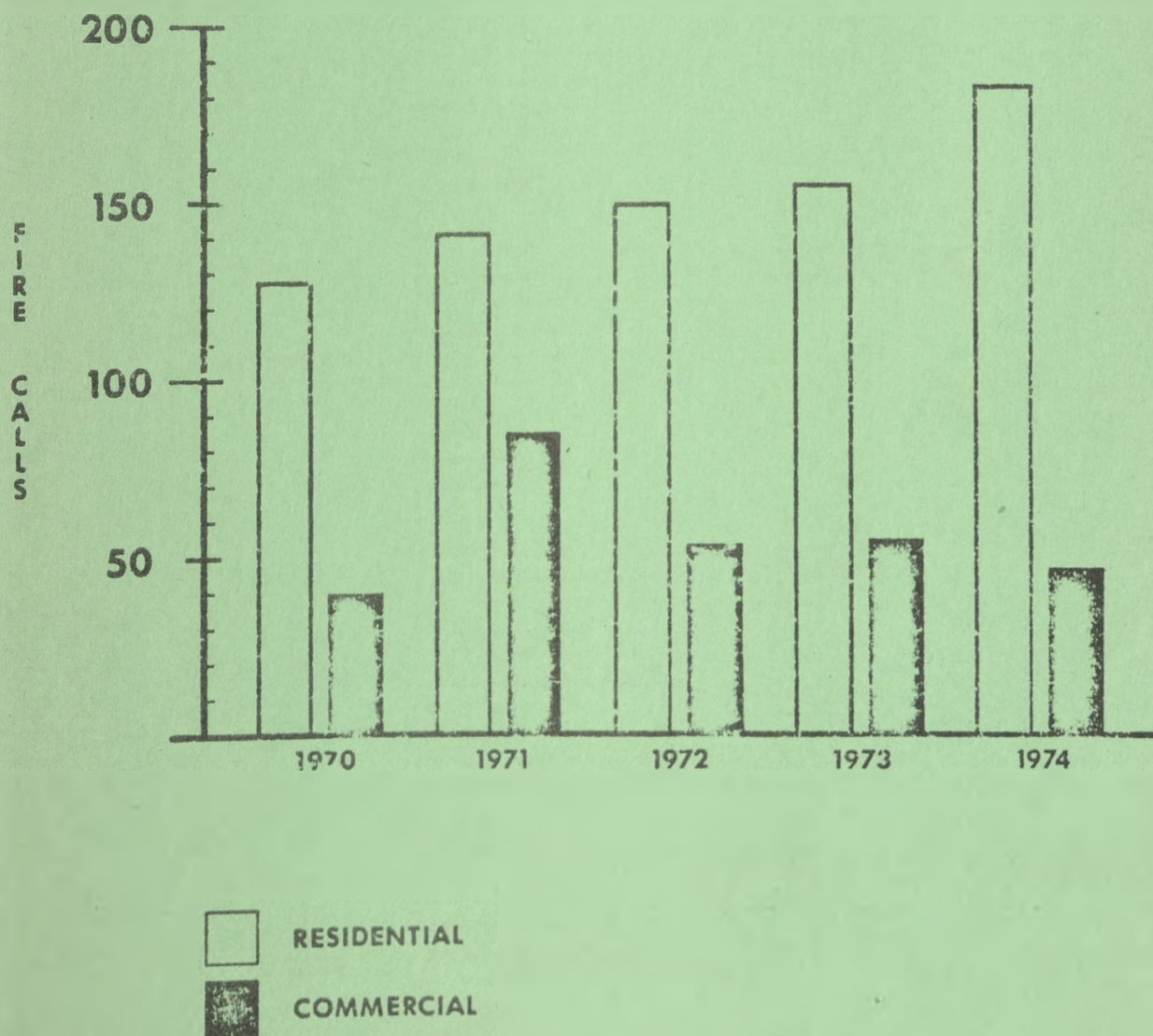






1974 FIRE RESPONSE CONCENTRATION

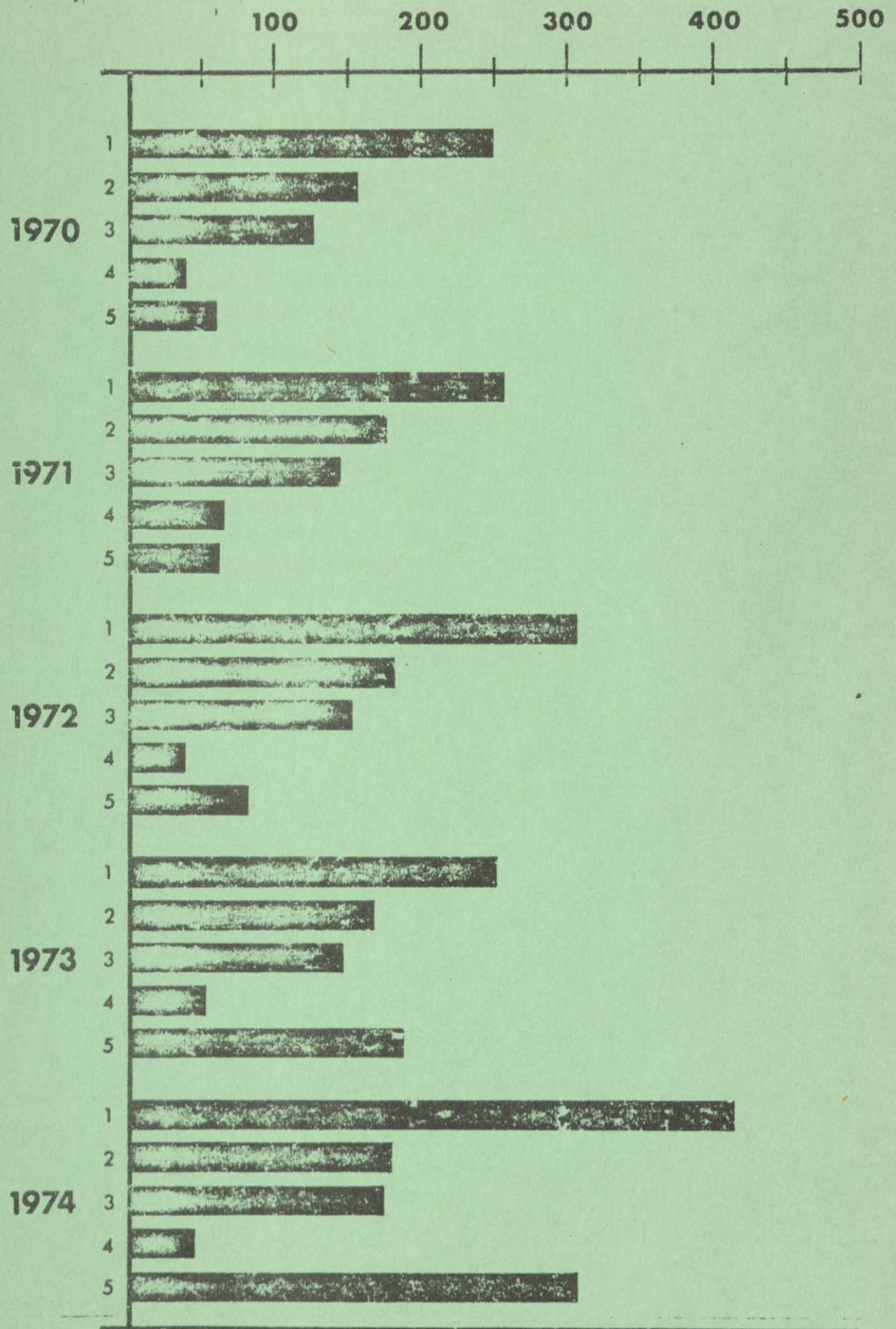
1,258



**RESIDENTIAL / COMMERCIAL  
INCIDENCE 1970 - 1974**



- 1- BRUSH & RUBBISH
- 2- VEHICLE
- 3- RESIDENCE
- 4- COMMERCIAL
- 5- DUMPSTER

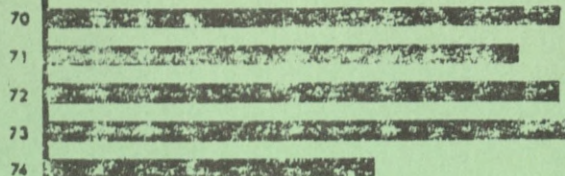


YEARLY FIRE INCIDENCE BY TYPE



5 10% 15 20% 25 30% 35 40% 45 50%

# ACCIDENTAL



# UNDETERMINED



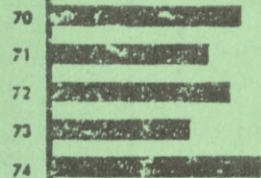
# INCENDIARY



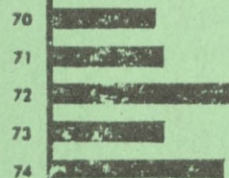
# ELECTRICAL



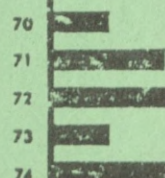
# SMOKING & MATCHES



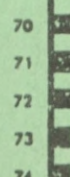
# CHILDREN & MATCHES



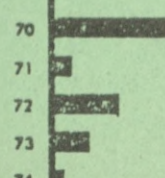
# MISC. KNOWN CAUSES



# FLAMMABLE LIQUIDS

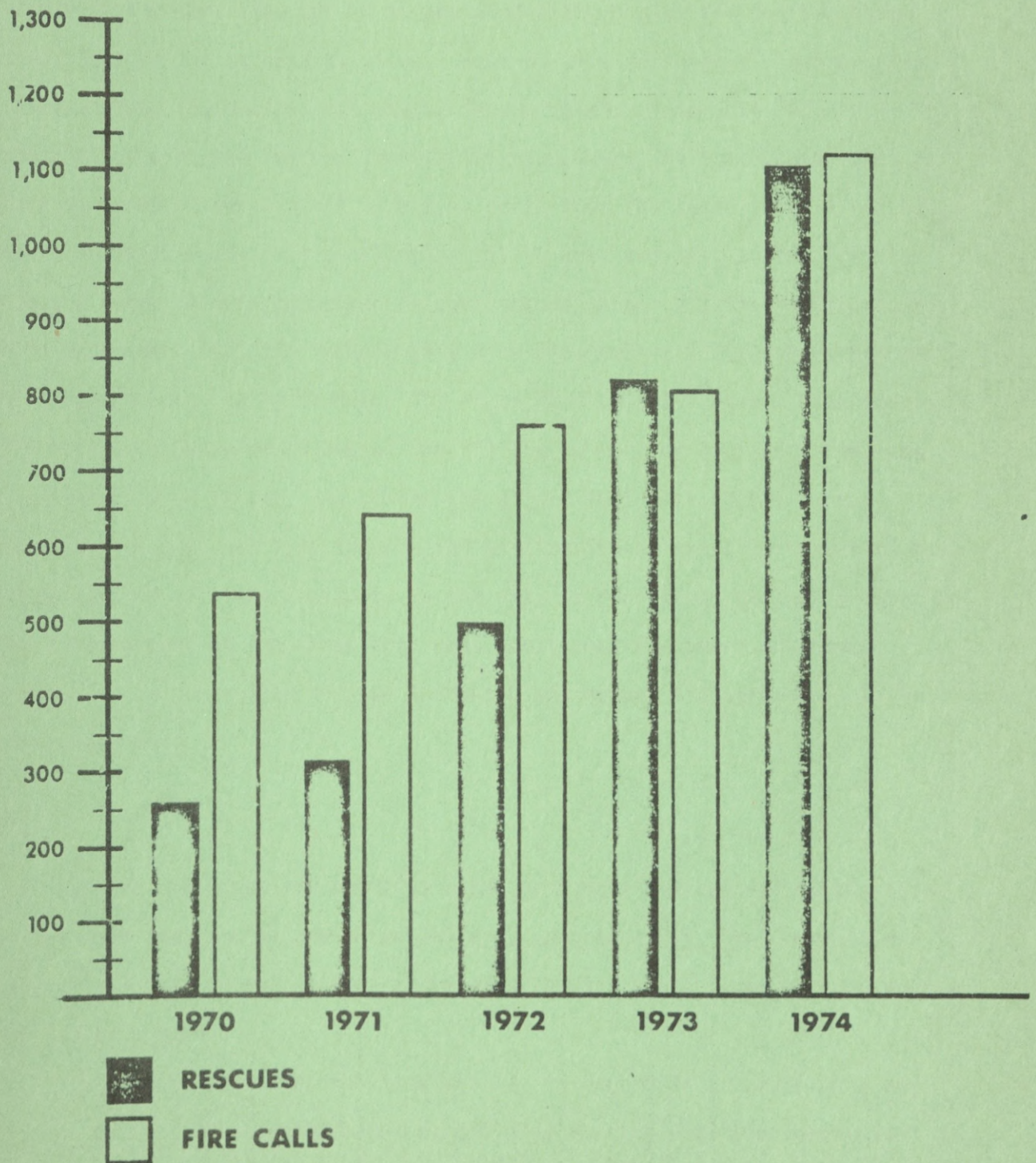


# GAS LEAK



PERCENTAGE BREAKDOWN  
STRUCTURE FIRE CAUSES





**COMPARISON OF RESCUE and FIRE CALL GROWTH**

## LOCAL MANAGEMENT RESPONSIBILITIES

The Oxnard City Fire Department has the capabilities of combating all normal fire potentials, but it is not adequately manned for conflagration conditions or for large area fires. Most of this deficiency, however, is alleviated by "Automatic Aid" and/or "Mutual Aid". Automatic Aid, in conjunction with the Ventura County Fire Department, helps to cover the various areas of the City of Oxnard -- north from the Santa Clara River Bed, south on Hales Road, east to Pleasant Valley Road and west to the Pacific Ocean. Mutual Aid is conducted in conjunction with: (1) the Ventura County Fire Department; (2) the Ventura City Fire Department; (3) the Port Hueneme Fire Department; (4) Point Mugu; (5) State Hospital; (6) Harbor Department; (7) Edison Company-Ormand Beach; and (8) the Office of Emergency Services. Like the City of Oxnard, few cities can afford full fire combat forces necessary to meet all fire threats and utilization of existing forces to meet 90 percent of all fire incidents in the City is considered optimum protection. The five percent of the fires that need additional equipment and combat forces can be controlled through Automatic and Mutual Aid agreements with other agencies.

## MANPOWER

Manning practices are normally based on a city's financial capabilities rather than the fire hazard potential and, unfortunately, few communities can fully man apparatus at the recommended level: i.e., 6 men on each engine and ladder company.

The average work week for firefighters in Oxnard is 60 hours on a two platoon basis. The manning level established for the Fire Department is Four-man Engine Companies, Three-man Snorkle Companies, and one Assistant Fire Chief per shift (See Exhibits I and II). This is the minimum number of



personnel that is safe and fire-combat effective based on present fire potential. As the City grows and high-rise buildings are erected, and industrial areas develop, the fire problem will change. More stations and higher levels of manning may be necessary if the Fire Department is to maintain the same level of service. When fighting large area fires, manpower and equipment must be provided through Automatic Aid and Mutual Aid agreements with other agencies. Off-duty firefighting personnel will be called back to duty in extreme emergencies.

Technical advances in the development of firefighting devices such as automated flow control nozzles, probeye infrared scanners, and rapid water chemicals are under investigation. Utilization of the devices may well increase our firefighting capacity and utilization of available manpower.

To aid in reducing the total number of fires, each fire is investigated to determine probable cause and origin, and every suspicious fire is investigated by our Fire Investigative Unit.

#### FIRE SUPPRESSION FACILITIES AND EQUIPMENT

The location of the fire stations defines the basic fire protection coverage of any area within the City. Of prime importance to the adequacy of the fire protection coverage is response time; which is basically the distance from the fire station to the incident location and the average speed of travel for fire apparatus. The distance from the fire station to the incident location cannot be straight-line travel but must be the actual travel distance. This distance may be increased considerably by street patterns, natural barriers (such as railroad tracks), freeways, street works, etc.

The average speed is affected by the type of street facility over which the response is made and by the amount of traffic. Fire stations should be located so as to provide an average response time of four minutes or less in 90 percent of the incidents.

Each of the City's five fire companies are stratigically located throughout the City's 22.75 square miles (See Exhibit I and Map IV). (At least one additional fire station is planned to meet the anticipated development of the Oxnard Beach Area.) Each of the five Oxnard Fire Stations' response time to most incidents is excellent.

The Oxnard Fire Department has five pumpers and one snorkel or ladder truck on duty 24 hours everyday. There are in reserve status two city pumpers and a State-owned pumper from the Office of Emergency Services (See Exhibit I). Also available now for immediate response through Automatic Aid are two additional pumpers and one rescue truck from the County of Ventura. Through Mutual Aid agreements with other agencies, special firefighting equipment and additional manpower can be obtained as needed.



# Exhibit I

Fire Stations	Address	Equipment	Number Assigned	Men Per Shift
Station 1	206 West Second Street	First Line Pumper Snorkel Reserve Pumper	Engine II Snorkel 1 Reserve II	8
Station 2	521 W. Pleasant Valley Road	First Line Pumper	Engine 12	4
Station 3	150 Hill Street	First Line Pumper	Engine 13	4
Station 4	231 W. Vineyard Avenue	1 City First Line Pumper 1 County First Line Pumper 1 County Rescue Truck	Engine 14 Engine 51 Rescue 5	4 4
Station 5	450 Colonia Road	1 First Line Pumper 1 Office of Emergency Service Pumper	Engine 15 Reserve 15	4
Station 6 (Immediate Future)	Vicinity of W. Hemlock and Victoria Boulevard	1 First Line Pumper Fire Boat (possible)	Engine 16 Boat ?	3 3



# Exhibit II

• Direct supervision by Fire Chief

**Fire Chief**  
 1. Long Range Planning  
 2. Department Coordinator  
 3. Personnel and Union Relations  
 4. Recruitment Coordinator  
 5. Capital Improvement Coordinator  
 6. Water Supply and Hydrants

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Secretary

Clerk

## Ca Cht Operations

1. Rescue and Bomb Detail
2. Liaison Officer, Interagency
3. Budget Officer, Operations
4. Communications, Mechanical
5. Department Coordinator
6. Maps and Drafting
7. Departmental Records
8. Fire Service Day Coordinator
9. Special Research Projects
10. Fire Suppression

## Ba Cht A Combat Chief

1. A Shift Platoon Commander
2. Fire Suppression
3. Apparatus and Equipment
4. Departmental Records - B Platoon
5. Miscellaneous Departmental Supplies
6. Personnel Manager - A Platoon
7. Capital Improvement, Apparatus and Equipment
8. Disaster Control
9. Annual Major Accomplishment Report
10. Annual Report
11. Chief Officer Meeting Coordinator
12. Communication Records Coordinator
13. Special Research Projects

## Ba Cht Fire Prevention Chief

1. Fire Prevention Bureau Commander
2. Jr. Fire Department Messenger
3. Fire Code Development
4. Fire Prevention Education Coordinator
5. Plan Check Supervisor
6. Fire Prevention Records Manager
7. Technical Surveys
8. Fire Suppression
9. Special Research Projects

## Ba Cht Training Chief

1. Training Bureau Commander
2. Assist. Area Coordinator, OES
3. Recruiting Officer
4. Public Information Officer
5. Estimate and Promotional Ensign, Formulation and Administration
6. Uniform Purchase and Control
7. Drill manuals and Manuals of operation, formulation, updating
8. Safety Gearment Purchase - Control
9. Public Relations Officer
10. Community Relations Officer
11. Fire Suppression
12. Special Research Projects

## Ba Cht B Combat Chief

1. B Shift Platoon Commander
2. Fire Suppression
3. Buildings and Grounds
4. Linen Control
5. Capital Improvement, Buildings and Grounds
6. Rules and Regulations, Formulating, Updating
7. Hazardous Chemical Storage
8. Fire Preplan Coordinator
9. Departmental Records - B Platoon
10. Personnel Manager - B Platoon
11. Target Marking and Planning
12. Special Research Projects

## A Platoon

Sta 6	Rel Gr 2	Rel Gr 1	Sta 4	Sta 3	Sta 2	Sta 1	Sn 1
1 Capt 1 Eng 2 Frns	1 Capt 1 Eng 2 Frns	1 Capt 1 Eng 2 Frns	1 Capt 1 Eng 2 Frns	1 Capt 1 Eng 3 Frns	1 Capt 1 Eng 3 Frns	1 Capt 1 Eng 3 Frns	1 Capt 1 Eng 1 Trkman
Rescue Code 2 Fire Prev Fire Supp	Rescue Code 2 Fire Prev Fire Supp	Rescue Code 2 Fire Prev Fire Supp	Rescue Code 2 Fire Prev Fire Supp	Rescue Code 2 Fire Prev Fire Supp	Rescue Code 2 Fire Prev Fire Supp	Rescue Code 2 Fire Prev Fire Supp	Rescue Code 2 Fire Prev Fire Supp
Capt Disaster Planning	Capt AV Officer	Capt Spec. Projects	Capt Inst. Pump Instructor	Capt Drafting maps St. Naming Ann. Bldg	Capt C.B. Mgr Ad. Rec. Mgr	Capt Hazard Chem. Storage	
• Engineer Training	•	Minority Community Relations • Environmental Impact Reports • Design Involvement	•	•	•	•	

## B Platoon

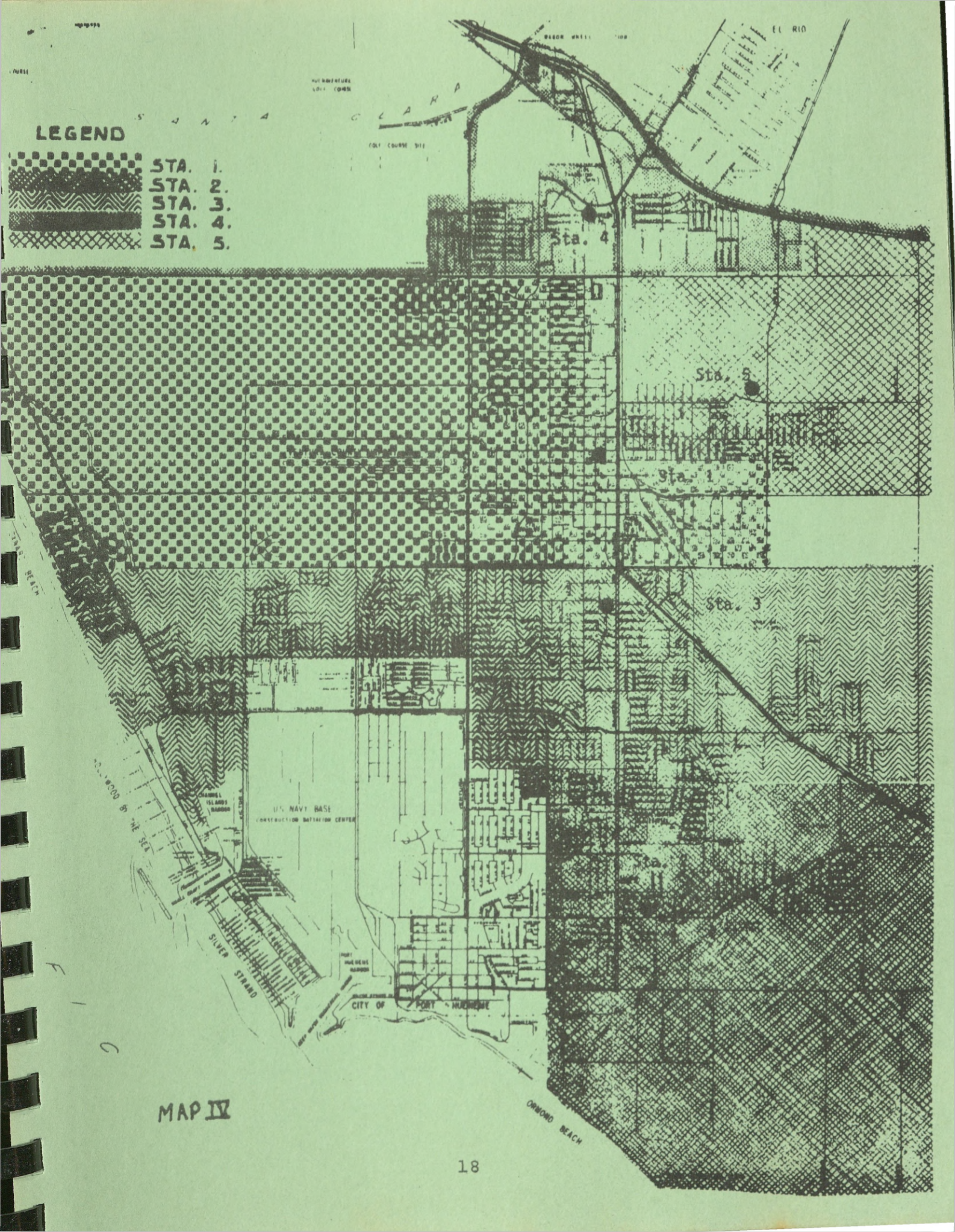
Sn 1	Sta 1	Sta 2	Sta 3	Sta 4	Rel Gr 1	Rel Gr 2	Sta 5
1 Capt 1 Eng 1 Trkman	1 Capt 1 Eng 2 Frns	1 Capt 1 Eng 2 Frns	1 Capt 1 Eng 2 Frns	1 Capt 1 Eng 3 Frns	1 Capt 1 Eng 2 Frns	1 Capt 1 Eng 2 Frns	
Rescue Code 2 Fire Prev Fire Supp	Rescue Code 2 Fire Prev Fire Supp	Rescue Code 2 Fire Prev Fire Supp	Rescue Code 2 Fire Prev Fire Supp	Rescue Code 2 Fire Prev Fire Supp	Rescue Code 2 Fire Prev Fire Supp	Rescue Code 2 Fire Prev Fire Supp	
Capt H2O Supply Fire Hydrants	Capt Hose Officer Supply Officer	Capt Fire Hydrants CPR and 1st Aid Coach SEFIRS	Capt Electronic Repair - Maint	Capt Spec. Project Rescue ISO Rescue operation Manuals	Capt Disaster Planning Physical Conditioning	Capt Hazard Chem. Storage	
•	•	•	• Firearm Instruct	•	•	•	



# LEGEND

- STA. 1.
- STA. 2.
- STA. 3.
- STA. 4.
- STA. 5.

MAP IV



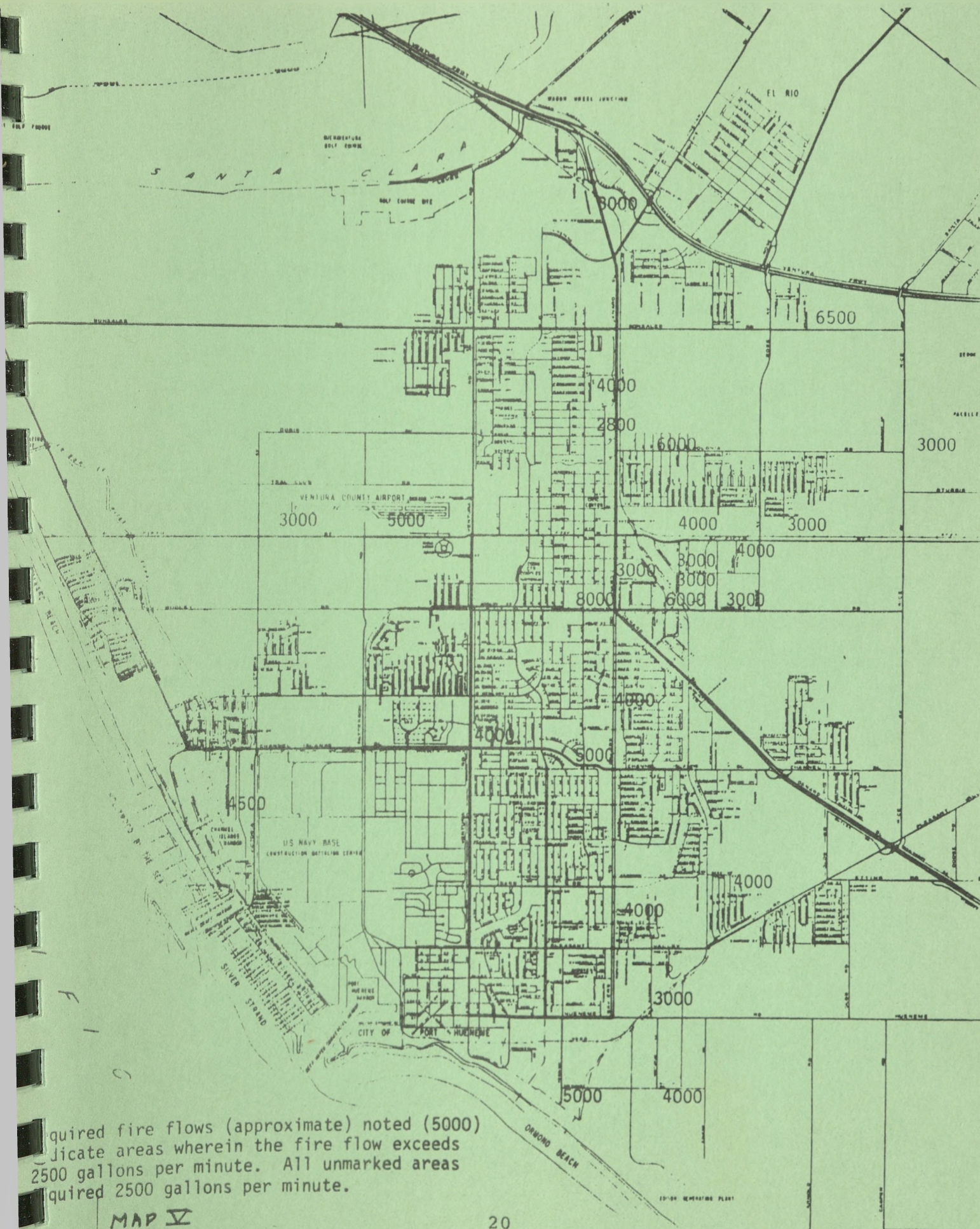


## WATER SUPPLY FOR FIRE PROTECTION

The water required for fire protection use is supplied from two sources: eight water wells located within the City and the Feather River water obtained through an agreement with the Calleguas Municipal Water District located at the Springville Reservoir. The City has three connections from the CMWD. One connection is located on Third Street with a capacity to deliver into the water system 14,000 gallons per minute. The second CMWD connection is located on Richmond Avenue with a capacity to deliver into the water system 14,000 gallons per minute. The third CMWD connection is located at Rose and Gonzales and should be completed in June or July of 1975, with a 14,000 gallon per minute capacity. The City also has six water wells and two reserve wells to augment the additional gallons per minute needed in case of emergency.

The required fire flow is the rate of flow in gallons per minute needed for firefighting purposes to confine and control a major fire to a building or physical confines of the area. Greater fire flows may be required for structures or developments which present additional hazard potential; such as building heights, exposures, minimum fire protection facilities, and hazardous process occupancies. Fire flow requirements throughout the City are a standard requirement by land use varying from 2,500 gallons per minute in residential development to a maximum required fire flow of 8,000 gallons per minute in the high hazard and industrial areas (See Map V).





Required fire flows (approximate) noted (5000)  
 Indicate areas wherein the fire flow exceeds  
 2500 gallons per minute. All unmarked areas  
 required 2500 gallons per minute.

MAP V



## FIRE PREVENTION

The Fire Prevention Bureau is responsible for fire prevention and code enforcement, fire investigations, public information and the coordination of fire protection systems needs with other agencies.

The prevention of fires is based upon knowledge of what there is to burn, where it is located, and what the sources and causes of ignition are. Prompt and thorough investigation of the cause of the fire is the cornerstone of any fire prevention program. Without accurate data relative to ignitions, all further fire prevention efforts are dubious.

The Fire Prevention Bureau monitors the fire prevention and inspection programs performed in the field for existing occupancies and provides expertise to the fire companies on code interpretation. All new construction plans are evaluated to determine fire protection needs. The fire protection specialists work closely with other City Departments in helping the developer provide a fire resistive and adequately protected structure. Adequate code enforcement for existing occupancies, along with evaluating the future fire problem and recommending code changes, is the primary responsibility of the Fire Prevention Bureau.



## FIRE PROTECTION SYSTEM RELATIONSHIP WITH OTHER SAFETY SERVICE SYSTEMS

Fire protection for the City of Oxnard is not the sole function of the Fire Department but is a system made up of many City Departments.

### BUILDING AND SAFETY DIVISION

The Building and Safety Division has the responsibility of enforcing building codes. Through the Uniform Building Code, a certain level of fire resistance is built into the structure at the time of construction. The primary elements of this fire resistance are life, safety, structural stability and reduction of fire hazards of built-in systems in structures. The Building Division also classifies occupancies and their required types of construction to assure that the structure meets the fire and life safety needs of the occupancy. The Division also issues occupancy permits which control changing occupancies to assure that the structure meets the fire protection and life safety needs each time the occupancy changes. The Building and Safety Division also has the responsibility of the rehabilitation program which serves to correct structural deficiencies, including fire protection problems in older structures.

### ENGINEERING DEPARTMENT

The Engineering Department, in conjunction with the Fire Department, prepares preliminary layouts of fire hydrants and water mains for new street developments; and considers fire apparatus access (street width, turning radius, cul-de-sacs) during street development. The Engineering Department also provides the Fire Department with utility maps for use in pre-fire planning and emergency operations, water system maps and storm drain maps. They also maintain an up-to-date City boundary map at Headquarters Fire Station.

## WATER DEPARTMENT

The Water Department has the responsibility of maintaining the water supply for use in fire suppression (fire flows). The Department performs periodic inspections (annually) of hydrant gate valves and assures that valving in mains is maintained so that maximum fire flow is available. The Water Department also maintains and repairs fire hydrants, including flushing and flow testing. The Water Department provides standby personnel for second alarm fires and greater to assist in water supply problems.

This Department also assists in maintaining records needed to meet Underwriters' grading requirements. The Water Department keeps the Fire Department informed of hydrants and water mains which are "out of service". They also provide connections for private fire protection systems and inspect and maintain street valves to assure uninterrupted water supply. If requested, the Water Department performs joint inspections with the Fire Prevention Bureau of "pit" installations on private fire protection systems.

## PLANNING DEPARTMENT

The Planning Department assists in providing the Fire Department with information through which future fire protection needs can be determined. They control designs of developments which affect access to buildings, separation of buildings and open spaces which serve as fire breaks. They also consider fire protection resource needs in determining density and types of development.

## POLICE DEPARTMENT

The Police Department provides traffic and crowd control at emergency incidents. The Police Department provides continuous fire watch service



and reports fires and fire hazards during patrols. The Police Department assists the Fire Prevention Bureau with fire investigation; especially the apprehension and prosecution of arsonists. They assist in handling and storing evidence and providing the Fire Department with background investigations and criminal records of suspected arsonists. The Police Department also provides advice on matters regarding law enforcement.

#### STREET DIVISION

The Street Division provides barriers for crowd control and safety at emergency incidents. They also maintain specialized equipment that may be utilized to protect the community when an emergency arises.

The Division also administers the annual weed abatement program, which reduces the hazard of fire in open areas.

#### CITY ATTORNEY

The Oxnard City Attorney assists in the adoption of nationally recognized fire safety codes, drafts local fire safety ordinances, and in general provides legal assistance in code enforcement and fire prevention matters.

#### LICENSE DIVISION

This Division supports the fire protection system by revoking licenses of businesses when life and fire safety conditions are not met.

#### GENERAL SERVICES

General Services supports the fire protection system by purchasing and providing maintenance of all major firefighting apparatus and firefighting equipment.

## FINANCE DIVISION

The Finance Division supports the fire protection system by providing not only those supportive services concerned with finances, i.e., budgeting control, salaries, overtime, workman's compensation, insurances, but also maintains responsibility for the Oxnard Fire Department's computer aided fire information retrieval system. Into Finance's computer is fed vital data relating to fire calls, fire losses, fire location, the times of day, year and month fires occur, fire causes, fire types, building construction, response times, fire casualties, and fire fatalities. The timely retrieval of this information serves to pinpoint fire station relocations, new fire station locations, and for special programs to meet local needs. This uniform system of fire reporting is recognized as being a tremendous assistance to the fruitful direction of fire protection efforts.



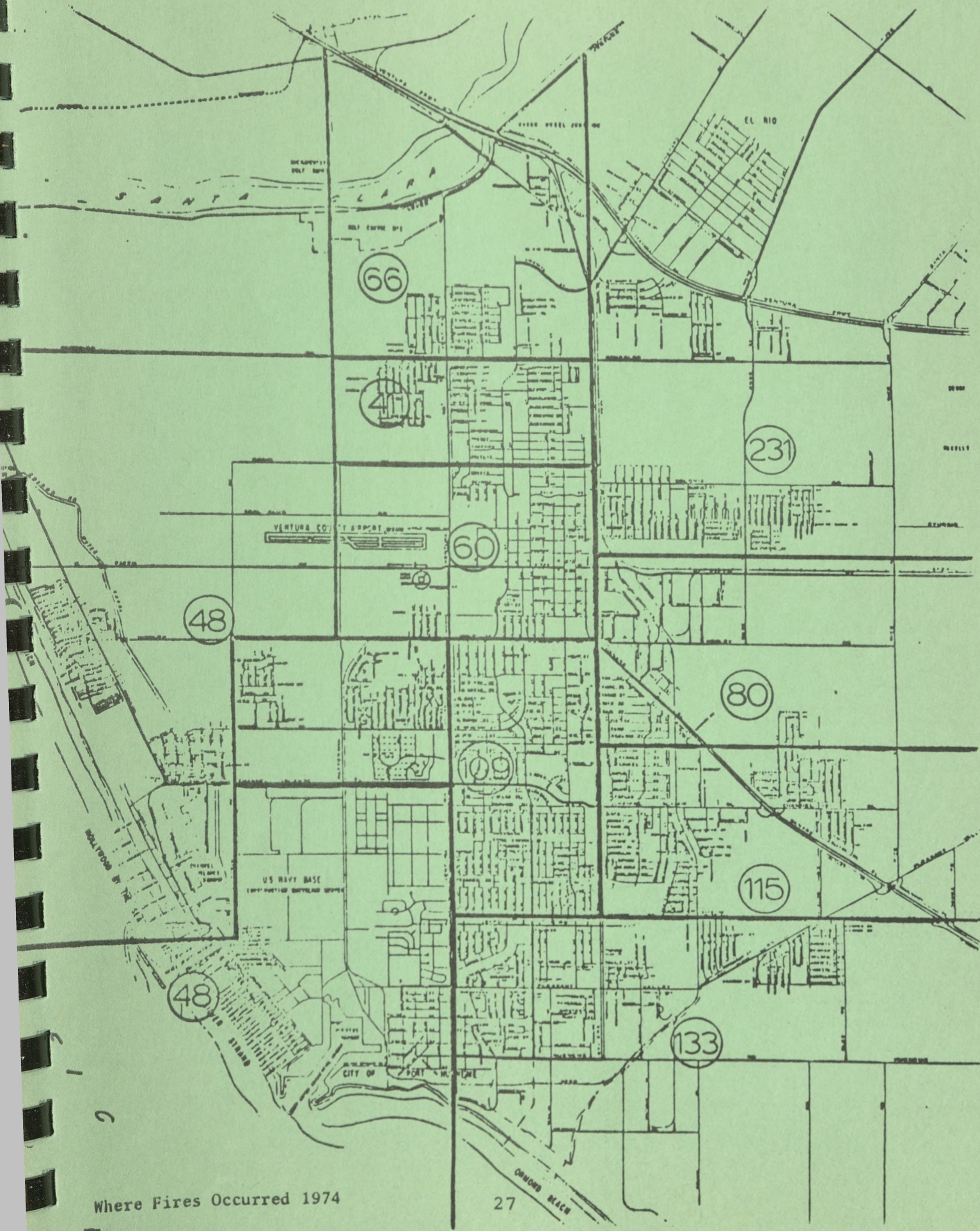
## FINDINGS

Land Usage and community development have determined the present fire hazard conditions in the City of Oxnard. There are many factors that affect the fire hazard situation; some of them are: adequate comprehensive codes; effective code enforcement; a complete and integrated communications system; in-depth training; standardization of methods; mutual aid from adjoining cities; rapid response time; and coordination of all activities by administration. The overall fire hazard to this City compared to other communities in this area is moderate. Some concern is justified for a conflagration potential in residential areas due to a combination of factors: Santa Ana winds, wood shingle roofs and close dwelling spacing (10 foot separation). This is a periodic threat that must be considered when evaluating the fire problem and fire defense capabilities.

## EXISTING FIRE SITUATION

The moderate fire hazard in the City is closely related to its land usage and development patterns. Because the number of industrial complexes, high-rise buildings, and commercial centers is limited, the fire problem is generally confined to single and multi-family dwellings. Because the frequency of fire and the opportunity for large-loss fires are less, this does not mean that fire hazard is minimized. Map I indicates the number of fires reported in each community during 1974.





Where Fires Occurred 1974



## RESIDENTIAL DEVELOPMENT

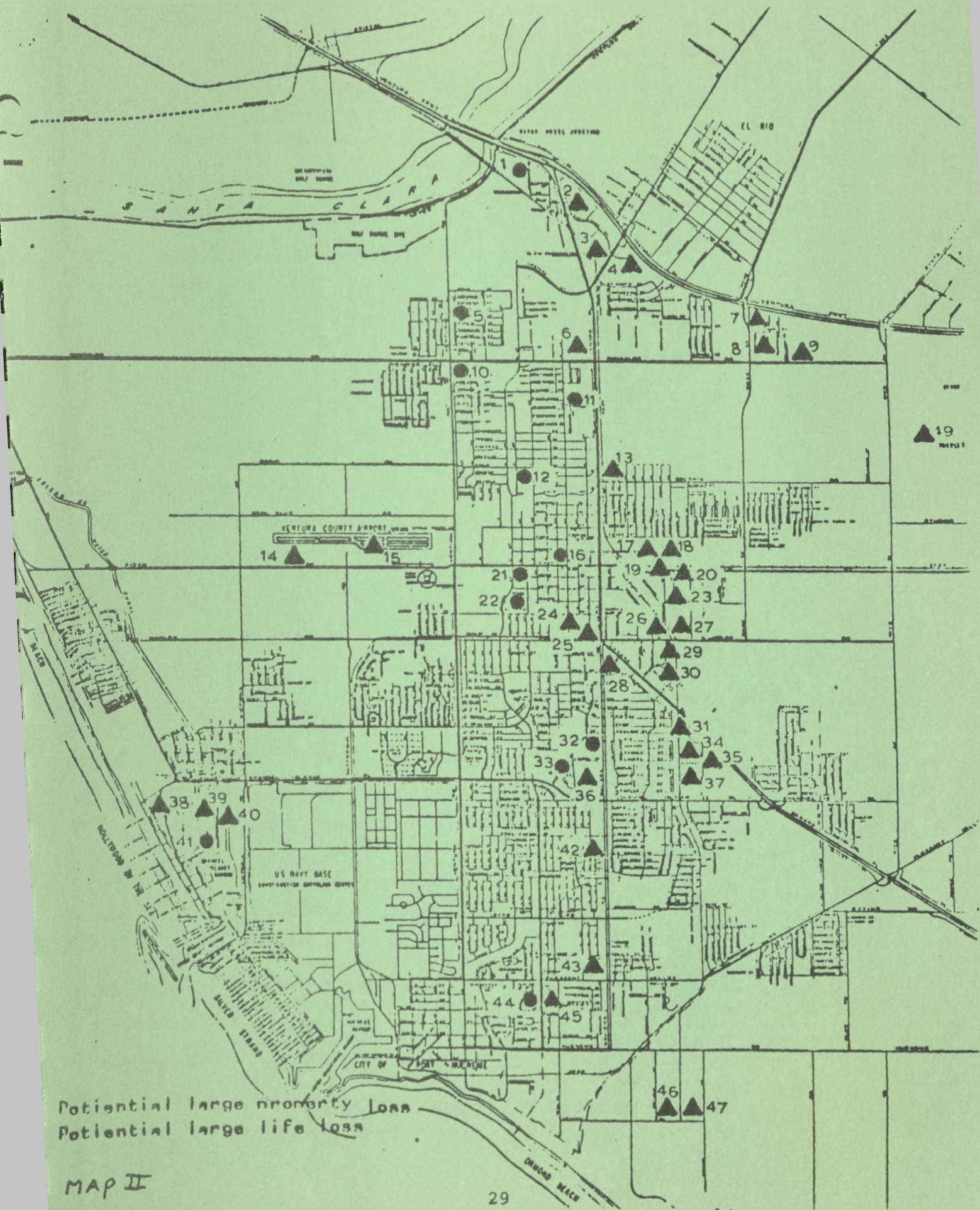
Because of its extensiveness in the City, residential use constitutes a major consideration in determining fire potential. This is especially true in high density, multiple-family areas which present fire hazards not found in other occupancies. There are common attics and separations that are routinely violated by occupants installing electrical, plumbing and other alterations that promote fire spread in hidden areas; misuse of storage areas for flammables in quantities not safely protected; access to occupancies limited due to deep setbacks; improper parking in alleys and roadways; security fences that inhibit movement of fire combat forces; and restricted traffic flow within the complex.

## HIGH VALUE AREAS

A high-value or large-loss fire is one in which \$250,000 or more in damages is incurred. High value areas such as the City's principal business districts; large single occupancies with minimum fire protection systems; large complexes (such as the Esplanade Shopping Center, Financial Plaza, Twin Centers Shopping Center, and Ormand Beach and Mandalay Edison Generating Plants) require massive and immediate fire control forces if fire loss is to be kept within acceptable limits (See Map II). Bulk storage of flammable liquids and multi-story buildings also demand special attention. In addition to individual loss to property owners, loss of these types of occupancies has a large financial impact on the community in terms of property taxes, sales revenue, employment and convenience.

To handle fire potentials, the City has adopted: (1) Uniform Building Code; (2) Uniform Fire Code; (3) applicable sections of Oxnard City Ordinance pertaining to fire protection, accumulation, collection and disposition of combustible refuse; and (4) is subject to Sub-Chapter 1, Title 19, California Administrative Code.







1. Wagon Wheel Bowl	2801 Wagon Wheel Road
2. Esplanade Shopping Center	Esplanade Drive
3. Two Guys North	2505 Vineyard Avenue
4. Financial Tower	500 Esplanade Drive
5. Guardian Convalescent Hospital	2130 North Ventura Road
6. Carriage Square Shopping Center	341 West Gonzales Road
7. Wallace Machinery	Highway 101 and Rose Avenue
8. Unigas	1850 Lockwood Street
9. Falcon Plastics	1950 Williams Drive
10. Oxnard Manor	1400 West Gonzales Road
11. Glenwood Convalescent Hospital	1300 North C Street
12. St. John's Hospital	333 North F Street
13. Seaboard Lemon	600 North Harrison Avenue
14. Abex	3151 West Fifth Street
15. Ventura County Airport	1812 West Fifth Street
16. Plaza Vista Apartments	401 South C Street
17. Somis Lemon	606 East Third Street
18. Universal Packing Company	804 East Third Street
19. Phillips 66 Bulk Plant	801 East Fifth Street
20. Mobil Oil Bulk Plant	1230 East Fifth Street
21. Oxnard Community Hospital	540 Hobson Way
22. Oxnard Auditorium	800 Hobson Way
23. Oxnard Frozen Foods	600 Diaz Avenue
24. General Telephone Company	900 South C Street
25. Peoples Lumber Company	1051 South A Street
26. Dual Wide Company	601 East Wooley Road
27. Gentry	950 Richmond Avenue

28. Thompson Lumber	1205 South Oxnard Boulevard
29. Architectural Fiberglass	1160 Mercantile Avenue
30. Raytheon	1278 Mercantile Avenue
31. Santa Clara Lemon Association	1801 South Oxnard Boulevard
32. Norton's Rest Haven	2105 Saviers Road
33. Maywood Manor	2641 South C Street
34. Statham Instruments	2230 Statham Road
35. Statham Instruments	2201 Statham Road
36. Two Guys South	2401 Saviers Road
37. Statham Instruments	2211 Statham Road
38. Harborwalk	Harbor Boulevard
39. Islander Marina	3101 & 2901 Peninsula Road
40. Villa Sirena Apartments	Peninsula Road
41. Casa Sirena Motor Hotel	Peninsula Road
42. Tournament Bowl	3443 Saviers Road
43. Pleasant Valley Shopping Center	Pleasant Valley & Saviers Road
44. Pleasant Valley Rehabilitation Hospital	5225 South J Street
45. Villa Tropicana Apartments	5200 South J Street
46. Diamond Shamrock	6000 Arcturus Boulevard
47. Kaiser Aluminum	1001 McWane Boulevard
48. Edison Generating Plant	Edison Road
49. Charmin Paper Company	800 North Rice Avenue

In addition to the above occupancies, the following occupancies should be considered as locations wherein large life and/or property loss potential exists.

50. Schools and Churches	Throughout City
51. Elks Club	801 South "A" Street
52. Neighborhood shopping centers	Throughout City



- |                                       |                                 |
|---------------------------------------|---------------------------------|
| 53. Knights of Columbus Club          | 600 South "D" Street            |
| 54. Lobster Trap                      | 3605 Peninsula Road             |
| 55. Apartment complexes               | Throughout City                 |
| 56. K Mart Shopping Center            | Channel Islands at Ventura Road |
| 57. Industrial complexes              | Central (East) sector of City   |
| 58. Mandalay Beach Generating Station | 500 N. Harbor Boulevard         |

## CONFLAGRATION POTENTIAL

A conflagration is so termed when a fire becomes widespread and crosses natural or prepared barriers; i.e., streets, fire walls, or prepared fire breaks. Fire in large complexes, although fire loss may be considerable, is not necessarily conflagration unless the fire extends beyond the perimeters of the complex.

In the City of Oxnard, there are potential conflagration areas in the residential quarter sections (Colonia Area), and in principal business districts (See Map III). These areas are identified as conflagration potential due primarily to the structural conditions of existing buildings prior to adequate code enforcement, lack of on-site fire protection facilities, horizontal fire spread due to inadequate fire separations, concentration of structures, and Santa Ana wind conditions.



# Chapter V

## Conflagration Fire Losses

The danger of a wide-spreading fire, commonly termed a conflagration, exists in varying degree in most cities and towns in the United States and Canada. Tables 1-57 and 1-59 list the principal conflagrations occurring in the United States and Canada since 1914, together with a summary of some of the larger conflagrations occurring before that year. Table 1-64 lists typical conflagrations in other parts of the world since 1900.

### A. Characteristic of Conflagrations

There is no universally accepted exact definition of a conflagration. Some list as conflagrations all fires causing more than a specified amount of loss, irrespective of the extent of spread or the number of buildings involved. The best practice is to apply the term only to fires extending over a considerable area and destroying numbers of buildings. A large fire in a group of buildings such as those belonging to a single industrial plant is not considered as a conflagration even though the area and values involved may be considerable. Neither is a fire in a closely exposed group of mercantile or warehouse properties classified as a conflagration unless the fire crosses natural or prepared exposure barriers, such as streets and fire walls.

This discussion is limited to the special type of fire regarded as a conflagration and excludes individual and group fires regardless of their magnitude. Forest fires have not been included except in instances where they spread to or destroy numbers of buildings. For forest protection, see Section 10, Chapter V.

It is best to use the term "conflagration" conservatively. For certain fires the term "group fire" is more closely descriptive. These include fires within the limit of an industrial plant property even if several buildings are involved, and fires in a group of mercantile buildings, particularly within a single city block. In both such cases, buildings may be so close together that a fire may spread from some of the buildings to adjoining ones, but it is unlikely to spread outside the plant area, or beyond the block or group of mercantile buildings because of fire wall barriers, streets or other open spaces.

Conflagrations have been of four general types:

(1) Fires starting in hazardous occupancies or fire breeders in congested sections which spread in one or more directions before effective resistance is organized to bring them under control. These fires usually spread first to nearby properties lacking exposure protection, cross streets by means of radiated heat and spread chiefly in the direction in which the wind is blowing. Failure to control such fires is due almost entirely to lack of sufficient water application through heavy stream devices by the fire department, and lack of exposure protection. Buildings equipped with automatic sprinkler adequately supplied by water have been extremely successful as barriers to the spread of such fires.

**Table 1-57. Famous Conflagrations in the United States Occurring Prior to 1914**

Date	Location	Property Destroyed	Loss
1835	New York, N. Y.	Buildings covering thirteen acres .....	\$15,000,000
1845	Pittsburgh, Pa.	1000 buildings .....	3,500,000
1849	St. Louis, Mo.	425 buildings, 27 steamships (1 killed) .....	3,500,000
1851	San Francisco, Calif.	2500 buildings .....	3,500,000
1861	Charleston, S. C.	.....	10,000,000
1866	Portland, Me.	1500 buildings .....	10,000,000
1871	Chicago, Ill.	17,430 buildings (250 killed) .....	168,000,000
1871	Peshigo, Wis.	17 towns destroyed by forest fires (1052 killed).....	no loss figure
1872	Boston, Mass.	776 buildings (13 killed) .....	75,000,000
1874	Chicago, Ill.	.....	5,000,000
1889	Seattle, Wash.	.....	5,000,000
1889	Spokane, Wash.	.....	6,000,000
1889	Boston, Mass.	52 buildings (4 killed) .....	1,600,000
1889	Lynn, Mass.	.....	5,000,000
1892	Milwaukee, Wis.	.....	6,000,000
1900	Hoboken, N. J.	Piers and steamships (326 killed) .....	4,600,000
1901	Jacksonville, Fla.	1700 buildings .....	11,000,000
1902	Paterson, N. J.	525 buildings .....	5,500,000
1904	Baltimore, Md.	80 city blocks in business section .....	50,000,000
1906	San Francisco, Cal.	28,000 buildings, earthquake-conflagration (452 killed) ..	350,000,000
1908	Chelsea, Mass.	3500 buildings (1 killed) .....	12,000,000
1911	Bangor, Me.	267 buildings (2 killed) .....	3,188,000

(2) Fires occurring in primarily residential sections which spread beyond control due to closely built combustible construction and wooden shingle roofs. Such conflagrations may occur where such construction practices are allowed, and where fire protection forces are weak and water supplies are inadequate.

(3) Conflagrations resulting from extensive forest and brush fires entering a municipality over a wide frontage.

(4) Conflagrations due to explosions with resulting fire over a wide area.

In many peacetime conflagrations, heated gases of combustion have been known to travel for considerable distances and then burst into flame, spreading the fire. Conflagrations also extend horizontally by means of radiated waves of heat. Exposed buildings ignite before flames reach them directly. Burning brands, such as flaming wooden shingles, also start fires well ahead of the flame front. This fact makes exposure protection of utmost importance in combating conflagrations.

## **B. Wartime Conflagrations**

In World War II, great fire destruction was visited on the cities of Germany and Japan.\* The cities of England and Scotland suffered bad fires in the early days of the war, but few were conflagrations in the strict definition of the word as given in this chapter. German cities, for the most part, were so built that

\* U. S. War Relocation Authority, published by the NEPA (out of print).



conflagrations in the technical sense simply were not possible, though the magnitude of destruction by fire far exceeded that of most conflagrations. The attacks with incendiaries, principally by the Royal Air Force, started thousands of fires, but these burned in individual buildings with little spread from building to building, except where fire storms developed.

On the basis of incomplete assessments, at least the fifty-four largest cities in Germany had their central zones destroyed, destruction varying from 10 to 70 per cent in individual cities with a median of 40 per cent, principally due to the fires.

In Dresden, Hamburg, Leipzig, Kassel, Darmstadt, Stuttgart, and possibly a few other cities, fire storms and fires of conflagration proportions occurred with great loss of life. These resulted from the merging of thousands of individual building fires.

The U. S. Army Air Force had destroyed 65 Japanese cities before the atomic bombs were dropped. Many of these fires were true conflagrations as the cities consisted predominantly of low buildings of combustible construction. Fire storms also occurred in a number of cases where incendiaries alone were used, and at Hiroshima as a result of the mass fire started by the atomic bomb. As in Germany, the centers of the Japanese cities were destroyed by fire, destruction varying from 12 to 96 per cent of the area, in individual cities, with a median of 50 per cent, wholly due to fires.

#### Fire Storms

The conditions described as "fire storms" in cities attacked with incendiary bombs in World War II were conflagrations in the sense of fires burning over a large area, but they differed from peacetime conflagrations in certain respects and were also different from the conflagrations which resulted from the incendiary attacks in most of the Japanese cities.

The fundamental characteristics of a fire storm occur in any fire; a column of burning gases and hot air rises over the fire, and air is drawn in at the sides. This may be observed at many peacetime fires; for example, when a large oil tank is burning. In such cases there is a strong air movement in toward the center of the fire. Where there is no natural wind, this air movement is all toward the center. Natural wind tends only to incline the column of rising and burning vapors.

In a fire storm, destruction is usually complete within the area. In a conflagration some buildings escape due to irregular convection currents, fire barriers, or fire fighting efforts.

### C. Conflagrations in the United States and Canada

In a 36-year period (1926-1961) conflagrations in the United States and Canada caused destruction or damage to more than 6,000 buildings. Conflagrations are still possible due to a combination of unfavorable circumstances, such as drought or high winds, failure of water supplies or simultaneous fires of accidental or malicious origin. This is true in spite of improvement in construction, such as reduction in the number of combustible roof coverings and stronger fire department protection and water supplies. The infrequency of conflagrations tends to

loss. Many of these fires occurred in small communities and although some of national prominence, were nevertheless major catastrophes to the particular community concerned. Hundreds of group or area fires, reports of which are entered in the NFPA Fire Record Department, have not been included.

The factors listed as responsible for the conflagrations in this record are those contributing to the spread of fire beyond the building or immediate area of origin. For this reason, the cause of the fire in the building of origin and its extension from the incipient stage to involve the entire building are not mentioned. Large area buildings of combustible construction, often with highly combustible contents, and without automatic sprinkler or alarm facilities, have been primarily responsible for a large number of conflagrations. Water supplies inadequate for fire fighting needs are often responsible for the failure of fire fighting forces to confine major fires to the buildings of origin.

Conflagrations prior to 1900 have not been analyzed, as conditions have substantially changed with the use of motorized fire apparatus and stronger water supplies. Table 1-57 records a few of the largest loss conflagrations in the earlier period. Table 1-63 records the principal factors contributing to conflagrations since 1900.

**Table 1-64. Typical Conflagrations in Other Countries Since 1900**

Date	Location	Property Destroyed
Aug. 26, 1908.	Constantinople, Turkey .....	1590 buildings
July 24, 1911.	Constantinople, Turkey .....	2463 buildings
July 26, 1915.	Constantinople, Turkey .....	1400 buildings
June 13, 1918.	Constantinople, Turkey .....	8000 buildings
April 1, 1921.	Manila, Philippine Islands .....	22 blocks (2 killed)
Feb. 10, 1923.	Suva, Fiji Islands .....	20 buildings
May 22, 1923.	Mexicali, Mexico .....	2 blocks (14 killed)
Sept. 1, 1923.	Tokyo and Yokohama, Japan .....	509,000 buildings (91,344 killed) (earthquake and conflagration)
July 4, 1925.	Manizales, Colombia .....	32 blocks
May 22, 1928.	Katais, Russia .....	359 buildings (22 killed)
April 19, 1930.	Fabrica, Philippine Islands .....	300 buildings (20 killed)
Feb. 3, 1931.	Napier and Hastings, New Zealand .....	150 buildings (250 killed) (earthquake and conflagration)
March 31, 1931.	Managua, Nicaragua .....	22 blocks (1000 killed) (earthquake and conflagration)
Dec. 23, 1932.	Tokyo, Japan .....	20 buildings (19 killed)
March 21, 1934.	Hakodate, Japan .....	11,102 buildings (2018 killed)
Nov., 1938.	Changsha, China .....	Practically all of city razed (2000 killed)
Nov. 14, 1939.	near Caracas, Venezuela .....	Town destroyed
April 15, 1940.	Colon, Panama .....	24 city blocks (293 buildings)
June 28, 1948.	Fukui, Japan .....	12,312 buildings (3000 killed) (earthquake and conflagration)
Sept. 2, 1949.	Chungking, China .....	8046 buildings (2513 killed)
Feb. 14, 1956.	Gerze, Turkey .....	1233 buildings (17 killed)
March 5, 1958.	San Juan, Puerto Rico .....	185 buildings
March 22, 1958.	Damat, Egypt .....	Hundreds of huts (16 killed)
July 10, 1958.	Alexandria, Egypt .....	
Aug. 24, 1958.	Bursa, Turkey .....	2500 buildings
Dec. 29, 1958.	Koniya, Japan .....	1000 buildings
May 29, 1961.	Hachioke City, Japan .....	717 buildings



### D. Other Conflagrations

Conflagrations have not been peculiar to the North American continent and recent experience indicates that in many parts of the world the conditions that breed conflagrations are even more prevalent today than in the United States or Canada. Typical examples of conflagrations that have occurred outside the United States and Canada since 1900 are listed in Table 1-64.

### E. Factors Responsible for Conflagrations

The factors listed in Table 1-63 are derived from a study of reports of the conflagrations which have occurred since 1900. Conflagrations are seldom due solely to any one factor and the tabular summary indicates the number of fires to which each factor has contributed rather than one outstanding factor for each fire. No attempt has been made to list all the minor factors responsible for the spread of these fires, but the principal ones have been determined as accurately as possible from the reports in the NFPA fire record files.

The changes in order of frequency of the contributing factors during the two time periods are significant. Wood shingle roofs, for example, dropped from number 1 position to position 4 in the more recent period. In this regard it is regrettable that wood shingle roofs have regained popularity in isolated areas of the United States. The 1961 Los Angeles conflagration involved one of these areas.

High winds comprise the leading factor in the 1926-1961 period. Inadequacy of water distribution systems is now the second most frequent contributing factor, an indication that the development of public fire protection has not kept pace with structural growth in many communities.

Inferior and combustible construction is the predominant factor in the development of conflagrations and is a particularly vital matter where large areas of closely built wood-framed structures exist in congested sections. Combustible construction and contents of buildings have obviously contributed to every conflagration and, for this reason, have not been specifically listed except where the factors of congestion and inaccessibility have been involved.

### F. Forecasting Conflagrations

Fire protection engineers are able to tell where conflagrations are likely to occur. Congested areas without fire cut-offs or exposure protection, hazardous occupancies without proper protection, dilapidated fire breeding structures, large areas of dry brush, and numerous wooden shingle roofs are conducive to conflagrations.

After locating the hazardous areas it should be realized that certain weather conditions are likely to develop fires into conflagration proportions. Tests indicate that serious fires are most likely to occur when there is a deficiency of moisture in the air. It will be noted from the list of fires in this chapter that many conflagrations have occurred during months noted for warm dry weather in the area where the fire occurred. A long dry spell prepares combustible roofs and exposures for ignition. Conflagrations almost always occur on days of low humidity. High winds increase the rapidity of spread of fire. A correlation study of fire and weather data in Raleigh, N. C., showed that days favorable to fires are these



with a relative humidity factor equal to or less than 40 per cent, precipitation factor equal to or less than 0.01 inch on the day of the fire and for three preceding days, maximum wind speed equal to or more than 13 miles per hour.

### G. Prevention of Conflagrations

It is doubtful if the possibility of conflagrations and serious group fires will be entirely eliminated, particularly in the older cities, but the best authorities agree that it can be greatly reduced. Systematic city planning and zoning is recognized as a means of preventing future conflagrations. Preventive measures include the segregation of hazardous manufacturing operations, the removal of or proper protection for particularly dangerous structures in congested sections, the development of wide streets and park areas to facilitate fire fighting and to serve as fire breaks, and the isolation of fire alarm central stations.

Other means of reducing the conflagration hazard include:

(1) Requirements for a high standard of building construction for all buildings, particularly in high value districts, by means of an adequate, enforced building code.

(2) The elimination of wooden shingles and other combustible roof covering by means of a suitable ordinance (see Sec. 8, Chap. VI).

(3) Adequate exposure protection wherever communicating fires are likely, including openings in fire-resistive buildings. Methods of protection include outside open sprinkler protection for all wall openings, blank walls with adequate parapets above the roof for serious exposure hazard, wired glass windows and shutters (see Sec. 8, Chap. XIII). Experience has shown that for serious exposure fires more than one form of protection is desirable. Wired glass windows and shutters must be closed to be effective.

(4) Conflagration breeders, the term for very dilapidated structures and the in which especially dangerous enterprises are carried on, are easily detected and should not be tolerated in high value districts. Buildings which have served their usefulness and are in a state of disrepair should be condemned and removed.

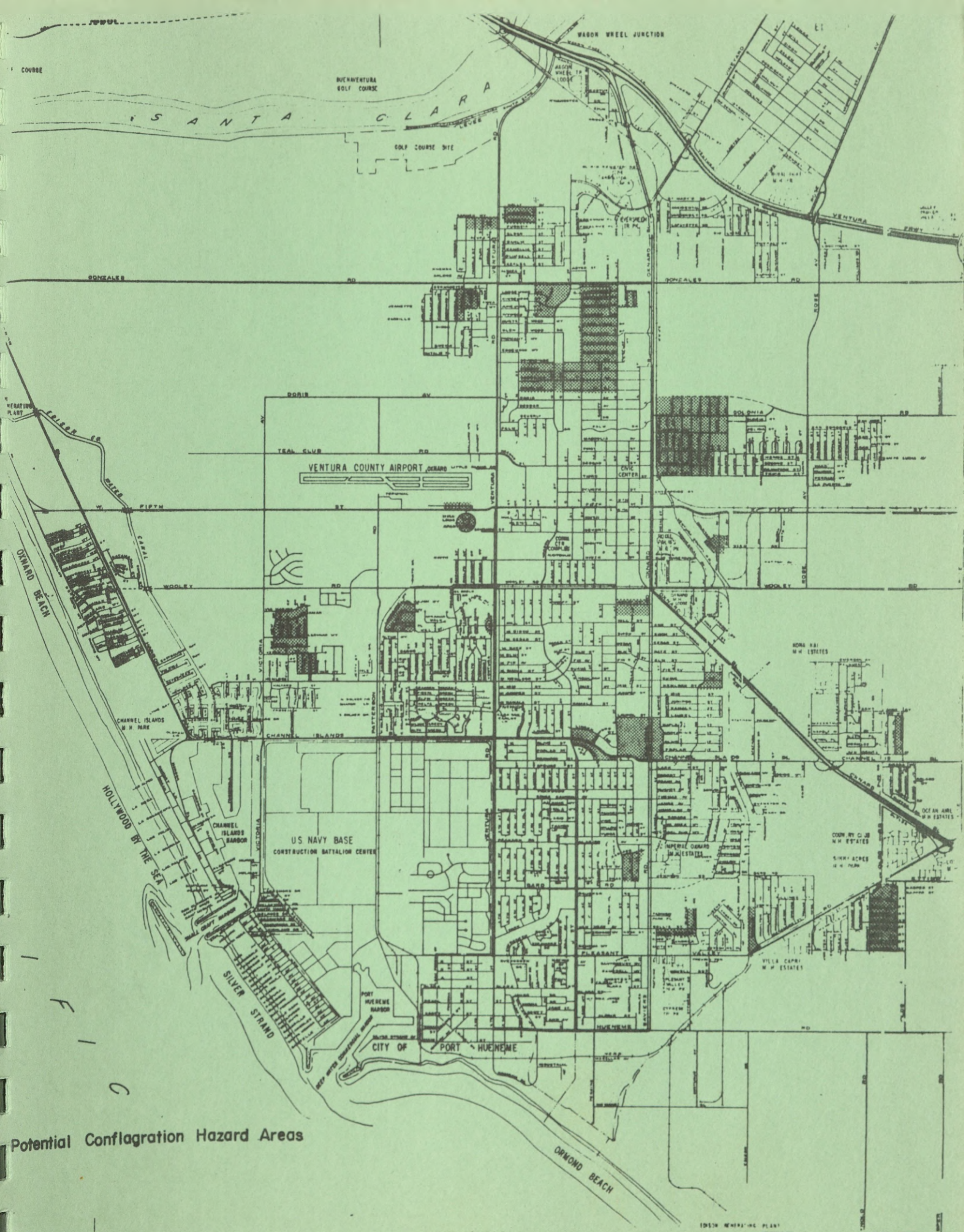
(5) General use of automatic sprinklers, particularly in high value districts and hazardous occupancies. Numerous fires are on record where sprinklers have prevented severe exposure fires from developing into conflagrations (see Sec. 8, Chap. XIII, and Sec. 16, Chap. IV).

(6) Improved public water supplies, including elimination of small and dependent mains (see Sec. 13, Chap. I). Developing auxiliary sources of water supply such as ponds, brooks and canals, by providing accessible locations from which fire department pumps can take suction.

(7) Improved fire department efficiency, including ample heavy stream equipment, better training of firemen for large operations and increased manpower where necessary (see Sec. 10, all chapters).

(8) Complete municipal fire alarm and radio systems to provide for the handling of all alarms and the dispatching of apparatus without the necessary dependence upon public telephone facilities, which are invariably severely taxed during emergencies. Automatic fire alarm installations in hazardous properties and arrangements for the prompt response of the fire department will contribute to the control of fires before they reach a stage where they may overtax available fire protection equipment (see Sec. 14, Chaps. I and II).





Potential Conflagration Hazard Areas



## RECOMMENDED ACTIONS - FIRE HAZARDS

### ACTION PLAN

Technological advances are experienced on an almost daily basis, and the projected growth and density in the City of Oxnard places a heavy burden of responsibility upon the Fire Department. Specialized skills and equipment must be constantly upgraded to meet the challenge of today and tomorrow.

- I. The most viable vehicle to implement the processes required to meet our goal to minimize life loss potential and property loss due to fire is to formulate a Master Plan for Fire Protection. The "Master Plan for Fire Protection" will be utilized to:
  - A. State the fire protection goals of our community.
  - B. Specify current and planned community environment in which fire protection is to be provided.
  - C. Describe current and planned fire services.
  - D. Identify needs for, and program allocation of, fire protection resources.
  - E. Promulgate inter and intra-departmental policies and operational procedures with assigned responsibilities and authority.
  - F. Formulate and implement management policy. The plan will include typical Fire Department goals such as:
    1. Establishment of an acceptable level of fire protection.
    2. Identify and articulate benefits.
    3. Formulate methods of measuring risk and performance.
    4. Provide methods for community participation in formulation of the plan.
    5. State level of required resource needs.
    6. Provide a basis for inter-departmental programming and budgeting.



7. Assign fire protection responsibilities.
8. Determine priorities for action.
9. Design a system of effective management.

Implementation of a Master Plan for Fire Protection will necessitate legislative action by the City Council to establish standards for built-in fire protection systems. This legislation should require that large facilities be designed to incorporate systems to furnish fire protection to the degree that these facilities will not require the general taxpayer to subsidize fire protection for the benefit of the few owners of the large facilities.

II. Several additional elements that should be specified in a Master Plan for Fire Protection are:

A. Fire Prevention:

1. An informed and concerned public is the most important factor in eliminating causative and contributive fire hazards. Only through an intensive program of dissemination of information and education can the public understand the problem and set personal objectives to eliminate fire hazards. The Fire Department must continue to improve its public information and education program if a desirable measurable impact of public effort on the elimination of fire ignition and fire hazard is to be accomplished.
2. Community-oriented neighborhood action programs should be encouraged in all neighborhoods to eliminate causative and contributive fire hazards. The currently organized Neighborhood Councils could be a valuable asset in this effort.
3. The current program of engine company fire prevention inspections should be intensified in the enforcement of the Uniform Fire Code to reduce life hazard, fire ignition and fire loading factors that cannot be eliminated through public education and cooperative approaches.
4. The Uniform Fire Code and the Uniform Building Code should be periodically reviewed in concert with the Master Plan with the intent of minimizing the size of public fire protection forces. Built-in fire protection systems have long been recognized as the best approach to standby fire protection in the most equitable and economical manner.

## B. Fire Detection and Reporting:

1. All large multiple family residential occupancies and all large non-residential structures should be designed to incorporate an approved automatic fire detection (products of combustion) system that will connect directly to an emergency reporting system.
2. A sophisticated public safety emergency reporting system is mandatory if we are to overcome the time lag between the recognition of an emergency situation and the dispatch of the appropriate emergency agency. The time lapse caused by indecision, wrong numbers, or locating the appropriate emergency number is a critical factor. One method to modify this critical factor is to employ mandatory operational standards applicable to a sophisticated 911 system of emergency reporting. Inter-agency cooperation between governmental jurisdictions and telephone companies' central offices to insure an "immediate call routing" capability is necessary. The ability to hold the reporting party on the line, to ring back the party, to selectively or automatically route calls, automatic number identification and automatic location identification are all critical requirements of a sophisticated 911 system.
3. The 911 system should be incorporated into the City's emergency system at the earliest possible date.

## C. Fire Control

1. The current practice of continual update of information relating to optimum location of fire station sites in conformance with the General Plan should be continued. The General Plan, properly implemented, will assure that fire stations will be located to provide timely response of emergency fire services to citizens in need.
2. Every large non-residential structure should be provided with automatic fire sprinkler systems. When activated by fire, an alarm shall be automatically transmitted to an emergency dispatch center.
3. As more modern equipment becomes available, obsolete Fire Department equipment should be replaced. This type of replacement program will contribute to a favorable cost benefit ratio.



4. Consideration should be given to continuing consolidation of response areas in Ventura County, Ventura City, and Oxnard City. These jurisdictions could gain through thoughtful consideration of the benefits to the taxpayer that may be derived.

#### SUMMARY

The foregoing recommendations were designed to lower life and property loss potential and to transfer the major cost of fire protection to those who create the greatest need for such protection. Placing the major cost of fire protection on the individual developer and/or land owner rather than allocating it to property tax funds more equitably places the cost upon those who receive the most benefit. The main objective is to reduce the discovery time of fires, insure reliable means of transmitting the alarm, and control all fires before they exceed the fire control capabilities of the on-duty fire combat forces.

Fire protection systems should be included in construction to minimize manpower and equipment required to prevent large losses. An active code enforcement program by the Fire and Building Departments should be intensified to insure that maximum precautions are taken to minimize the ignition and spread of fire.

The City of Oxnard's goals in the Safety Element regarding Fire Protection are:

1. Maintain a fire prevention and fire protection system that benefits all Oxnard residents equitably.
2. Provide protection and relief to residents in the event of uncontrolled major disasters.
3. Safeguard the economy and well being of the community through fire protection and immediate and temporary medical assistance.

To accomplish these goals, the following objectives and programs are planned:

1. Prevent fires from starting - objective: development of an intensified fire prevention activity. Programs:
  - a. Continue intensive fire prevention training for all companies.

- b. Intensify the current public fire prevention educational activity.
  - c. Continue the comprehensive home inspection activity.
  - d. Intensify commercial fire prevention inspections.
  - e. Develop budgetary support for increased fire prevention activities.
  - f. Upgrade local ordinances through continuous review of applicable standards.
  - g. Upgrade fire and arson investigative capacity.
2. Hold to an acceptable minimum, life and property loss as to unpreventable fires and major disasters - objective: implementation of a master fire plan. Programs:
- a. Design and cause to be implemented local legislation to provide for self protection and alarm notification for privately-owned structures.
  - b. Upgrade communications.
  - c. Upgrade apparatus and equipment.
  - d. Strategically locate men and equipment.
  - e. Upgrade traffic signal devices (for quicker fire response).
  - f. Make a new list of priorities of the Fire Department function, giving greater emphasis to fire prevention.
  - g. Institute intensified training:
    - 1) Joint training with mutual aid partners
    - 2) Expanded local fire fighter training
    - 3) Expanded Emergency Medical Training
  - h. Recruit the best qualified and most highly motivated fire fighters.
  - i. Intensify fire pre-plan activity.
  - j. Intensify disaster training (area-wide).
  - k. Continuously upgrade response maps and run cards.



# STRUCTURAL DEFICIENCIES



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STRUCTURAL DEFICIENCIES - XV-1 thru XV-16

The pages listed below have not had changes made.

XV-1

XV-3

XV-6

XV-7

XV-8





Illustration 15.1

*Ruins of San Francisco City Hall, 1906. Cornerstone laid February 22, 1872. Dedication July 1, 1899.*

*Source: Seismic Study, West Wing California State Capital, June, 1972.*



# GENERAL DISCUSSION

## GENERAL DESCRIPTION

Simply stated, the greatest single cause of life-loss and property damage in an earthquake is the effect the shock has upon man-made structures, i.e. shattered glass, falling bricks and other materials, building collapses, etc.

The science of earthquakes and their influence on man-made structures is relatively new and imprecise. Since 1933, tremendous improvement has been made in the safety features of buildings subjected to earthquakes. Substantial knowledge gained through experience in the relationship between actual earthquakes and structures has produced improved structural design and construction techniques; however, we are far from developing "earthquake-proof" buildings.

This section on structural deficiencies focuses on 1) the evaluation and identification of hazardous structural deficiencies and 2) the development of land use and construction standards to minimize any hazard created. The subject will be treated generally since local inventories of the hazard are not available and such research is beyond the capability of this report.

In discussing structural deficiencies an understanding of the types of structures and their response to earthquakes is essential.

In general, unreinforced masonry, brick and concrete buildings are very susceptible to damage in earthquakes. Parapets, chimneys and other appendages are also hazardous, when not properly attached or reinforced. Another indication of a hazard is the year when a structure was built, since seismic safety standards in buildings were not required or generally used until 1933, after the Long Beach earthquake. Upgradings of the building code to incorporate the latest information and technique have occurred periodically since then.

The problem of seismic structural safety is two-fold, involving 1) the prevention of the hazard, and 2) the abatement of hazards already existing in buildings. This requires responsibility in 1) the formulation of engineering standards and the enforcement of the standards and 2) the identification and abatement of the hazard in existing structures.

Obviously, the potential severity of the earthquake hazard increases as density of settlement increases, as unsafe structures continue to be used, and as new seismically inadequate structures are built. A graphic illustration of the possible effects of structural deficiencies

took place in Agadir, Morocco. In 1960 an earthquake calculated at a Richter magnitude between 5.5 and 6.0 shook Agadir's 33,000 inhabitants. After it was over 12,000 persons had been killed and 12,000 were injured from structural failures. Reviewing the structures in Agadir:

*The most prevalent construction material was older masonry which varied from stone (with mortar of mud and sand) to more modern construction of stone or clay tile with mortar ranging from weak mud and sand to good quality sand cement. None of the masonry was reinforced. The second most prevalent type of construction was usually a very poor quality reinforced concrete which had not been designed to resist earthquake forces. (Department of Commerce, NOAA, 1972, Part B, pg. 9)*

In magnitude this earthquake compares to the Point Mugu quake of February 21, 1973, which measured 5.7 on the Richter scale. This moderate shock caused minor damage in the Point Mugu-Oxnard area. One of the main differences being that our construction standards were much better than those in the Morocco experience.

A more relevant experience is the 1971 San Fernando earthquake. Calculated at a Richter magnitude of 6.6, it was a moderate shock near a highly developed area and has since been considered a test of the modern city's ability to undergo seismic shock. The number of deaths totaled 58 which were directly attributed to earthquake effects, a number thought to be low due to a combination of fortunate circumstances. From a Report of the Los Angeles County Earthquake Commission, it is worth repeating the following scenario which makes one aware of the possibilities of a catastrophe in our own area.

*Had the earthquake centered twenty miles farther south close to the center of population in metropolitan Los Angeles, it would have done much more damage and caused the collapse of many more old buildings. Had it occurred three hours later, there would have been many more occupants in the buildings that did collapse. Had the freeways been crowded, the bridges that collapsed would have caused many more deaths and injuries, and other casualties would have resulted from automobile accidents caused by the sudden disruption of the thoroughfare. Had the earthquake occurred when more people were on downtown streets there would have been many more casualties from falling debris. Finally, the lower San Fernando Dam had only four feet of freeboard after its partial failure; had*



it failed completely - or even after emptying was well along an area inhabited by 80,000 people would have been inundated.

The 1971 earthquake pointed out major structural deficiencies in the ability of old and new buildings to undergo seismic stress. The San Fernando Veteran's Administration Hospital had a number of buildings built between 1925 and 1927 without earthquake resistance measures which were severely damaged. Forty-six persons died in the collapse of two such buildings constructed of reinforced concrete frame. The main Olive View Medical Center buildings, recently completed, were constructed of reinforced concrete under earthquake resistant standards. It suffered extensive damage including the collapse of the Psychiatric building, causing the deaths of three persons.

The cause of structural deficiencies may be any one or combination of factors. Construction practices, policies on land use, enforcement of building codes and rehabilitation programs have not always considered the consequences of seismic activity.

Building codes are the basis for establishing minimum standards to meet seismic safety in buildings. The goal of seismic safety was aptly expressed by the structural Engineers Association in their publication, "Recommended Lateral Force Requirement and Commentary, 1963," when discussing the purpose of the seismically oriented building codes. The intent is to construct structures which will:

COUNTY  
Paragraph  
Added.

1. Resist minor earthquakes without damage.
2. Resist moderate earthquakes without structural damage, but with some non-structural damage.
3. Resist major earthquakes of the intensity of severity of the strongest experienced in California, without collapse, but with some structural as well as non-structural damage.

If one considers these intents as valid, then it is quite obvious that these standards have not been met in past earthquakes.

## GENERAL EFFECTS OF THE HAZARD

### PRIMARY EFFECTS

The primary effects of the hazard is the loss of life and property. During an earthquake, structures can be expected to undergo the forces of fault displacement of ground-shaking. If a structure is built over faults which rupture, it could be severely damaged. However,

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the area affected is localized over the fault. On the other hand, ground-shaking effects normally extend over many square miles. The actual damage and effect are dependent on other variables besides distance to fault rupture epicenters.

The amount of damage sustained by any particular structure is also dependent on its condition and the intensity of the forces affecting it. "Ground motion is excited by the propagation of waves which emanate from the hypocenter (source) of an earthquake." (Department of Commerce, December, 1971, p. 31). Such waves generate a vibrational force whose accelerations determine the stress applied to a structure. Accelerations are measured by seismographs strategically located throughout the state. During the 1971 San Fernando earthquake, the largest motion ever recorded was located at the Palomares Dam, the forces exceeded 1.25g and there was almost continuous accelerations ranging from 0.5g to 0.7g for 12 seconds. Previous thinking considered .5g to be a "practical maximum that could be transmitted by an earthquake." (Department of Commerce, December, 1971, p. 34).

With this type of acceleration, structures which have been reinforced to withstand seismic forces have proven to do much better than those not reinforced. This, of course, does not consider the effects on a structure of liquefaction, ground failure or subsidence which are considered in other sections.

The extent of damage covers all structures including buildings, utilities, gas, water and sewage lines, highway bridges and dams. In the 1971 San Fernando earthquake, it has been estimated that over \$500 million worth of damage occurred and 58 deaths were directly attributed to the earthquake, nearly all from structural failures. "It was reported that approximately 850 homes, 65 apartment buildings and 574 commercial-industrial buildings were so damaged that they were vacated, some 4,800 homes, 265 apartment buildings and 1,125 commercial-industrial buildings had appreciable damage, and about 30,000 structures had lesser damage." (L.A. County, 1971). Generally, structures that suffered the most major damage were older masonry buildings not reinforced against lateral forces. This included the Veterans Administration Hospital Buildings that collapsed and killed 46 persons.

Not all modern structures withstood the seismic forces. Collapse of the first floor of the 2-story Psychiatric Building and severe damage to other buildings at the recently completed Olive View Medical Center is evidence that building to the minimum code specifications without regard to the special design modifications is not enough. Other structural weaknesses appeared in connectors of roofs to masonry or tilt-up walls in commercial or industrial buildings, and inadequate reinforcements of some



concrete columns, leading to collapse of those buildings. (Department of Commerce, December, 1971, p. 369).

Another direct effect was the near collapse of the lower Van Norman Reservoir which could have inundated an area inhabited by 80,000 persons. The upper and lower Van Norman Reservoirs are old earthen dams constructed by the hydraulic-fill method in 1915 and 1919. The lower dam, built in 1915, nearly collapsed and is no longer in use. The upper dam built in 1919 settled about 3 feet and moved laterally about 5 feet at the crest, but did not collapse and is being used at reduced capacity. (Department of Commerce, December, 1971, p. 369).

The collapse of five new freeway overpasses disrupted transportation arteries. Public utilities were interrupted and underground water, gas and sewer lines were also damaged. The converter station at the Pacific Intertie of PG & E, completed in 1970 suffered \$30 million worth of damage. The General Telephone Company suffered \$4.5 million in damages and 10-20,000 customers lost service for a month. Gas pipelines broke because of ground deformation and 17,000 customers lost service from 4-12 days. In addition the water pipes ruptured in over 1,000 places and the lines were plugged with sand and debris put into the system from damages at the Lower San Fernando Dam. (Jennings, 1971).

## SECONDARY EFFECTS

A major secondary effect resulting from the damage of structures is the disruption of transportation, communication and power systems. In times of disaster these systems are essential for mitigating disaster effects. Structures which house vital or critical facilities such as public buildings which coordinate and administer disaster services, fire stations and hospitals, should remain operational after an earthquake. The disruption of transportation arteries could increase the chance of accidents and prevent movement of emergency vehicles.

Another effect is the cost of rebuilding. Replacing a building is often more expensive than when it was originally built. Since reinforcement during ordinary construction projects only adds 1-2% to the cost it is not very practical to exclude sufficient reinforcements. (Joint Legislative Committee, 1974, p. 9). Both government and individuals are burdened with heavy replacement costs. Some things can never be replaced.



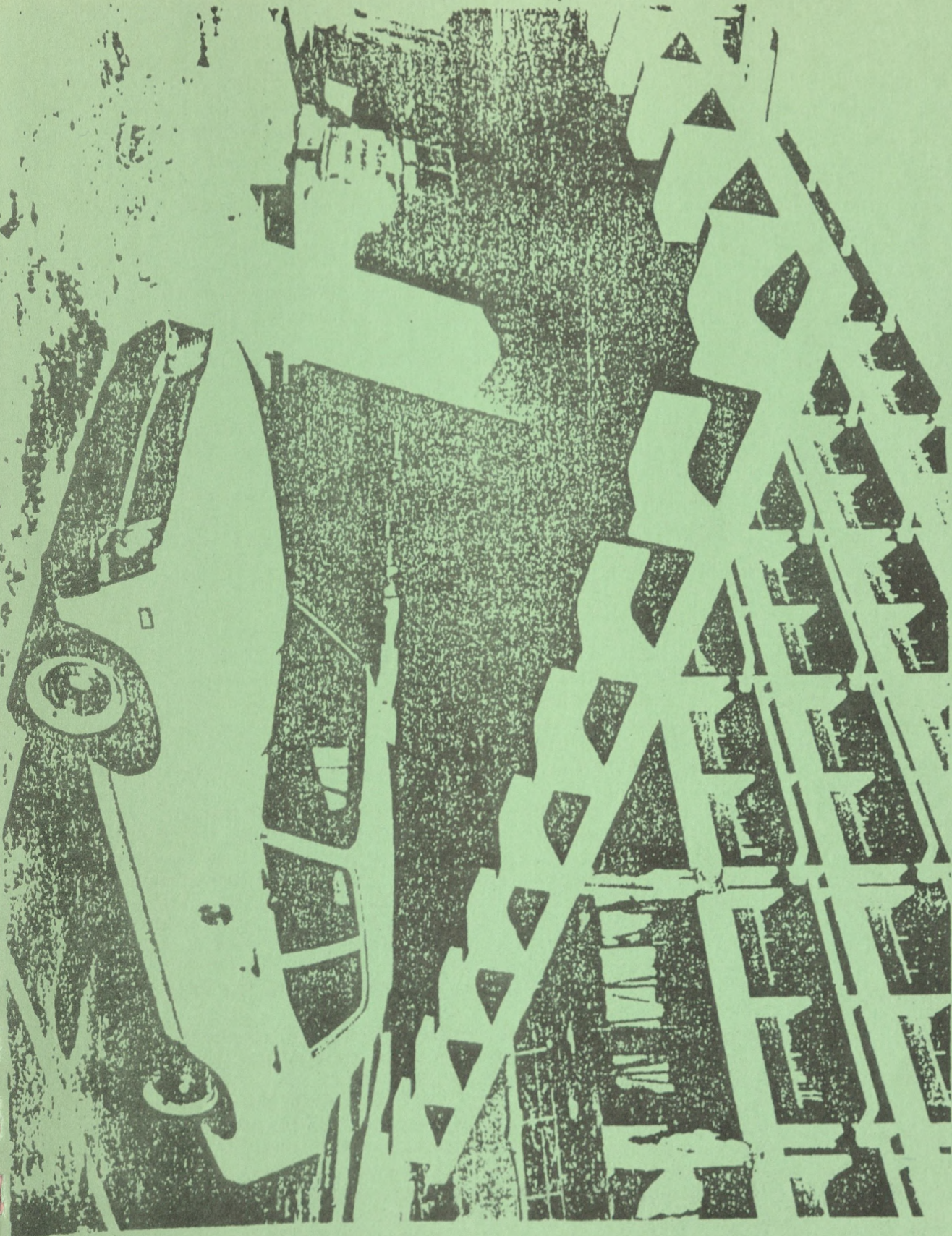
Illustration 15.4



Old building at Veterans Hospital had a skeleton concrete frame and unreinforced hollow tile filler walls. Newer parts of the hospital complex built under modern structural codes performed much better than the older sections.

SOURCE: R. IACOPI, Earthquake Country





CRUSHED AMBULANCES

Olive View Hospital

SOURCE: California Earthquake, 1971, J.E.K. Publications



## GENERAL INVENTORY OF THE HAZARD

### LOCATION OF THE HAZARD

At the present time there is no comprehensive survey or information available on the location of structural deficiencies in the County of Ventura, and it is beyond the scope of this report to conduct this survey. Such an inventory would identify the seismic risk that presently exists, through survey and evaluation of public buildings, hospitals, schools, churches, industrial buildings, freeways, dams, utilities, etc. From this the need for the abatement of this risk can be evaluated and programs developed.

In a study of a small portion of Camarillo which was surveyed in a general manner by the Ventura County Building and Safety Department, the majority of the residences were discovered to be in some way "substandard" as would be defined in the housing code. Though "substandard" reflects many deficiencies and not necessarily seismic safety, nearly all of these structures were built before 1933. This could be considered a hazardous condition, because structures built before 1933 did not require reinforcement against seismic forces and past experience indicates they have generally done very poorly in earthquakes. This is especially true for masonry and concrete buildings, such as those found extensively in Ojai. Wood frame residences are generally much safer, but if they were built over 40 years ago and not kept in good condition, a hazard could exist.

There are other concentrations of structures considered substandard and these areas warrant further study to evaluate existing levels of risk and the abatement of risk. Such areas which might warrant further study include: Saticoy, Nyeland Acres, El Rio, Moorpark, Box Canyon, and older parts of Ventura and Oxnard.

### HISTORY OF THE HAZARD

The largest earthquake known to have affected Ventura County was centered near Fort Tejon in 1857. The damage was severe from a shock estimated around a magnitude of 8.0. It was reported that the roof of the Mission church at San Buenaventura collapsed, and six miles from the mouth of the Santa Clara River the bed of the river was severely cracked. The cracks were described as 6-8 inches across, which was probably due to lurching and there was indication of liquefaction in the saturated alluvium. (California Division of Mines and Geology, 1973, p. 40). Such severe ground-shaking in the same area today would undoubtedly cause severe damage.



Since that time no major earthquakes centered in the County have been recorded.

The two strongest recorded have measured 5.7. On February 21, 1973, an earthquake was centered near Pt. Mugu and measured 5.7 on the Richter scale at 5.7. Unreinforced brick chimneys and buildings in Oxnard were damaged. Other types of buildings and structures suffered minor structural damage. Moderate architectural and mechanical/utility features were damaged. Another earthquake with a magnitude of 5.7 caused minor damage in Ventura during the 1925 Santa Barbara earthquake.

During the 1971 San Fernando earthquake, a structural damage occurred in Simi Valley to older buildings, including a church. Another earthquake within the County in 1957, measured 4.7 and centered near Pt. Hueneme caused minor structural damage.

#### DEFINITION OF THE HAZARD ZONE

For this study no delineation of a hazard zone is possible within the scope of this study. Such a zone could only be developed after a survey identifying and classifying various structures that may create seismic hazard.

The following criteria could be considered as guidelines for determining whether a building is in need of inspection for structural deficiencies. These criteria were presented in the report of the Joint Committee on Seismic Safety to the State Legislature.

- 1) The building was constructed before 1933, or a later designated date. Later dates may be established for a specific local jurisdiction, based on an evaluation of each jurisdiction's history with respect to design standards and effectiveness of enforcement. This should probably be done by the proposed State Commission on seismic safety.
- 2) The building lies within a zone designated as probably subject to substantial earthquake shaking. To facilitate administering the hazards reduction program, the zone areas should conform to existing governmental boundaries, and avoid bisecting individual local jurisdictions.
- 3) The building is of a construction with "load-bearing-unreinforced masonry walls using lime and mortar, and wood floors and roof.

## GENERAL MANAGEMENT RESPONSIBILITY

### INVESTIGATION

Structural deficiencies has been and continues to be studied by the Structural Engineers Association of California, who have a state-wide Seismology Committee. This committee was first formed in 1957 to resolve differences in existing codes and prepare a single set of recommendations for lateral-force criteria. (Joint Legislative Committee, 1974, p. 198). These recommendations are updated regularly and represent the present state of knowledge regarding structural safety and are incorporated in the Uniform Building Code.

In 1969 the State Legislature formed the Joint Committee on Seismic Safety and has since conducted hearings and investigations of past disasters. They have developed current standards, policies and program proposals. Their final report was published in January, 1974. Information on structural characteristics of buildings throughout the County is presently being gathered by the County Planning Department.

### WARNING AND ALLEVIATION

The State Legislature has adopted amendments to the Health and Safety Code that requires the State Commission of Housing and Community Development and the governing body of each city and county to in part adopt rules and regulations which are contained in the Uniform Building Codes, Uniform Plumbing Code, Uniform Mechanical Code, and the National Electrical Code.

The City Council has the responsibility for the implementation of building standards and the alleviation in hazardous situations for nearly all structures. These policies are enforced by the Building and Safety Division and Public Works Department in the case of roads, bridges and other public facilities which are not defined as buildings.



Because of the technical nature of the subject only the ability of various departments to enforce the standards will insure seismic safety. Trained personnel capable of checking plans and inspection are of utmost importance.

For meeting seismic safety standards, the approval and inspection of the construction of public schools (excluding State Colleges and Universities) and recently of hospitals is regulated at the state level. The Department of Transportation is responsible for State highways and freeways. The Department of Water Resources is responsible for the safety of dams in California, except Federally owned dams.

# FINDINGS

## PROBABILITY OF OCCURRENCE

From the evidence and the studies of geologists, the possibility of a major earthquake occurring in or near Ventura County is inevitable. From the past performance of structures in earthquakes it can be assumed that a significant hazard does exist in Ventura County. However, there can be no definitive statement, since information for a local inventory is not available at this time. Such an assessment requires a thorough evaluation of existing structures.

The probability of occurrence can be reduced to a minimum through careful land use planning and adequate reinforcement of structures against seismic forces.

Higher earthquake safety can be achieved through a comprehensive approach. Such an approach would include these areas of concern: "1) formulating engineering standards for new construction, 2) enforcing such standards and 3) reviewing existing structures and repairing or replacing those found hazardous." (Joint Committee, p. 164)

## SEVERITY OF THE HAZARD

During an earthquake the greatest cause of death and property loss are structural deficiencies. In the event of an earthquake, the severity of the effects is dependent on many variables which include the condition and the structural details of the building.

The structural failure of vital and critical facilities can increase the severity of damage. It should be recognized that such facilities as hospitals, fire stations, public buildings and communications centers should remain functional after the earthquake to help mitigate the disaster effects. Other facilities such as dams could have catastrophic effects if they failed.

## RESOURCES AFFECTED

Should an earthquake affect the area, there could be substantial loss of lives and property. In addition public utilities, gas, water, and sewage lines could be disrupted and may be difficult to re-establish rapidly.

## NATURE OF INFORMATION

There is a wealth of information on the ability of structures to withstand lateral forces and much of this



has been documented in engineering studies of the San Fernando earthquake. However, specific information on Ventura County's seismic structural deficiencies has not been accumulated. Therefore, conclusions in this study are mainly based on experiences of other areas and some studies on the effects of past earthquakes in Ventura County.

#### OTHER FINDINGS

The implementation of seismic safety is a very complex task and it requires qualified individuals to develop, interpret and enforce the regulations that will insure an acceptable level of risk. The City of Oxnard has in the Housing and Community Development Department the staff with such expertise for adequate plan checking and inspection of structures.

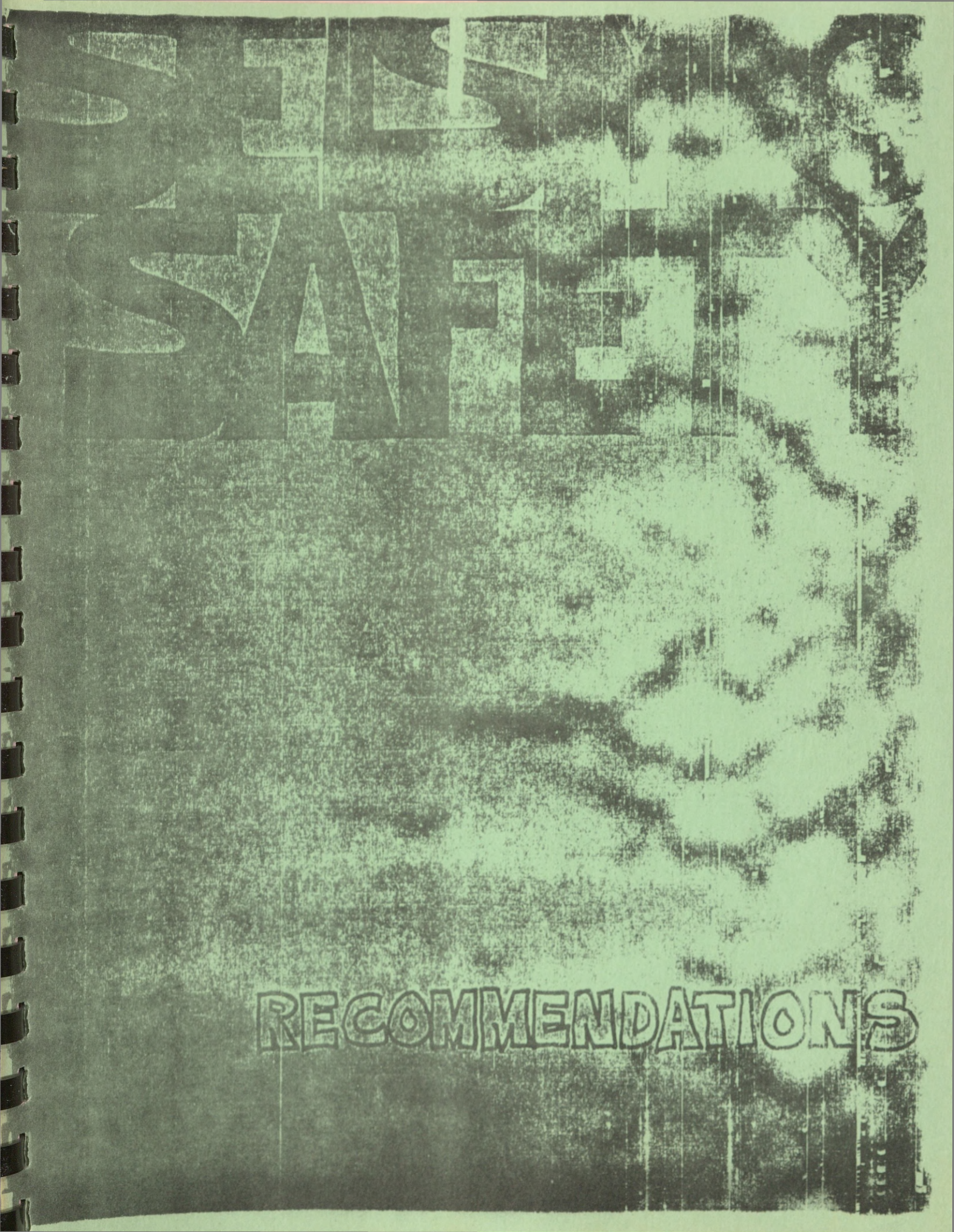
## RECOMMENDED ACTIONS - STRUCTURAL DEFICIENCIES

1. Survey structures constructed, on a statistical basis, to identify and evaluate possible hazards.
2.
  - a. Survey structures constructed after 1933, by sampling techniques, to identify and evaluate existing hazards.
  - b. Identify and survey all structures constructed prior to 1933 to identify and evaluate existing hazards.
3. Identify and survey places of public assembly, such as hospitals, schools, fire stations, churches, and buildings that could expose a large number of persons to injury in case of structural failure.
4. Eliminate the most hazardous structures through the removal or reinforcement of the structures against seismic forces. Make allowances to protect and preserve buildings of historical interest. Priorities should be decided based on these criteria:
  - a. Those facilities whose continued performance is critical immediately after an earthquake.
  - b. Those structures whose failure would cause significant numbers of injuries and perhaps substantial loss of life.
  - c. Those structures whose failure would result in an unacceptable level of potential economic loss.
5. Adopt a "parapet" ordinance whereby existing hazardous parapets must be removed or reinforced.
6. Continue to adopt building codes which reflect the most recent findings in the field of structural seismic safety.
7. Support any means to insure the general availability of earthquake insurance.



8. Maintain on a continuing basis a specific current list of:
  - a. Those facilities whose continued performance is critical immediately after an earthquake.
  - b. Those structures whose failure would cause significant numbers of injuries and perhaps substantial loss of life.
  - c. Those structures whose failure would result in an unacceptable level of potential economic loss.
  - d. Those facilities or structures identified as a hazard in regard to structural deficiencies survey.





RECOMMENDATIONS

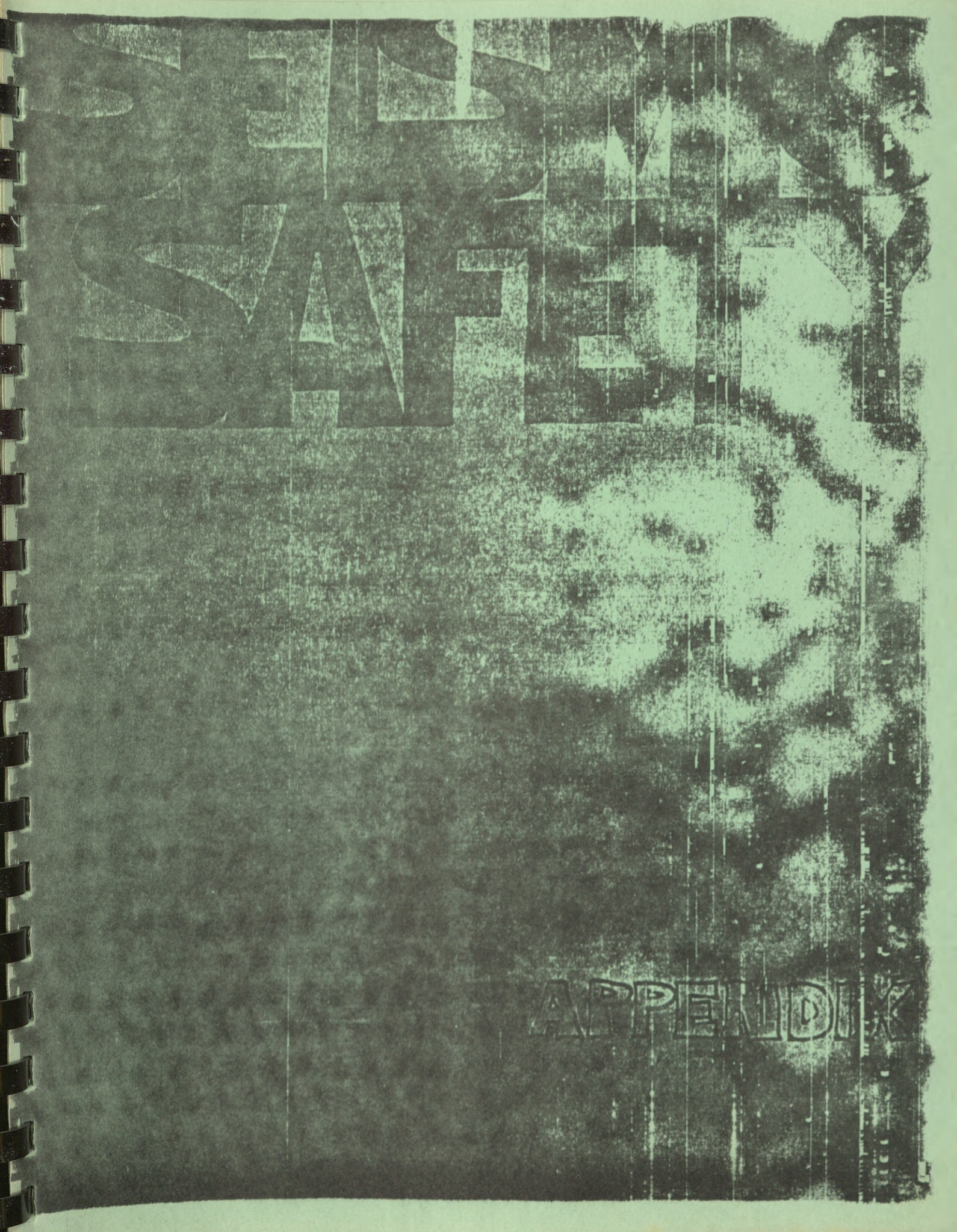


## SEISMIC AND SAFETY RECOMMENDATIONS

### FINAL RECOMMENDATIONS

1. When appropriate, revise all General Plan Elements which may be affected by the Seismic and Safety Element.
2. Include appropriate requirements and procedures for all City programs, including but not limited to zoning, subdivision and site development regulations, and building codes, as necessary to implement the approved Seismic and Safety Element and associated programs.
3. Establish and enforce criteria and standards to eliminate unacceptable levels of risk.
4. Categorize, update, and maintain the disaster planning process to reflect data and policy considerations of the Seismic and Safety Element and contingency planning in the field.
5. Encourage State or Federal agencies and universities, as well as private groups such as the Structural Engineers Association and the American Society of Civil Engineers, to undertake or sponsor research in design and construction to develop methods of providing greater resistance of structures to withstand the effects of seismic and natural hazards.
6. That all people affected by a potential hazard or imminent danger receive a general notification.
7. Institute a Major Disasters Education Program.
8. Budget sufficient funds to carry out the recommendations of this element.





APPENDIX



## CITY/COUNTY PLANNING ASSOCIATION

### GENERAL RECOMMENDATIONS

That all the entities in the county cooperate in further investigation of the hazards affecting the agencies within the county.

That all people affected by an immediate hazard receive a general notification.

That the concept of a Special Studies Zone or other similar designation be established for all applicable hazard zones which would require detailed studies of the hazard before certain development or activity could take place.

That each entity should undertake a general evaluation of its warning and evacuation plans in response to the hazards in this element.

### SPECIFIC RECOMMENDATIONS

#### TSUNAMI

That each affected entity adopt or update their seismic sea wave warning plan, possibly along the lines of the County Basic Plan.

#### TSUNAMI AND SEICHE

That vital or critical facilities be restricted in the hazard zone or designed to mitigate the hazard.

#### FIRE

That each entity adopt the provisions of a comprehensive fire prevention program such as the FIRE SAFE! program of the County Supervisor's Association of California.

#### AIRCRAFT ACCIDENT

Restrict land uses in the high hazard areas to those having only low population densities and no critical facilities. Limit facilities with high concentrations of population in the low hazard areas.

#### BEACH EROSION

Discourage buildings and facilities from locating in beach erosion hazard zones, so that the shoreline can undergo its natural fluctuation patterns.

Discourage all uses that would contribute to beach erosion from locating on sandy beaches.

Local governments should coordinate with the County Public Works Department and the Army Corps of Engineers in setting up a county-wide beach (sand) management program. Such a program would deal with all aspects of beach management, including the sources of sand. It would anticipate problems dealing with flood control operations and beach erosion prevention measures, conduct relevant studies, emphasize flood plain management as an alternative to flood control, and assist local governments in planning in beach erosion hazard zones.

#### LANDSLIDE/MUDSLIDE

Incorporate the use of the landslide/mudslide hazard zones in future land use determinations by avoiding intense development. Require soils investigations and the use of appropriate safeguards in the design.

#### FAULT DISPLACEMENT

Adopt the Policies and Criteria of the State Mining and Geology Board with Reference to the Alquist-Priolo Geologic Hazard Zones Act in regard to requirement of geologic-seismic investigations prior to approval of any proposed development within the primary and secondary fault zones to prevent development directly over an active fault.

#### GROUND SHAKING

Conduct a structural evaluation of all vital and critical facilities to insure conformance to current Uniform Building Code requirements in regard to resistance to ground shaking.

Adopt and provide qualified enforcement of the Uniform Building Code and other appropriate design requirements for all land development.

#### LIQUEFACTION

Require geologic-seismic and soils engineering investigation of soil liquefaction potential for proposed critical facilities and structures designed for large concentrations of people.

#### STRUCTURAL DEFICIENCIES

Develop a program to evaluate the seismic structural safety of existing public and vital facilities and to bring up to the standards of the current Uniform Building Code facilities which are considered hazardous.

Continue to support the adoption and enforcement of the most current provisions of the Uniform Building Code regarding seismic safety.



## SUBSIDENCE

That Ventura County give all possible support to programs aimed at fulfilling the State's recommendations on subsidence which allow us to knowledgeably assess the degree of hazard it presents.

## EXPANSIVE SOILS

Continue to conduct the existing control programs which have adequately minimized damage from expansive soils.

## FLOOD

Owing to the necessity of Federal Flood Insurance to qualify for loans from federally regulated lending institutions, it is recommended that:

Each entity adopt the standards of the National Flood Insurance Act to qualify for or maintain eligibility and that these standards be enforced by those departments having enforcement responsibility.

ADOPTED: August 8, 1974  
September 19, 1974

# VCAG GENERAL PLAN ELEMENTS POLICY ADVISORY COMMITTEE POLICY RECOMMENDATIONS SEISMIC AND SAFETY ELEMENT

## GENERAL RECOMMENDATIONS

All the entities in the county continue to cooperate in investigation and alleviation of the seismic and safety hazards affecting the county.

All people affected by a hazard receive a general notification of their inclusion in a hazard zone. \*Hazard Zone: A General Geographic Area Potentially Affected by the Hazard.

The concept of a Special Studies zone, or other similar designation, be established for all applicable hazard zones which would require detailed studies of the hazard potential before certain types of development or activity could take place.

Vital and critical public services should be required, if located within the Special Studies zone, to conduct detailed studies of the hazard and be required to take the appropriate action to alleviate potential hazard impacts.

In each entity there be a general evaluation and updating yearly of its warning and evacuation plans in response to the hazards defined and described in this General Plan Element.

That all entities seek, through cooperative action, to adopt Uniform Building Codes that include the appropriate safeguards for the hazard potentials existing in their jurisdiction. The standards should be established on a uniformly consistent basis throughout the County.

## SPECIFIC RECOMMENDATIONS

### TSUNAMI

Adopt or update their seismic sea wave warning plan, along the lines of the nationally recognized "County Basic Plan".

### TSUNAMI AND SEICHE

Seiche is wave action in an enclosed body of water, e.g. lake or harbor. Vital or critical facilities be restricted in the hazard zone.

### FIRE

Adopt the provisions of the comprehensive fire prevention program "Fire Safe" program of the County Supervisors Association of California.

### FLOOD

Adopt the standards of the "National Flood Insurance Act" to qualify for or maintain eligibility and that these standards be enforced by those departments having enforcement responsibility.

### AIRCRAFT ACCIDENT

Restrict land uses in the high hazard areas to those having only low population densities and no critical facilities. Limit facilities with high concentrations of population in the low hazard areas. Avoid locating airports in highly populated areas.

### BEACH EROSION

Discourage buildings and facilities from locating in beach erosion hazard zones, so that the shoreline can undergo its natural fluctuation patterns. Discourage all uses from locating on sandy beaches which would tend to cause beach erosion. Local governments should coordinate with the County of Ventura, the Army Corps of Engineers and others in setting up a county-wide beach (sand) management program. Such a program would deal with all aspects of beach management, including the sources of sand. It would anticipate problems



dealing with flood control operations and beach erosion prevention measures. The program would emphasize flood plain management as an alternative to flood control and assist local governments in planning in beach erosion hazard zones.

#### LANDSLIDE/MUDSLIDE

Incorporate the use of the landslide/mudslide hazard zones in future land use determinations by avoiding intense development. Require soils investigations and the use of appropriate safeguards in the design of structures.

#### FAULT DISPLACEMENT

Adopt the Policies and Criteria of the State Mining and Geology Board with Reference to the Alquist-Priolo Geologic Hazard Zones Act in regard to requirement of geologic-seismic investigations prior to approval of any proposed development within the primary and secondary fault zones to prevent development directly over an active fault.

#### GROUND SHAKING

Conduct a structural evaluation of all vital and critical facilities to insure conformance to current Uniform Building Code requirements in regard to resistance to ground shaking. Adopt and provide qualified enforcement of the Uniform Building Code and other appropriate design requirements for all land development.

#### LIQUEFACTION

Require geologic-seismic and soils engineering investigation of soil liquefaction potential for proposed critical facilities and structures designed for large concentrations of people.

#### STRUCTURAL DEFICIENCIES

Develop a program to evaluate the seismic structural safety of existing public and vital facilities and to bring up to the standards of the current Uniform Building Code facilities which are considered hazardous. Continue to support the adoption and enforcement of the most current provisions of the Uniform Building Code regarding seismic safety.

#### SUBSIDENCE

Support programs aimed at fulfilling the State's recommendations on subsidence as referenced in The Urban Geology Master Plan for California, which allows us to knowledgeably assess the degree of hazard it presents.

#### EXPANSIVE SOILS

Continue to conduct the existing City and County control programs

which have adequately minimized damage from expansive soils.



ADOPTED BY THE GENERAL PLAN ELEMENTS POLICY ADVISORY COMMITTEE --  
September 4, 1975




# CITY OF OXNARD - north portion HAZARDS PLATE I


This Secondary Fault Hazard Zone is Based Only Upon Potential Linear Projection of Faults to the East. Boundary of the Fault is Highly Conjectural


## FAULT HAZARD ZONES

-  primary: zones which contain faults which have been active during historic or holocene time.
-  secondary: zones which may contain active or potentially active faults.

## EARTH FAULT

 concealed; conjectural where queried. faults in areas of offshore submarine sediments are surmised to be concealed.

 suggested trace as identified on aerial photos but not verified.

 note: all faults not included in the primary or secondary fault hazard zones - presently considered inactive.

Source: California division of mines and geology  
Ventura county department of public works

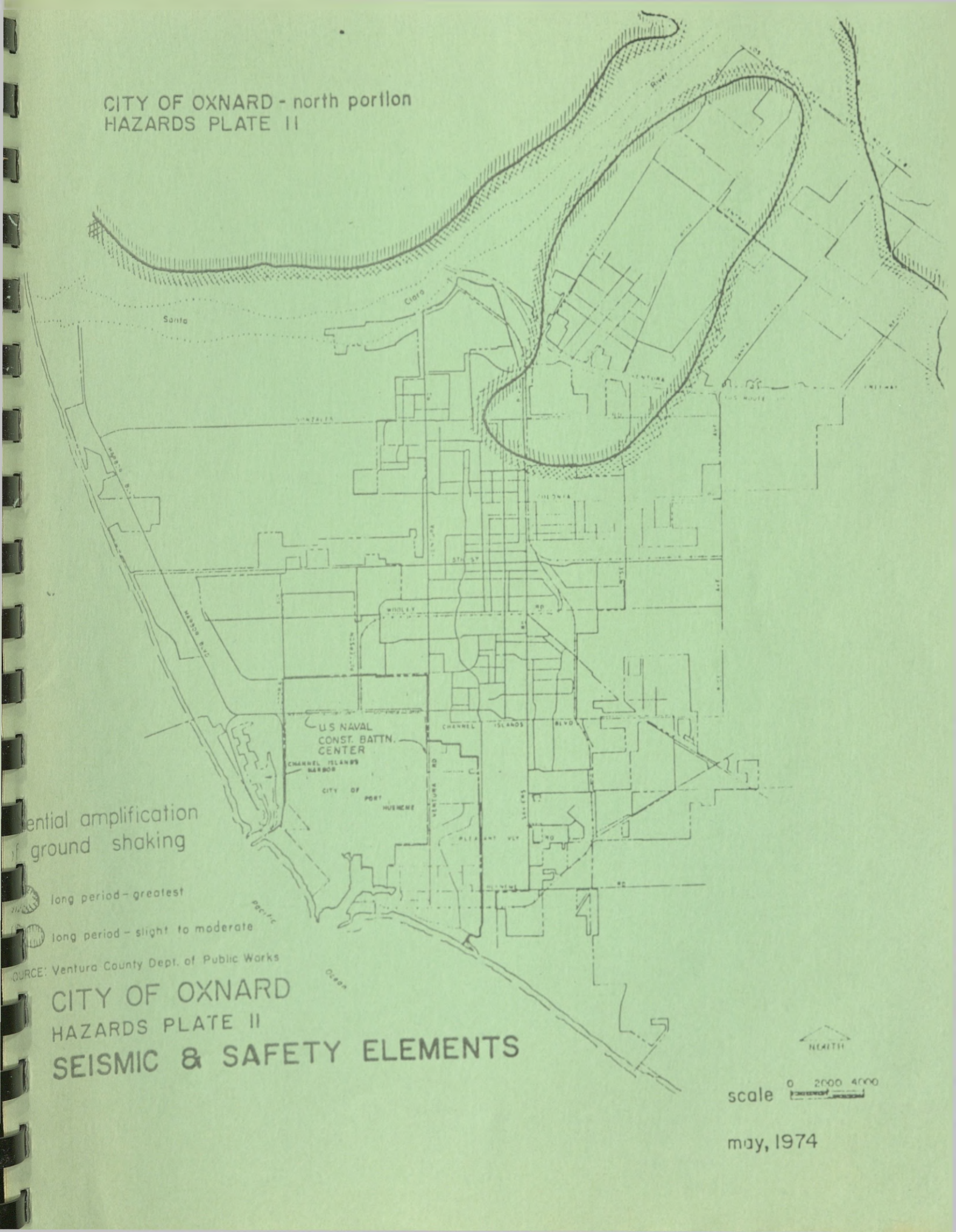
# CITY OF OXNARD HAZARDS PLATE I SEISMIC & SAFETY ELEMENTS



scale 0 2000



CITY OF OXNARD - north portion  
HAZARDS PLATE II



potential amplification  
of ground shaking

long period - greatest

long period - slight to moderate

SOURCE: Ventura County Dept. of Public Works

CITY OF OXNARD

HAZARDS PLATE II

SEISMIC & SAFETY ELEMENTS

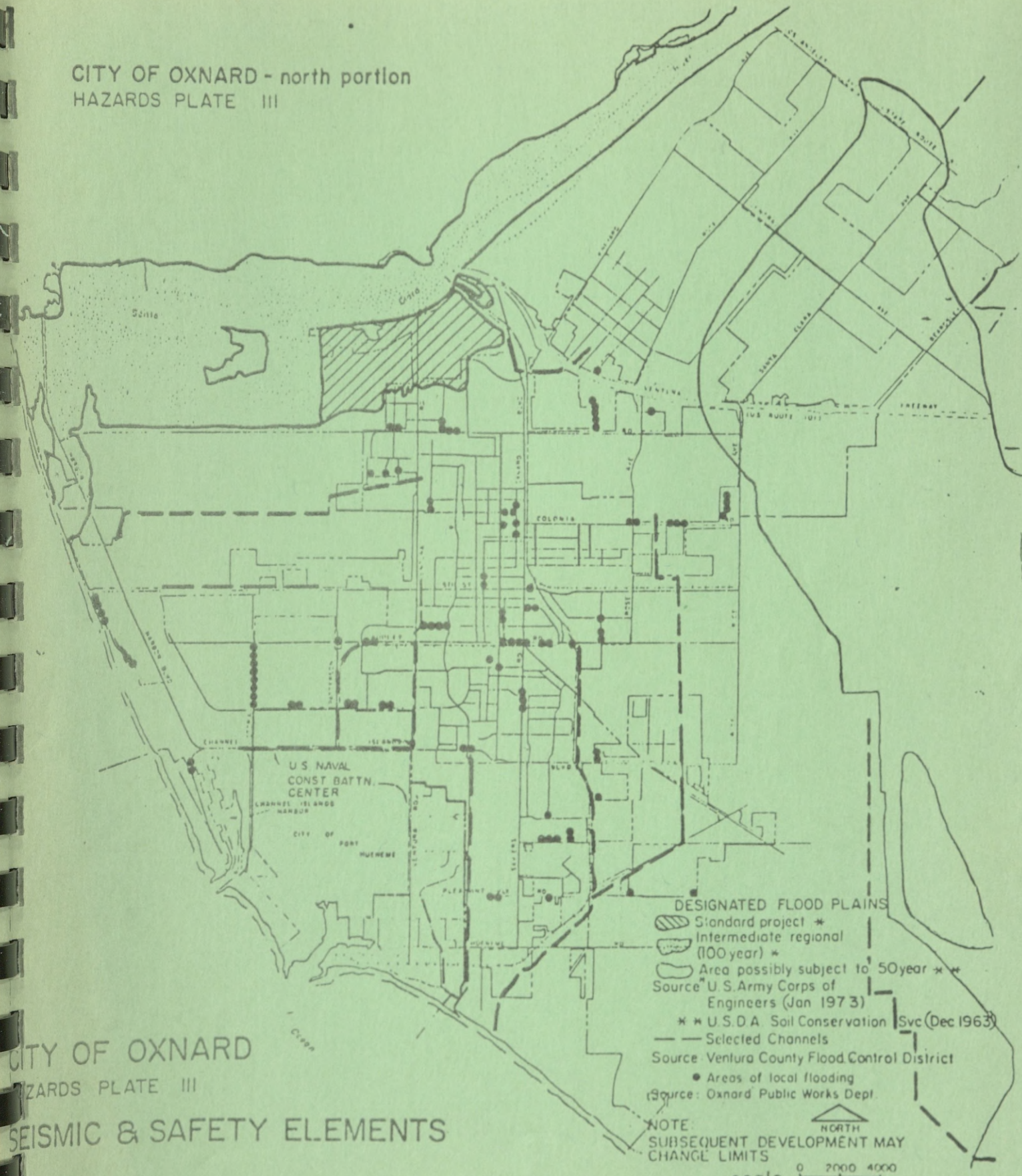


scale 0 2000 4000

may, 1974



CITY OF OXNARD - north portlon  
HAZARDS PLATE III



CITY OF OXNARD  
HAZARDS PLATE III  
SEISMIC & SAFETY ELEMENTS

*CITY Addition*

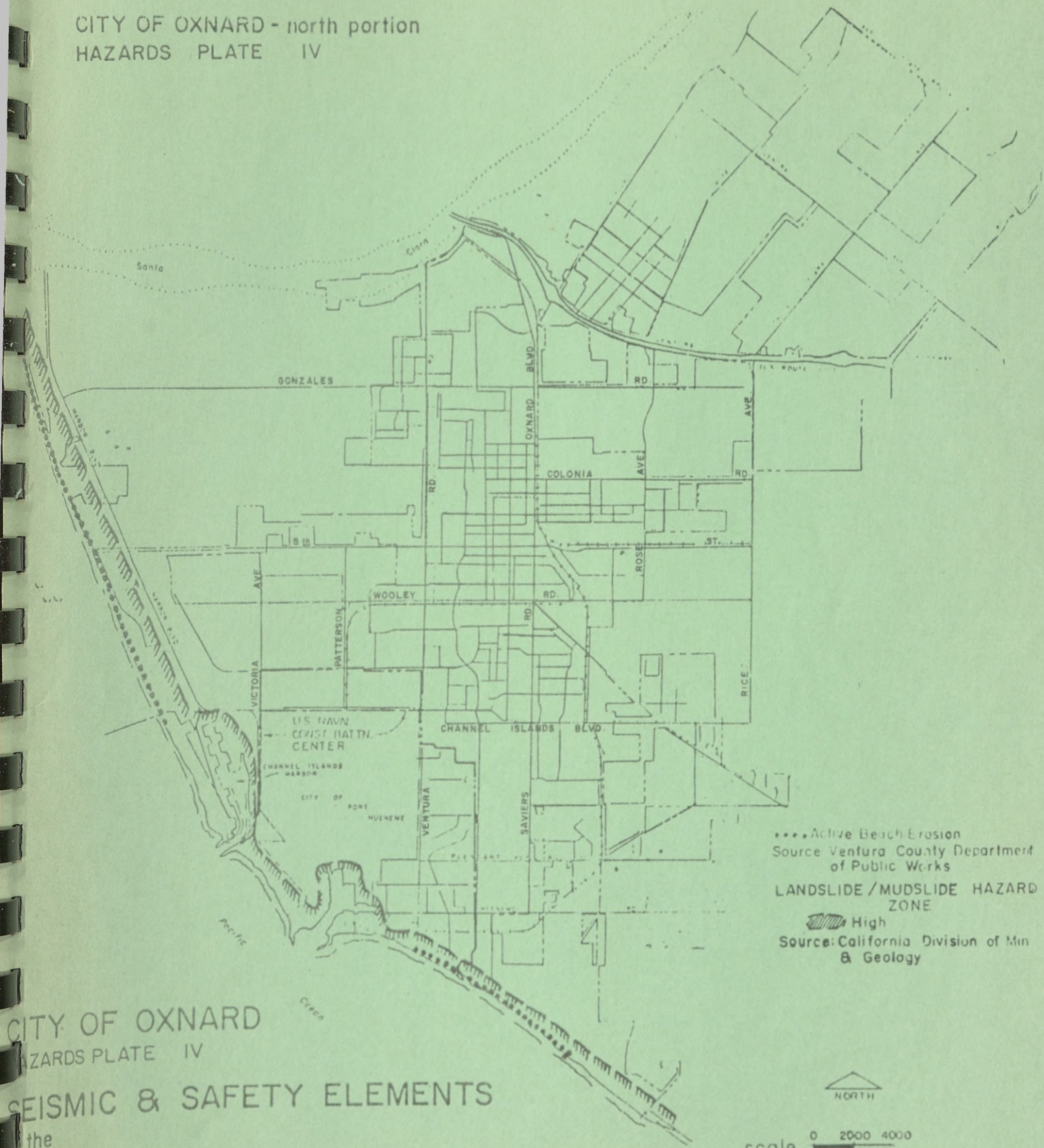
NOTE: THE PENDING REVISION OF THE NATIONAL FLOOD INSURANCE ADMINISTRATION HAZARD MAP WILL UPDATE THIS PLATE.

october 1974

prepared by  
ward planning department



CITY OF OXNARD - north portion  
HAZARDS PLATE IV



..... Active Beach Erosion  
Source: Ventura County Department  
of Public Works

LANDSLIDE / MUDSLIDE HAZARD  
ZONE

High  
Source: California Division of Min  
& Geology

CITY OF OXNARD  
HAZARDS PLATE IV

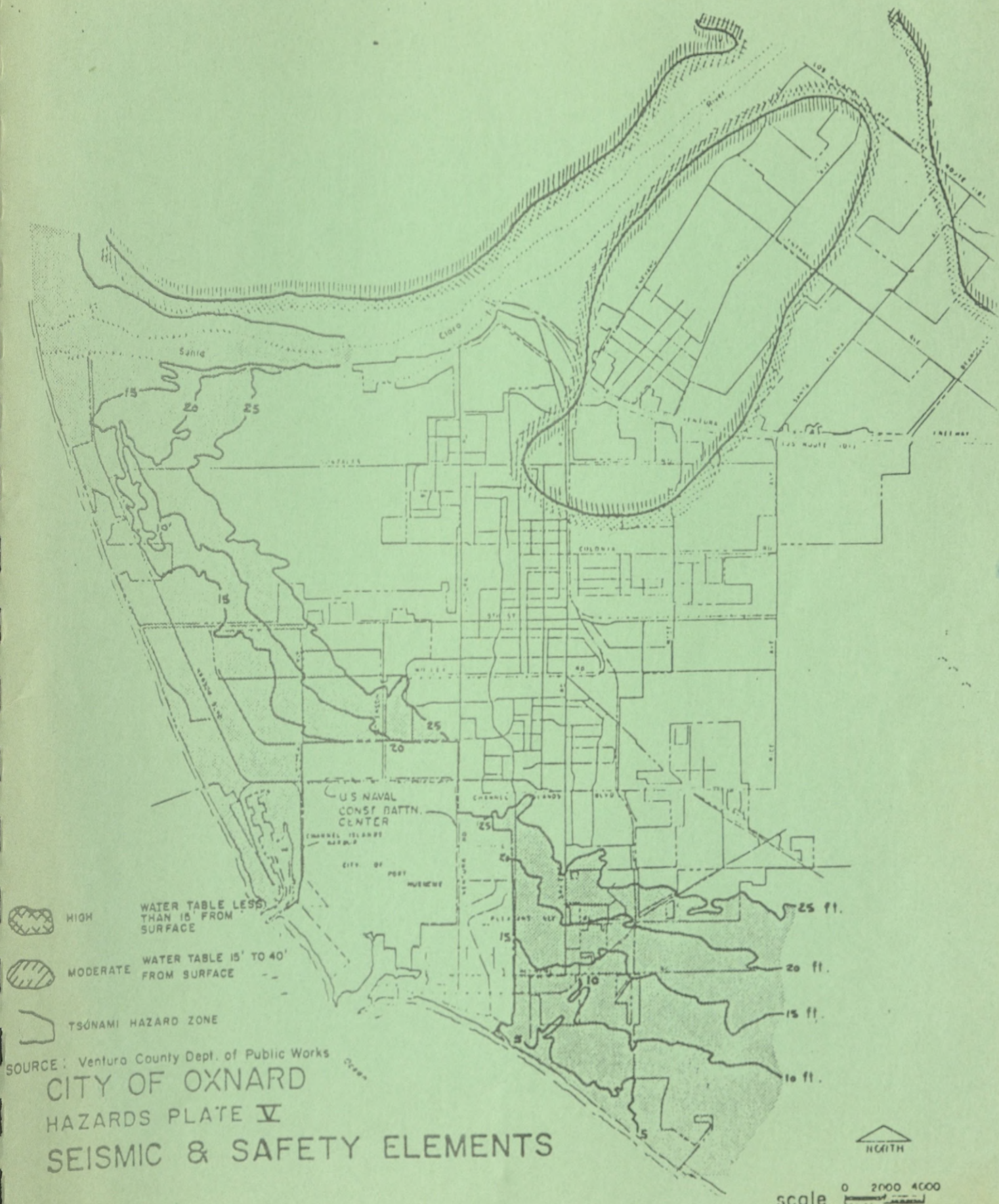
SEISMIC & SAFETY ELEMENTS

the  
RESOURCES PLAN & PROGRAM

NORTH

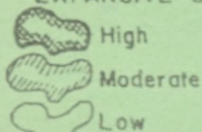
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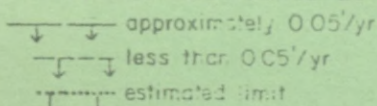


EXPANSIVE SOIL ZONES



SOURCE: U.S.D.A. Soil  
Conservation Service

PROBABLE SUBSIDENCE ZONES



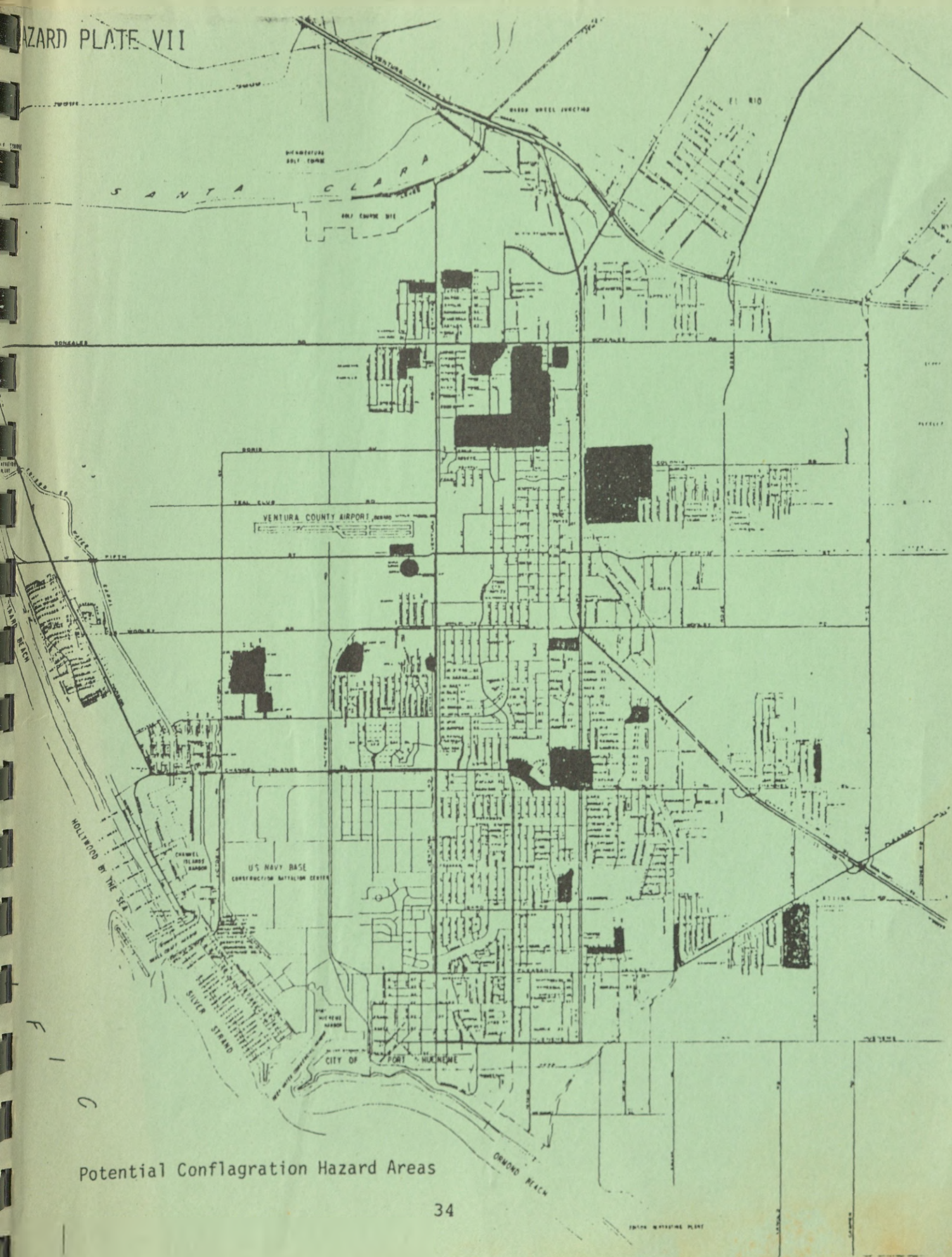
SOURCE: Ventura Co. Dept. of Public Works

CITY OF OXNARD  
HAZARDS PLATE VI  
SEISMIC & SAFETY ELEMENTS



scale 0 2000 feet





Potential Conflagration Hazard Areas