NIST-GCR-98-743

FIRE-RELATED ASPECTS OF THE NORTHRIDGE EARTHQUAKE

Charles Scawthorn, Andrew D. Cowell and Frank Borden

**EQE International, Inc.
San Francisco, CA 94104**

**United States Department of Commerce
Technology Administration**
National Institute of Standards and Technology

NIST-GCR-98-743

FIRE-RELATED ASPECTS OF THE NORTHRIDGE EARTHQUAKE

Prepared for
U.S. Department of Commerce
Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

By
Charles Scawthorn, Andrew D. Cowell
and Frank Borden
EQE International, Inc.
San Francisco, CA 94104

October 1996
Issued March 1998

DEPARTMENT OF COMMERCE
UNITED STATES OF AMERICA

Notice

This report was prepared for the Building and Fire Research Laboratory of the National Institute of Standards and Technology under grant number 60NANB5D0147. The statement and conclusions contained in this report are those of the authors and do not necessarily reflect the views of the National Institute of Standards and Technology or the Building and Fire Research Laboratory.

FIRE-RELATED ASPECTS OF THE NORTHRIDGE EARTHQUAKE

October 1996

Charles Scawthorn
Andrew D. Cowell
Frank Borden

EQE International, Inc.
San Francisco CA 94104

Prepared for the

Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899-0001

NIST Grant Award No. 60NANB5D0147
EQE Proj. No. 710013.010

ABSTRACT

Data collection and analyses relevant to fires following the M_w 6.7 Northridge Earthquake on January 17, 1994 were performed with the support of the National Institute of Standards and Technology. In the period 4:31AM (i.e., time of main shock) to midnight, there were approximately 110 earthquake related fires. Incident data is compiled in a database termed **FFNRE** (**F**ires **F**ollowing the **N**orth**R**idge **E**arthquake), which is provided in hardcopy form and magnetic media (diskette), as well as being available on the Internet (at **www.eqe.com**). Fire department operations are detailed at five selected fire incidents. Analyses, and comparison with the 1971 San Fernando and 1995 Hanshin (Kobe) earthquakes, identified a number of ignition factors and provides important observations, lessons and avenues for future research (regarding ignition sources, fire service operations, and utility performance) towards mitigation of this problem.

EXECUTIVE SUMMARY

Fires following large earthquakes are a potentially serious problem, due to the multiple simultaneous ignitions which fire departments are called to respond to while, at the same time, their response is impaired due to communications, water supply and transportation problems, and demanded other emergencies caused by the earthquake, such as structural collapses, hazardous materials releases, and emergency medical aid. Large earthquakes offer the potential for major conflagrations, which have occurred several times in this century.

The M_w 6.7 January 17, 1994 Northridge earthquake occurred beneath the San Fernando Valley, in northern Los Angeles and was the largest earthquake to occur within a US city in more than 20 years. It caused 57 deaths, significantly damaged 12,000 structures and caused direct damage whose total cost is estimated to be more than $40 billion. In the period 4:31AM (i.e., time of main shock) to midnight, there were approximately 110 earthquake related fires. In order to record valuable data and insights regarding fires following the Northridge earthquake, research was conducted with the support of the National Institute of Standards and Technology. Emphasis was on collection, documentation and preservation of data, with some limited analysis.

Data (operational, quantitative, textual, figures, maps and photos) were collected by contacting local fire departments and obtaining their records, and by interviewing selected senior officers in several of the affected departments. Fire incident data is compiled in a database termed **FFNRE** (**F**ires **F**ollowing the **N**orth**R**idge **E**arthquake), which is provided in hard-copy form and magnetic media (diskette), as well as being available on the Internet (at **www.eqe.com**). Fire department operations at five selected fire incidents (Balboa Blvd.; Tahitian Mobile Home Park; Oakridge Mobile Home Park; Los Olivos Mobile Home Park; and Cal State Northridge) are provided in detail, including apparatus deployment at various times, and estimates of total water usage. The criteria for selection of these incidents included size (all were multiple structure fires), problems of water supply, and potential for insights regarding urban conflagration (the fires occurring in mobile home parks are indicative of dense urban settings).

Limited analyses of the data were performed - the most important findings included: (a) more than 70% (66) of the earthquake-related fires occurred in single- or multiple-family residences, (b) the major cause of ignition was electric arcing as the result of a short circuit, although gas flame from an appliance is also a recurring source of ignition, (c) where identification could be made, escaping natural gas (presumably from a broken gas line) is the single most common ignition material, and (d) a very important parameter in the analysis of post-earthquake fires is the earthquake-related ignition rate - the ignition rates for the Northridge earthquake was found to be comparable to prior U.S. earthquakes. Additionally, Northridge data and experience is compared with the February 9,1971 M_w 6.7 San Fernando and January 17, 1995 M_w 6.9 Hanshin (Kobe, Japan) events - note that all three events share winter early morning occurrence times.

Relevant non-fire related aspects included (a) significant damage to several fire stations which however did not impair departmental operations, (b) several instances of significant communications impairment, (c) approximately 1,400 water system leaks were caused by the earthquake, and pump stations and storage tanks also sustained damage. This damage resulted in a lack of water pressure at hydrants in much of the west and north portions of the San Fernando Valley. LAFD resorted to using water tankers and drafting from alternative sources, including the large number of backyard swimming pools in the area. (d) approximately 151,000 gas customer outages occurred (81% customer-initiated). As of three months after the earthquake, there were approximately 800 gas system locations where repairs had been made. There are approximately 8,000 seismic gas shut-off valves in the region, about 10% (841) of which tripped - of the valves tripping, 19% (162) had leaks.

Review of the data, analytical results and comparison with the 1971 and 1995 events provide a number of observations - (i) while there were a significant number of earthquake-related fires, these were all brought under control within several hours of the earthquake; (ii) the resources of the Los Angeles region were sufficient to deal with all fire ignitions, as well as other emergencies, such as search and rescue, hazardous materials releases, etc., due to the large well-equipped, experienced, fire service in the Los Angeles region, (iii) water supply failed in the heavily affected area, and firefighters resorted to alternative sources, which however would likely not suffice had conflagrations developed, (iv) incendiary (arson) fires were not a significant factor. Lessons include (a) alternatives to water for fire suppression need to be developed - concurrently, water systems need to significantly improve their seismic reliability, (b) gas and electric seismic shut-off devices offer significant potential for mitigation, and should be encouraged in their development and use. Lastly, several areas of additional research are indicated, including work on ignition sources, fire service communications, water supply and advancements in modeling.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

TABLES

TABLES (cont.)

FIGURES

FIGURES (Cont.)

FIGURES (Cont.)

PHOTOGRAPHS

PHOTOGRAPHS (Cont.)

1. INTRODUCTION

Fires following large earthquakes are a potentially serious problem, due to the multiple simultaneous ignitions which fire departments are called to respond to while, at the same time, their response is impeded due to impaired communications, water supply and transportation. Additionally, fire departments are called to respond to other emergencies caused by the earthquake, such as structural collapses, hazardous materials releases, and emergency medical aid. Because of these factors, large earthquakes offer the potential for major conflagrations, which have occurred several times in this century.

The January 17, 1994 Northridge earthquake was the largest earthquake to occur within a US city in more than 20 years. As such it offers valuable data and insights regarding the potential for major fires following a larger earthquake. In order to record these data and insights, research was conducted with the support of the National Institute of Standards and Technology, to collect and analyze fire-related data occurring as a result of this earthquake.

1.1 PURPOSE AND SIGNIFICANCE

The purpose of this research was to document and understand fire-related aspects of the Northridge earthquake, and record observations based on this experience, regarding the potential for major fires in future earthquakes. Emphasis was on collection, documentation and preservation of data, rather than analysis, although some results of analyses are presented.

A comprehensive investigation into the causes and effects of all fires resulting from the January 17, 1994 Northridge earthquake is significant in that:

1. Fires from previous U.S. earthquakes have not been well documented, with the exception of several recent earthquakes (Scawthorn et al 1984; 1985; Callahan, 1987; Wiggins, 1988; Scawthorn et al, 1992).

2. Fires occurred throughout the affected area on January 17, which need to be well documented.

3. Fires have been a major agent of damage in previous earthquakes. Recent estimates (AIRAC, 1987, Natural Disaster Coalition, 1993) indicate that the potential exists for major conflagrations in Los Angeles, San Francisco or other US metropolitan areas in the event of great earthquakes. Justification of initiatives to Congress by the insurance industry regarding a national program of earthquake insurance rely heavily on estimates of losses due to fires following earthquakes - data from the January 17, 1994 Northridge earthquake will help to improve these estimates.

1.2 OBJECTIVES

The objectives of the proposed project are to (i) investigate and document fires, fire spread and fire department operations resulting from the 17 January 1994 Northridge earthquake, (ii) provide analysis of this data in support of future estimation of fires following earthquakes, and (iii) extract lessons and insights resulting this earthquake, in support of loss reduction practices and mitigation of potential conflagrations and large loss fires following earthquakes.

1.3 RESEARCH PLAN

The overall plan for this research consisted of: (i) a survey of the fire departments in the affected area, to determine fires they responded to, causes of ignition, suppression requirements, problems of water supply, communications, other incidents, command etc, (ii) visits to fire sites and/or contacting of relevant persons, to obtain photographs, determine economic loss etc, (iii) limited analysis of this data, in terms of causes of ignition, factors of water supply, wind, delayed response, impaired fire alarms, etc, as well as comparison with fires following the 1971 San Fernando earthquake, and (iv) documentation of these findings in a report.

1.4 ACKNOWLEDGMENTS

We would like to thank the following individuals for the information and assistance that they provided in preparing this report: D.O. Manning, Chief Engineer and General Manager, LAFD, D.F. Anthony, LAFD; Fire Marshall Michael Carter, Glendale FD; William Cass, Senior Arson Investigator, LAFD; Fire Marshall Darryl Forbes, Burbank FD; Battalion Chief Jim Hone, SMFD; John McIntyre and Vic Mesrobian, Information Management Division LACo FD; Leon Older, Information Services Department LAFD; Captain Roy Prince, LAFD; Dan Rosetti, Fire Investigation Unit, Pasadena FD.

Particular appreciation is due the National Institute for Standards and Technology, Building and Fire Research Laboratory, for support of this research, and Mr. William Walton, P.E., and Mr. Dan Madrzykowski, P.E., Project Officers, BFRL, NIST, for their generous assistance.

1.5 OUTLINE OF REPORT

The remainder of this report consists of the following sections:

- Section 2 provides a brief overview of the Northridge earthquake in general, summarizing seismological, building damage and lifelines-related aspects, so as to better put into context the fires ignited as a result of the earthquake.

- Section 3 presents a database for fires occurring as a result of the earthquake.

- Section 4 provides selected analysis based on the database, including overall geographical and temporal distribution of ignitions, statistics of causes and locations of ignitions, demands on fire department resources, etc.

- Section 5 selects five specific incidents, and provides detailed accounts of fire department operations at the fireground of each incident.

- Section 6 presents observations and lessons learned
- Section 7 presents concluding remarks
- Section 8 presents relevant references, tables, figures and photographs.

2. THE NORTHRIDGE EARTHQUAKE

2.1 OVERVIEW

The M_w 6.7 Northridge Earthquake occurred at 4:31 A.M. on January 17, 1994. The epicenter of the magnitude 6.7 earthquake was beneath the San Fernando Valley, in northern Los Angeles. Figure 2-1 shows the location of the epicenter and the distribution of peak ground acceleration in the Los Angeles area.

The earthquake caused 57 deaths and more than 1,500 people were injured. More than 12,000 structures were significantly damaged, and several major highways were damaged or collapsed. Total cost of direct damage (note that this is not total economic loss - items such as business interruption costs are omitted) is estimated to be more than $40 billion (Eguchi et al, 1996). In the first day following the main earthquake shock, there were estimated to be over 100 earthquake related fires (see Table 2-7).

2.2 SEISMOLOGY

The Northridge Earthquake occurred at 4:31 A.M. PST on January 17, 1994 on a south-southwest dipping thrust ramp beneath the San Fernando Valley. The hypocenter of the moment magnitude M_w 6.7 earthquake was about 19 km beneath the San Fernando Valley, about 32 km west-northwest of Los Angeles. Figure 2-1 shows the location of the epicenter and the distribution of peak ground acceleration in the Los Angeles area. Figure 2-2 shows an Modified Mercalli Intensity (MMI) map compiled by Dewey et al (1995). Intensities higher than IX were not assigned to any site or region. Significance of MMI intensities is indicated in Table 2-1.

Some of the highest accelerations ever recorded were obtained in the Northridge earthquake - as seen in Figure 2-1, peak ground accelerations (PGA) were on the order of 0.6g and higher for a significant portion of the urban and suburban San Fernando Valley, and several records were obtained with accelerations exceeding 1.0g. Strong vertical accelerations were also recorded. In combination with the developed nature of the epicentral region, these high ground motions made the Northridge earthquake event to the most important, and damaging earthquake in recent U.S. history.

2.3 BUILDING DAMAGE

Detailed building inventory and damage statistics are available in a report prepared for the Governor's Office of Emergency Services (EQE, 1995). The principal source of information on building inventory was the County Tax Assessor's Office, which were provided to OES by the Assessor's Offices of Los Angeles and Ventura Counties in digital format. The total number of buildings for Los Angeles County within MMI VI and greater isoseismals was more than 1.7 million. A breakdown by structural material is indicated in Table 2-2.

Immediately following the earthquake, local building departments structural safety inspections, according to the following guidelines:

- Green Tag **Inspected** No apparent hazard found, although repairs may be required. Original lateral load capacity not significantly decreased. No restriction on use or occupancy.
- Yellow Tag **Limited Entry** Dangerous condition believed to be present. Entry by owner permitted only for emergency purposes and only at own risk. No usage on continuous basis. Entry by public not permitted. Possible major aftershock hazard.
- Red Tag **Unsafe** Extreme hazard, may collapse. Imminent danger of collapse from an aftershock. Unsafe for occupancy or entry, except by authorities.

Figure 2-3 shows a regional distribution of red, yellow and green tagged buildings for the affected areas, while Table 2-4 presents summary tag data by structural material, and

Table 2-3 provides a summary of tagging results by city. As can be seen in Table 2-3, the City of Los Angeles accounted for 75% of all inspected (damaged and undamaged) buildings. The city boundaries encompass many heavily affected areas including Northridge, Reseda, Sherman Oaks, Van Nuys, Sylmar, Chatsworth, North Hollywood and Encino, among other locales. Approximately 20,000 residential units were vacated, and another 45,000 units significantly damaged, as a result of the earthquake (Hall, 1996).

Significant damage occurred to a variety of building types including:

- Extensive cracking and failure of welded connections in steel moment-resisting frames.
- Significant cracking and failure of columns in older concrete frame buildings, usually due to shear, resulting in structural collapse in a number of cases.
- Major damage to approximately 400 of 1,200 tilt-up wall buildings, including partial roof collapse and collapse of exterior walls.
- Significant economic damage to thousands of wood structures, including the loss of about 60,000 housing units (sum of red- and yellow-tagged buildings).

Insurance payments, primarily for residential building damage, totaled approximately $12 billion.

2.4 EFFECTS ON WATER SUPPLY

The Northridge earthquake affected the water supply for portions of the San Fernando Valley. The damage in that area is shown in Figure 2-4. Breaks occurred in at least six trunk lines and a large number of leaks occurred at other locations. The Department of Water and Power estimated that approximately 1,400 leaks were caused by the earthquake, including two lines of the Los Angeles Aqueduct (Lund et al, 1995). Pump stations and storage tanks also sustained damage. The damage to the system resulted in a water shortage that had to be made up by water tenders. LAFD reported lack of water pressure at hydrants in much of the west and north portions of the San Fernando Valley. Due to this lack of water pressure, LAFD resorted to drafting from alternative sources, including the large number of backyard swimming pools in the area. SMFD reports the water supply system for Santa Monica suffered no significant impairment as a result of the earthquake.

2.5 EFFECTS ON GAS SUPPLY

The natural gas system in Los Angeles is owned and operated by the Southern California Gas Company (SCG), and is the largest gas system in the U.S., with approximately 4.6 million metered services (Lund et al, 1995). Summary system statistics include 3,803 miles of steel transmission pipelines, and 26,809 and 14,935 miles of steel and plastic distribution mains, respectively. There were approximately 151,000 gas outages as a result of the Northridge earthquake, of which 123,000 were customer-initiated. As of three months after the earthquake, there were approximately:

- 209 reported instances of damage to metallic distribution mains and services where <u>no</u> corrosion or construction-related damage was observed
- 563 reported instances of damage to metallic distribution mains and services where damage was attributed to corrosion, being construction-related or of unknown origin
- 27 instances of damage to polyethylene pipes

There were 35 non-corrosion-related repairs made to the transmission system, of which 27 were at cracked or ruptured oxacetylene girth welds in pre-1932 pipelines, Figure 2-5. Gas escaping at the break in Line 1001 under Hwy. 126 near Fillmore ignited, possibly by a downed power line. On Balboa Blvd. between Rinaldi and Lorillard, significant permanent ground deformations were experienced due to liquefaction (Holzer et al, 1996), resulting in distinct tension and compression regions affecting several water and gas transmission lines under Balboa Blvd. (Figures 2-6 and 2-7). Line 120 (22 inch. diam. steel) failed, and escaping gas was ignited, reportedly by sparks from the ignition system of a pickup truck. The resulting gas flare ignited neighboring buildings (this fire is discussed in detail in section 5). Also broken at the same locations were 49 inch and 68 inch water lines, which caused flooding and loss of nearby water pressure.

There are an estimated approximately 8,000 seismic gas shut-off valves in the region, about 10% (841) of which tripped and were serviced by SCG. Of the valves tripping, 19% (162) had leaks (Lund et al, 1995).

2.6 EFFECTS ON FIRE DEPARTMENTS

This section discusses regional fire protection and non-fire related effects of the Northridge earthquake on local fire departments. Fires and fire department response are discussed in sections 3 and 4.

Regional fire protection

The January 17 earthquake was centered under the Northridge section of the San Fernando Valley area of the Los Angeles region, resulting in Modified Mercalli Intensity (MMI) shaking intensities greater than MMI VIII over approximately 700 square miles of the northern Los Angeles area. The population most heavily affected was in the San Fernando Valley, which is primarily protected by the Los Angeles City Fire Department. Table 2-5 lists fire departments significantly involved in response, and their summary statistics.

The two largest departments are the Los Angeles City and Los Angeles County fire departments. Table 2-6 presents LAFD's expanded Emergency Incident Command System, as employed in the Northridge earthquake. While Los Angeles City FD only protects the City of Los Angeles, Los Angeles County protects unincorporated parts of Los Angeles County as well as a number of incorporated cities in Los Angeles County, which contract with the Department for fire protection services.

In addition to their own resources, fire departments in California have access to resources beyond their own boundaries through the California Master Mutual Aid Agreement. There are six mutual aid regions in the state, and Los Angeles County is Region I. The Los Angeles County Fire Department is the regional coordinator for

Region I. The region is subdivided into seven areas that are designated A through G. Area A, for instance, includes Los Angeles City, Beverly Hills, Culver City and Santa Monica. The Area Coordinator for Area A is the Los Angeles City Fire Department. When a local fire department finds that an emergency incident exceeds its resources, it requests additional resources from the Area Coordinator. Requests that cannot be fulfilled by other departments within the Area are passed up to the Regional Coordinator, who may contact other regions or request assistance from various state offices.

Fire Station Damage

Damage to fire stations was sporadic and not a significant factor in response. Los Angeles City vacated three fire stations on the day of the earthquake, due to minor to moderate damage. The most damaged of the stations was Station 70 on Reseda Blvd. in Northridge. The station was constructed in 1979 and is a three bay reinforced masonry building with two stories adjacent to the apparatus bays. The worst damage was crushing of wall elements at the north end of the east apparatus doors, with other damage generally confined to moderate cracking of wall elements, and some distress to the roof membrane.

Communications

In California almost all fires are reported via telephone lines. Following the Northridge earthquake, fire departments needed to be able to receive telephone calls for assistance. In the larger departments, such as the Los Angeles City Fire Department, the process of receiving calls and dispatching resources is automated with the aid of a computer system that maintains the status of calls and of resources. These systems are potentially vulnerable to shake damage and to loss of power. Communications with the dispatch center and between resources in the field is usually through both telephone and radio systems that are also vulnerable during an earthquake. Because of these vulnerabilities, fire departments routinely drill dispatchers on manual mode, where computer-aided dispatch is assumed to be not functioning.

Following the Northridge earthquake, the experiences of the Los Angeles City Fire Department and the Santa Monica Fire Department point out potential weaknesses in the communications network. Both departments suffered damage to some portion of their communications system which forced them to adopt an altered mode of operation.

Los Angeles City FD: LAFD Operations Control Dispatch Section (OCD) is located in the Los Angeles City Hall East basement, and receives calls for assistance and also dispatches resources. OCD uses a computerized dispatch system that maintains the status of each call. After the earthquake, a power outage occurred that forced OCD onto emergency power. Two emergency generators immediately came on line. The two generators supply the OCD computer system as well as the city's mainframe computer. After two hours of operation, a radiator hose on one of the generators broke, causing that generator to overheat and cease operation. The remaining generator, forced to supply both the OCD computer and the city's mainframe, sensed an overload and shut down. A battery backup continued supplying power for about 15 minutes, after which the power to the computer was lost. As a result, the status of all incidents and resources was also lost.

Without the computerized dispatch system, OCD reverted to a manual mode in which several stand-alone computers were used to generate documentation for each call. Each request was then handed to one of 23 dispatchers for prioritization and assignment. Several hours passed before OCD regained control of resources status and assignment.

Even though outside power was restored at about 7:30 AM, the OCD computer could not be restarted. The overheated emergency generator had set off a sprinkler that caused the flooding of the cable space under the OCD computer. Consequently, the computer was not on line until about noon when all water was removed.

The radio system that LAFD uses to communicate with resources also suffered impairment during the earthquake. After the earthquake, both repeater sites that cover the San Fernando Valley were not functioning on Channel 8, the dispatch channel for that area. Until approximately 10:00 AM, radio coverage to the West San Fernando

Valley was affected. An alternate radio channel was used until the repeaters could be repaired.

In addition, OCD was not able to receive all 911 calls that were being placed to the fire department. The telephone system public service access point (PSAP) was severely overloaded and could only relay about 65% of the calls coming through. There were also certain areas in the earthquake effected region that lost local phone service.

Santa Monica FD: SMFD also suffered problems with power and a potential problem with incoming calls for assistance. The emergency generator at the headquarters building on Seventh Street failed, resulting in a total loss of power for about 15 minutes until a backup generator could be started. The city's 911 system was unmanned after the earthquake until about 9 AM due to the fact that the building in which it is housed had to be evacuated, due to damage. However, 911 calls continued to come through to the fire department. Apparently, an alert operator had patched through calls to the fire department prior to evacuating.

Mutual Aid

On January 17, 1994, LAFD requested mutual aid from the Region I coordinator (LA County FD) for strike teams, search and rescue teams, and water tenders. The initial request to Region I was for six strike teams. Four teams were sent to Fire Station 88 in Northridge and two teams were sent in response to a request from the Santa Monica Fire Department. SMFD's request at about 5:30 AM could not be filled from Area A, and was only filled when Region I received resources from Orange County, at about 10 AM. Later on the 17th, a request was placed with Region I for nine water tenders to assist with water supply in the San Fernando Valley. Region A also placed an advisory request for the OES 6-inch portable rigid aluminum water mains.

LA County FD made use of over 775 personnel from outside of Region I to assist in LA County and for dispatch on Region I mutual aid requests. A total of 102 mutual aid agencies eventually participated. Mutual aid units assisting LAFD during and after the day of the earthquake included five strike teams from Orange County, four strike teams from Los Angeles County, one strike team from the Southbay Region of Region I, two

Los Angeles County foam apparatus, three Los Angeles County USAR (Universal Search and Rescue) teams, one Orange County USAR team, one Riverside County USAR team, and 29 public and private water tenders.

Table 2-1

MODIFIED MERCALLI INTENSITY SCALE EXCERPT, ABRIDGED

I - V	Not significant to structures.
VI	Felt by all; many are frightened and run outdoors. Some heavy furniture moves; a few instances of fallen plaster or damaged chimneys. Damage slight.
VII	Everybody runs outdoors. Damage negligible to buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars.
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Chimneys, factory stacks, columns, monuments and walls fall. Heavy furniture overturned. Disturbs persons driving motorcars.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; damage great in substantial buildings with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed. along with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.

Table 2-2

SUMMARY BUILDING INVENTORY WITHIN MMI ≥ VI, LOS ANGELES COUNTY

(Source: EQE, 1995)

Structural Material	Total No. Buildings
Wood Frame	1,677,951
Steel Frame	1,455
Concrete Frame	2,300
Brick / Block / Other	60,334

Table 2-3

BUILDING AND SAFETY CLASSIFICATION OF INSPECTED STRUCTURES BY CITIES (EQE, 1995)

	Red	Yellow	Green	Unknown	Total
Los Angeles County					
Agoura Hills	0	1	96	74	171
Alhambra	5	8	77	230	320
Arcadia	0	0	0	33	33
Azusa	0	0	0	1	1
Bellflower	0	0	0	0	0
Beverly Hills	29	83	680	389	1,181
Burbank	31	88	952	883	1,954
Calabasas	2	220	547	1	770
Commerce	0	0	0	1	1
Compton	0	0	0	9	9
Culver City	24	10	1	588	623
Downey	0	0	2	0	2
Glendale	26	11	1,073	1,133	2,243
Hermosa Beach	0	0	11	1	12
Hidden Hills	0	46	33	4	83
Huntington Park	0	0	0	5	5
Inglewood	0	0	0	49	49
La Canada/Flintridge	0	0	0	34	34
La Habra Heights	0	0	2	0	2
La Mirada	0	0	0	16	16
Lakewood	0	0	9	10	19
Los Angeles	1,867	8,169	69,396	271	79,703
Manhattan Beach	3	231	26	13	273
Maywood	0	0	0	2	2
Montebello	0	0	0	8	8
Norwalk	0	0	0	7	7
Paramount	0	0	0	5	5
Pasadena	8	14	84	129	235
San Fernando	116	133	1,210	0	1,459
San Marino	0	0	5	2	7
Santa Clarita	83	159	3,230	112	3,584
Santa Monica	90	261	1,494	7	1,852
South Gate	0	1	35	3	39
South Pasadena	0	0	0	0	0
Torrance	0	0	4	0	4
Unincorporated LA County	0	0	0	0	0
Vernon	3	1	5	0	9
West Hollywood	2	4	10	102	118
Whittier	1	5	158	8	172
Los Angeles County Totals	**2,290**	**9,445**	**79,140**	**4,130**	**95,005**
Ventura County					
Fillmore	200	301	5	2	508
Moorpark	3	24	4	18	49
Oxnard	0	3	11	0	14
Santa Paula	0	22	0	101	123
Simi Valley	60	466	1,992	4,404	6,922
Thousand Oaks	57	129	952	0	1,138
Unincorporated Ventura Coun	22	49	174	2	247
Ventura County Totals	**342**	**994**	**3,138**	**4,527**	**9,001**
Orange County					
Anaheim	1	1	10	3	15
Santa Ana	0	0	0	1	1
Sunset Beach	0	0	3	0	3
Orange County Totals	**1**	**1**	**13**	**4**	**19**

NOTES: Data provided by County and City Building and Safety Departments.
The unknown category includes reports which did not provide a red, yellow, or green classification.

Source: OES Plans and Operations Geographical Information Systems (GIS) Unit P:\36386-02\juntl.xls

Table 2-4

BUILDING INSPECTION DATA BY BUILDING TYPE (HOLMES ET AL, 1996)

Tag Color	Wood Frame	Steel frame	Concrete Frame	Brick, Block, or Other Concrete	Total
Green	67,618	134	117	2,087	69,956
Yellow	7,650	32	38	546	8,266
Red	1,614	10	26	277	1,927
Unknown	2,354	13	9	158	2,534
Total	**79,236**	**189**	**190**	**3,068**	**82,683**

Source: Data compiled from OES (1995)

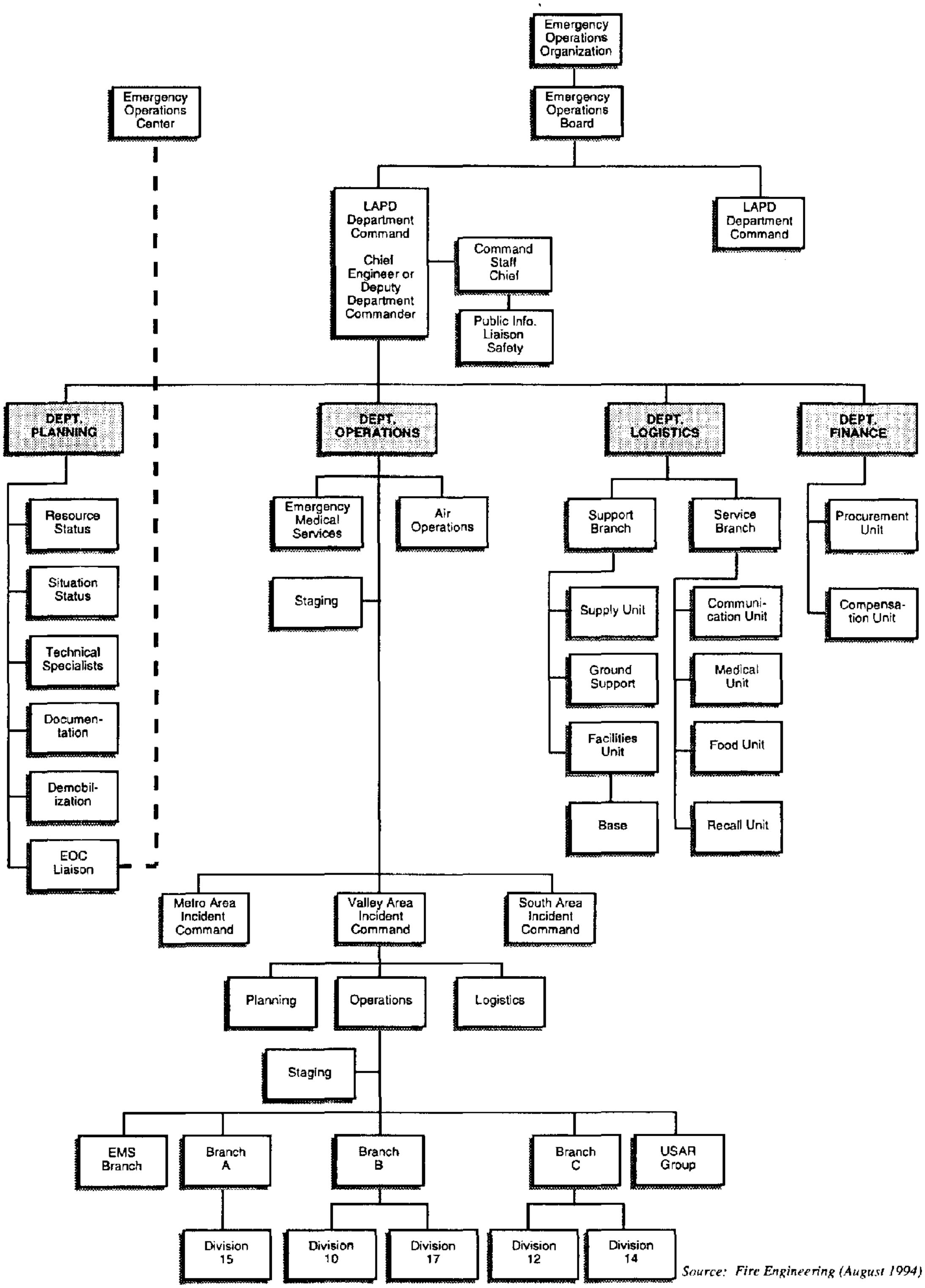
Table 2-5

FIRE DEPARTMENTS AFFECTED BY THE JANUARY 17, 1994 NORTHRIDGE EARTHQUAKE

Fire Department	Estimated Population (thousands)	Area (Sq Miles)	Number of Stations	Fire Fighting Personnel	Number of Engines
Los Angeles City	3,400	469	104	2,865	104
Los Angeles County	2,896	2,234	127	1,842	144
Ventura County	700	126	30	327	40 +/-
Santa Monica	97	8	4	100	5
Burbank	94	17	6	120	6
Pasadena	132	23	8	150	8
Glendale	166	30	9	167	9
South Pasadena	25	3	1	27	2
Beverly Hills	34	6	3	81	7
Culver City	41	5	3	66	5
Fillmore	12	2	1	9	1

Table 2-6

LAFD EXPANDED EMERGENCY INCIDENT COMMAND SYSTEM, NORTHRIDGE EARTHQUAKE



Source: Fire Engineering (August 1994)

Table 2-7
SUMMARY OF FIRES FOLLOWING THE JANUARY 17, 1994 NORTHRIDGE EARTHQUAKE

Community	Number of Earthquake-Related Fires
Los Angeles City	77
Los Angeles County	~15
Ventura County	~10
Santa Monica	4
Burbank	0
Pasadena	1
Glendale	0
South Pasadena	0
Beverly Hills	1
Culver City	0
Fillmore	2
TOTAL	**~110**

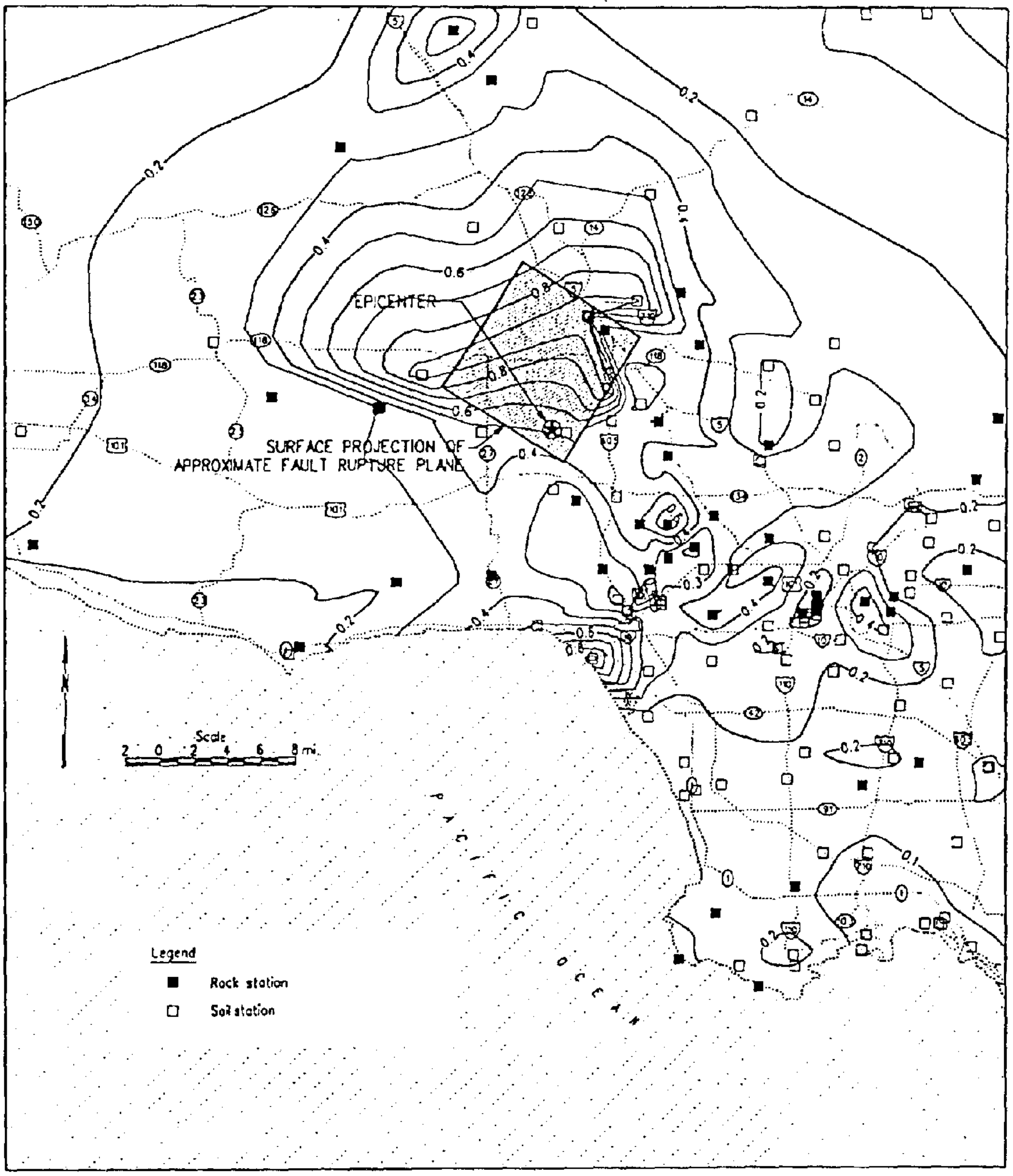


Figure 2-1: Contours of maximum horizontal acceleration based on recordings at rock and soils sites

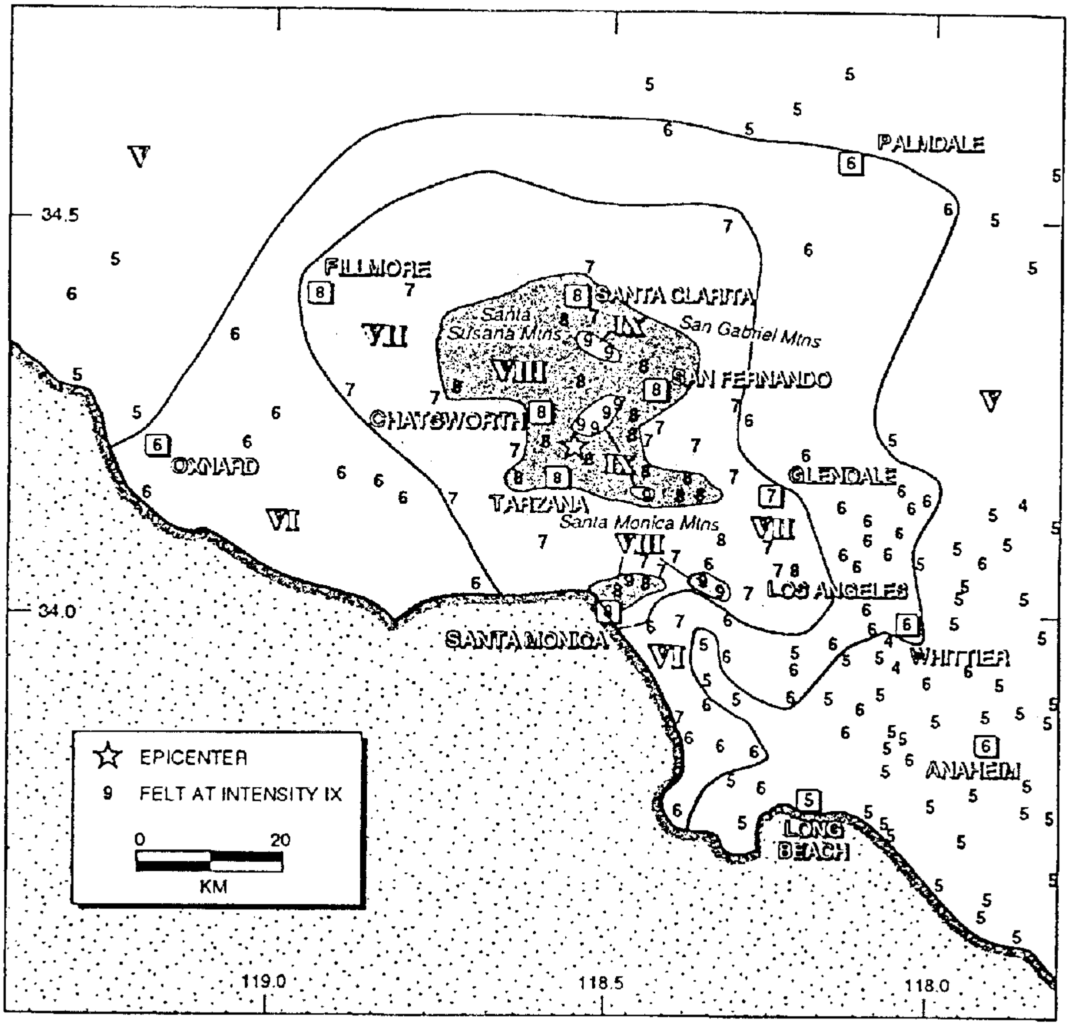


Figure 2-2: Map of MMI Isoseismals, January 17, 1994 Northridge Earthquake

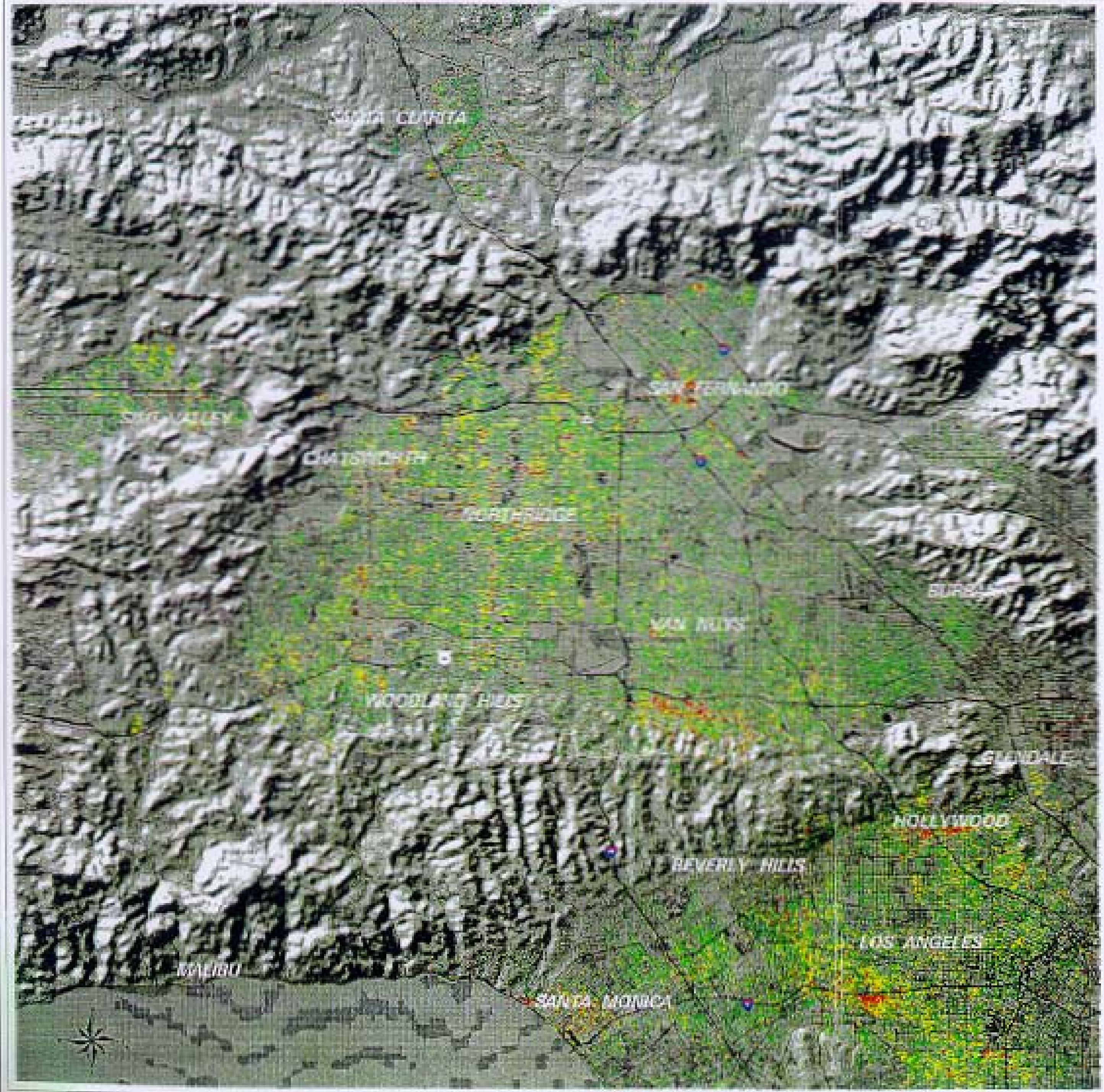


Figure 2-3: BUILDING AND SAFETY DAMAGE ASSESSMENT

Northridge Earthquake Disaster DR-1008

- UNSAFE - No Entry or Occupancy Allowed
- LIMITED ENTRY - Off Limits to Unauthorized Personnel
- INSPECTED - No Restriction on Use or Occupancy
- INSUFFICIENT DATA

Data Sources:

O.E.S

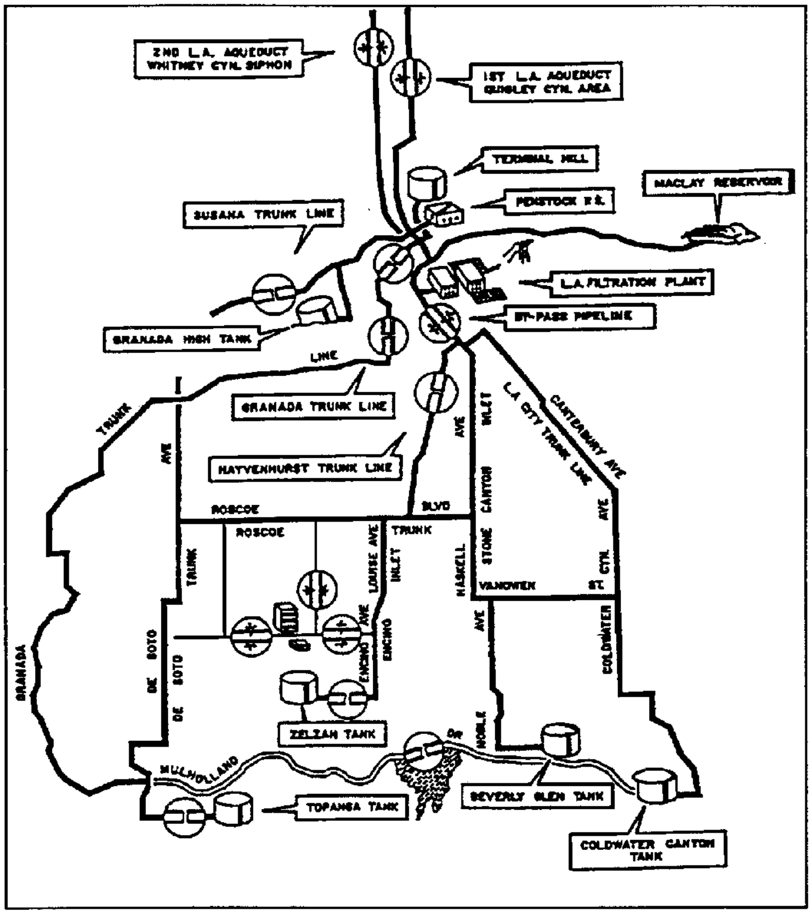


Figure 2-4. Water System Damage, Northridge Earthquake (Courtesy of LAFD)

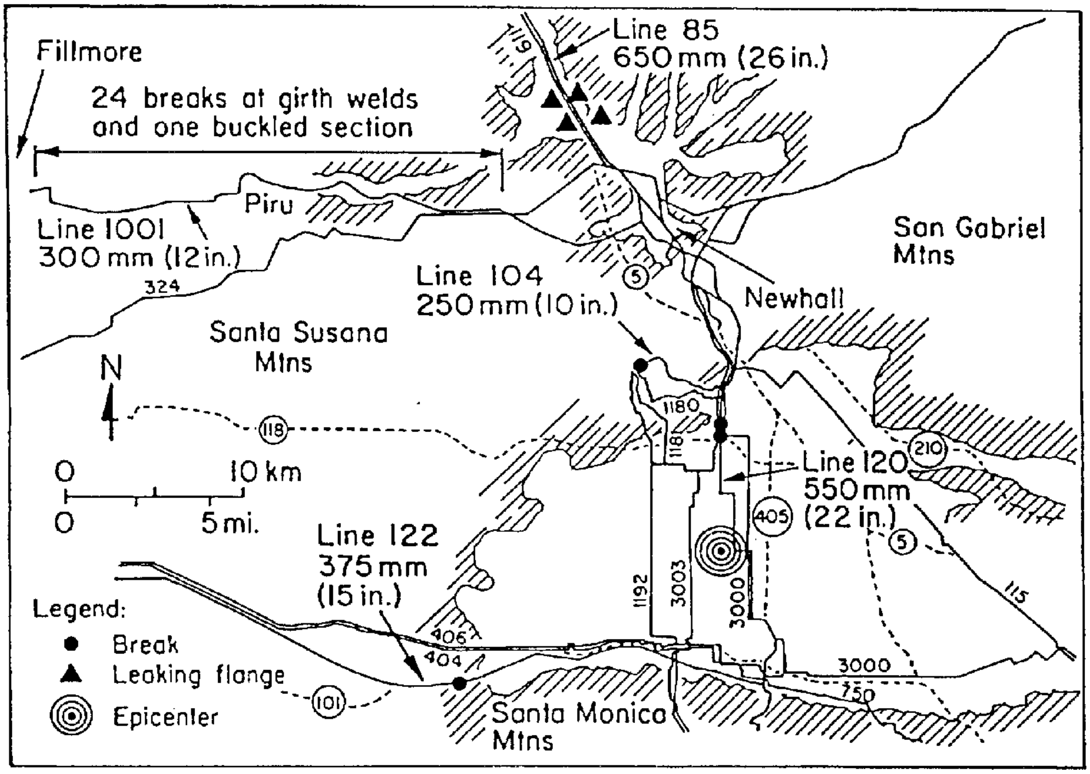


Figure 2-5: Map of selected gas transmission pipes in the Northridge earthquake (after Holzer et al, 1996)

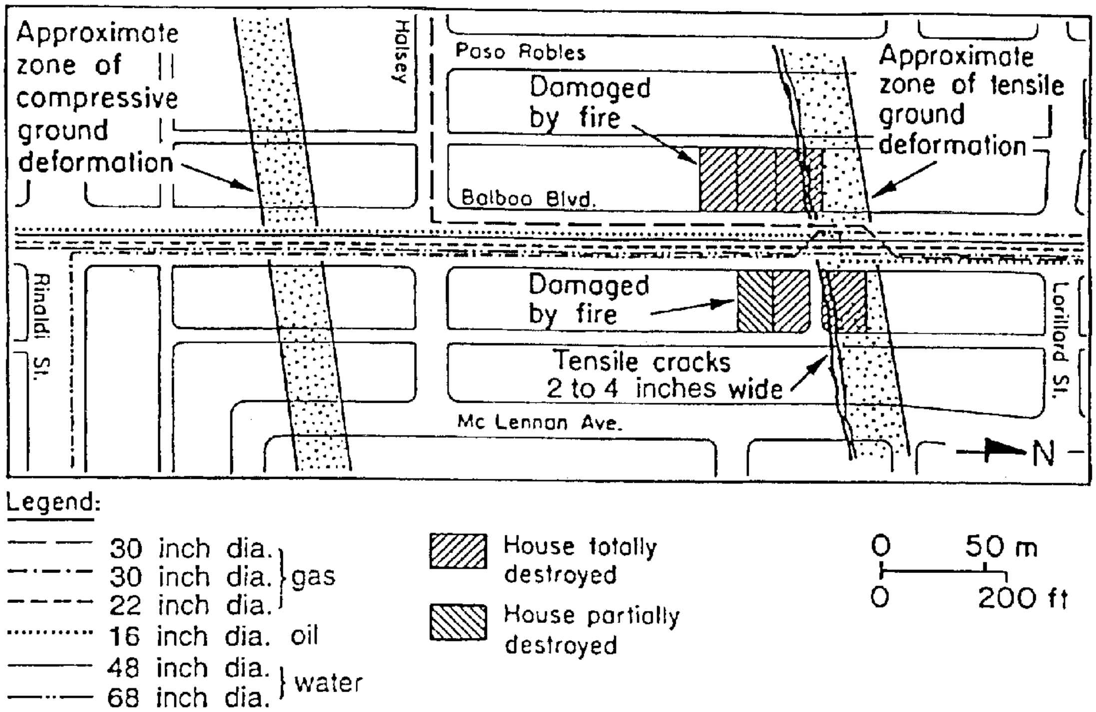


Figure 2-6: Map of major pipelines, fire damage and ground deformation on Balboa Blvd. (after Holzer et al, 1996)

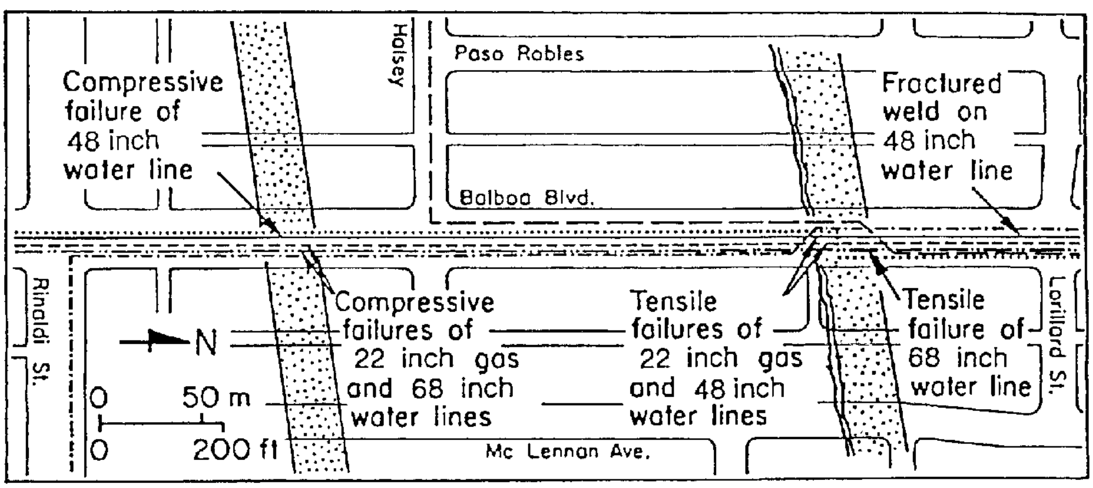


Figure 2-7: Map of major pipelines, ground deformation zones and pipeline damage, Balboa Blvd. (after Holzer et al, 1996)

3. DATA ON FIRES FOLLOWING NORTHRIDGE EARTHQUAKE

3.1 INTRODUCTION

This section describes our data collection procedure, and presents a database of fires occurring as a result of the Northridge earthquake. The database is termed **FFNRE** (**F**ires **F**ollowing the **N**orth**R**idge **E**arthquake). The data is provided in hard-copy form, as well as in an attached diskette (Excel worksheet), and is also available on the Internet (at **www.eqe.com**).

3.2 DATA

Data Collection Approach

Data on fires caused by the January 17 earthquake were collected by contacting local fire departments and obtaining their records, and by interviewing selected senior officers in several of the affected departments. Approximately 110 fires were reported as earthquake-related on January 17, as shown in Table 2-7. For Los Angeles City, Santa Monica, Pasadena, Burbank, and Glendale, the number of fires is shown as reported by each fire department's incident reports. These reports reflect initial assessment of the probable cause, and may or may not include all earthquake-related fires. Furthermore, what is counted as a single incident report may involve multiple structures. Lastly, in the case of mobile home parks, a single incident in some cases even involves multiple ignitions, since several mobile home parks had several fires, but were only listed as one incident, at one address.

The number of earthquake-related fires is only approximate for the unincorporated areas in Los Angeles County due to the fact that not all fires on January 17 were recorded in incident reports. The number of earthquake-related fires in Table 2-7 for several of the smaller cities in Los Angeles County, and for Ventura County were obtained through telephone interview with the respective fire departments, and are therefore preliminary. The locations of most Los Angeles County earthquake-related fires are shown in Figure 4-1 (some outlying locations have been excluded).

FFNRE Database

Los Angeles Fire Department Field Incident Report Data. The majority of the data contained in our database is taken directly from the Field Incident Reports (FIRs) logged on January 17, 1994, from 4:31 AM to 11:59 PM, by the Los Angeles Fire Department (LAFD). A total of 2177 incidents were reported on that day by the city fire department, a portion of which were earthquake-related or fire-related. We have retained all of these incident reports in our database, along with all relevant data fields. Those data fields are described below.

A subset of reports covering earthquake-related fire incidents was extracted from the all incident reports of January 17. Any fire that had an ignition factor or a contributing factor related to the earthquake, as specified by the incident report, was included in this list. The list of 77 incident reports is shown in Table 3-1.

Incident Number (IKEY)

A unique number is assigned to each incident by the LAFD emergency control center. The number contains six digits for the incident date (year, month, day) followed by a four-digit incident number which is assigned sequentially throughout the day.

Time of Alarm (AT)

This data field is the time that the initial assignment received the dispatch from the emergency control center. Time is given in the 24 hour clock that runs from midnight (hr.mi.ss) to 23.59.00 the following night.

Time on Scene (SCNE_TIME)

This data field is the time that the first fire department unit arrived on scene. Time is given in the 24 hour clock that runs from midnight 00.00.00 (hr.mi.ss) to 23.59.00 the following night.

Street Address (LOCATION)

The actual street address of the location of the incident or a description of the location if an address is not available is given in this data field.

Census Location (CEN_TRACT)

The seven-digit field specifies a six digit U.S. Census Tract number, followed by a block group number which may be specified as zero if not known.

Type of Incident (TYPE_INC)

This data field describes the broad category of incident dealt with. If conditions change during the operation, the most serious situation encountered is described for the incident. For example, if the first arriving company found a fuel spill and it subsequently ignited, the incident is recorded as a fire. The numeric codes entered in this data field are described below.

TYPE_INC	FREQUENCY	DESCRIPTION
BLANK	870	INSUFFICIENT INFORMATION TO CLASSIFY
2	43	ASSUME CODE 20: OVERPRESSURE RUPTURE
3	1	RESCUE CALL
4	3	HAZARDOUS CONDITION, STANDBY
5	19	SERVICE CALL
10	1	EXPLOSION WITH NO AFTER FIRE
11	127	STRUCTURE FIRE
12	5	MOBILE STRUCTURE FIRE
13	1	FIRE IN MOBILE PROPERTY INSIDE STRUCTURE
14	6	FIRE IN MOBILE PROPERTY OUTSIDE STRUCTURE
15	4	GRASS FIRE
16	7	RUBBISH FIRE
17	5	OUTSIDE FIRE BURNING PROPERTY OF DEFINABLE VALUE

TYPE_INC	FREQUENCY	DESCRIPTION
18	1	BRUSH FIRE
19	4	TREE FIRE
31	68	EMERGENCY MEDICAL CALL, PARAMEDIC
32	155	EMERGENCY MEDICAL CALL, EMT OR FIRST AID
33	7	LOCK-IN
35	27	PEOPLE TRAPPED/CAUGHT/BURIED
39	5	OTHER RESCUE CALL
40	2	HAZARDOUS CONDITION
41	72	FLAMMABLE GAS/LIQUID LEAK OR SPILL
42	10	TOXIC CONDITION, INCLD CHEMICAL SPILLS
44	58	ELECTRICAL HAZARD: ARCING OR SHORTING
46	41	VEHICLE ACCIDENT OR POTENTIAL ACCIDENT
49	7	OTHER HAZARDOUS CONDITION
51	10	PERSON(S) IN DISTRESS
52	41	WATER PROBLEMS
53	21	SMOKE, ODOR PROBLEM
55	2	PUBLIC SERVICE/AGENCY ASSISTANCE (E.G., POLICE ASSIST)
56	7	UNAUTHORIZED OR ILLEGAL BURNING
59	5	OTHER SERVICE CALL
60	1	GOOD INTENT CALL
61	39	GOOD INTENT CALL CLEARED BY RADIO BEFORE ARRIVAL
62	1	GOOD INTENT CALL WRONG LOCATION
63	1	CONTROLLED BURNING
64	9	MULTIPLE CALLS ON SAME INCIDENT
65	35	SMOKE BY SMOKE, STEAM OR OTHER GAS
66	35	EMS CALL WHERE INJURED PARTY LEFT SCENE
69	6	OTHER GOOD INTENT CALL
71	12	MALICIOUS FALSE CALL
72	5	BOMB SCARE, NO EXPLOSION
73	3	ALARM MALFUNCTION CAUSING FALSE ALARM
74	201	UNINTENTIONAL FALSE ALARM
75	26	CODE ERROR
79	1	OTHER FALSE ALARM
81	10	NATURAL DISASTER: EARTHQUAKE
91	25	OTHER SITUATION
92	52	OTHER SITUATION
93	2	OTHER SITUATION
94	26	OTHER SITUATION
95	7	OTHER SITUATION
96	39	OTHER SITUATION
97	1	OTHER SITUATION
99	5	OTHER SITUATION

Property Use - General (USE_GEN)

This category describes the occupancy or use of the property and includes property meeting all three of the following criteria:

1. Located within a continuous boundary, and
2. Operated under one business management or ownership.
3. A single multi-use building or multiple buildings with a single use.

If more than one occupancy is present, the predominant type is specified in this data field. The numeric codes entered in this data field are described below.

USE_GEN	FREQUENCY	DESCRIPTION
BLANK	914	NOT SPECIFIED
0	1	NOT SPECIFIED
2	1	NOT SPECIFIED
12	1	STADIUM, EXHIBITION USE
14	1	CLUB COMPLEX
16	3	RESTAURANT, FOOD SERVICE
17	1	PASSENGER TERMINAL
21	10	PRIMARY AND SECONDARY EDUCATION
22	1	POST SECONDARY EDUCATION
31	8	CARE OF HANDICAPPED
33	11	MEDICAL CARE
34	2	PRISON
35	1	NOT SPECIFIED
36	1	NOT SPECIFIED
41	398	ONE AND TWO FAMILY RESIDENCE
42	355	APARTMENTS, CONDOS
43	1	BOARDING HOUSE, DORMITORY, BARRACKS
44	12	HOTELS, MOTELS, INNS
47	2	MOBILE HOME PARK
51	14	RETAIL AND SHOPPING CENTERS
52	1	SERVICE CENTERS
53	1	NOT SPECIFIED
54	1	NOT SPECIFIED
57	1	NOT SPECIFIED
58	2	NOT SPECIFIED
59	58	BUSINESS, OFFICE
61	7	POWER, ENERGY PRODUCTION OR DISTRIBUTION
62	1	RESEARCH FACILITY OR LABORATORY
70	3	INDUSTRIAL OR MANUFACTURING
74	1	NOT SPECIFIED
79	1	NOT SPECIFIED

USE_GEN	FREQUENCY	DESCRIPTION
80	1	STORAGE, WAREHOUSE
81	1	NOT SPECIFIED
86	1	NOT SPECIFIED
88	7	NOT SPECIFIED
89	1	NOT SPECIFIED
92	9	WILDLAND, VACANT PROPERTY
93	8	REFUSE DISPOSAL
94	5	WATER, WATERFRONT AREA
95	1	RAILROAD
96	327	PUBLIC ROADWAYS
97	1	AIR TRANSPORT USE

Agent Application Time (AGT_APT_T)

Agent application time is the time that extinguishing agents were first applied to the fire. The time is expressed as a four-digit number, where the first two digits are the hour (0 to 23) and the second two digits are the minute (0 to 59).

Knock Down Time (KNK_OWN_T)

The knock down time is the time at which the fire is brought under control. The time is expressed as a four-digit number, where the first two digits are the hour (0 to 23) and the second two digits are the minute (0 to 59).

Area of Origin (AREA_ORIG)

This data field describes the room or area where the fire originated. The area of origin is either a room, an area or portion of a room, a vehicle or a portion of a vehicle, or possible some open area devoted to a specific use. The numeric codes used in this field are described below.

AREA_ORIG	FREQUENCY	DESCRIPTION
BLANK	1812	NOT SPECIFIED
0	259	NOT SPECIFIED
1	1	HALLWAY, CORRIDOR
2	1	EXTERIOR STAIRWAY
5	1	LOBBY, ENTRANCE OR EXIT
14	10	LOUNGE OR LIVING AREA
15	2	SALES, SHOWROOM AREA

AREA_ORIG	FREQUENCY	DESCRIPTION
21	15	SLEEPING ROOM FOR <5 PEOPLE
22	1	SLEEPING ROOM FOR >5 PEOPLE
23	1	DINING AREA
24	10	KITCHEN
25	3	LAVATORY, LOCKER ROOM, CLOAKROOM
26	1	LAUNDRY ROOM OR AREA
27	1	OFFICE
31	2	LABORATORY
38	1	PROCESS, MANUFACTURING AREA
41	2	STORAGE ROOM, AREA, TANK OR BIN
42	1	CLOSET
43	1	SUPPLY STORAGE ROOM OR AREA
46	1	SHIPPING, RECEIVING, LOADING AREA
47	10	GARAGE, CARPORT, VEHICLE STORAGE
51	1	ELEVATOR OR DUMB-WAITER
62	7	HEATING EQUIPMENT OR WATER HEATER AREA
71	3	CRAWL SPACE
73	2	CONCEALED SPACE BETWEEN FLOORS
74	3	CONCEALED SPACE BETWEEN CEILING AND ROOF
75	2	CONCEALED WALL SPACE
76	3	EXTERIOR WALL SURFACE
79	1	OTHER STRUCTURAL AREAS
81	2	VEHICLE PASSENGER AREA
83	2	VEHICLE ENGINE AREA
84	1	VEHICLE FUEL AREA
92	8	ON OR NEAR PUBLIC THROUGHFARE
94	5	LAWN, FIELD, OPEN AREA
99	1	OTHER AREA

Form of Heat of Ignition (FORM_IGN)

This field describes the form of the heat which started the fire, as near as can be determined. The form the heat of ignition takes can be an open flame, a hot surface, an arc or spark, or some other form.

The numeric codes used to describe this data field are given below.

FORM_IGN	FREQUENCY	DESCRIPTION
BLANK	1812	NOT SPECIFIED
0	269	NOT SPECIFIED
14	13	FLAME, SPARK, EMBER FROM GAS FUELED SOURCE
15	2	HEAT RADIATED FROM GAS FUELED SOURCE
17	2	HEAT RADIATED FROM FLAMMABLE LIQUID SOURCE
21	2	FLAME, SPARK, EMBER FROM WOOD OR PAPER FUEL

FORM_IGN	FREQUENCY	DESCRIPTION
		SOURCE
25	1	FLAME, SPARK, EMBER FROM SOLID FUEL SOURCE
30	2	HEAT FROM ELECTRICAL EQUIPMENT ARCING, OVERLOADING
32	7	SHORT CIRCUIT, ARC FROM MECHANICAL DAMAGE
33	13	SHORT CIRCUIT, ARC FROM DEFECTIVE INSULATION
34	5	UNSPECIFIED SHORT CIRCUIT
35	3	ARC FROM FAULTY CONTACT, BROKEN POWERLINE
36	6	ARC, SPARK FROM NORMAL EQUIPMENT OPERATION
37	1	HEAT FROM OVERLOADED EQUIPMENT
39	1	HEAD FROM OTHER ELECTRICAL EQUIPMENT
41	1	FRICTION HEAT OR SPARKS
43	1	HOT EMBER, ASH
44	4	ELECTRIC LAMP
45	5	REKINDLE, REIGNITION
46	5	HEAT FROM NORMAL ELECTRICAL EQUIPMENT OPERATION
48	1	CATALYTIC CONVERTER EXHAUST SYSTEM
49	1	HEAT FROM OTHER HOT OBJECTS
56	1	INCENDIARY DEVICES
65	10	MATCH, LIGHTER
68	1	BACKFIRE FROM INTERNAL COMBUSTION ENGINE
72	2	SPONTANEOUS IGNITION, CHEMICAL REACTION
81	5	HEAT FROM DIRECT FLAME, CONVECTION CURRENTS
92	1	OTHER FORM OF HEAT

Ignition Factor (IGN_FACT)

This data field describes whether an act or lack of action on the part of a person or group of persons appears to have caused the fire to start. Ignition factors are not only accidental or deliberate acts, misuse or neglect of equipment, but also design, construction and installation failures.

The numeric codes that are entered in this data field are described below.

IGN_FACT	FREQUENCY	DESCRIPTION
BLANK	1812	NOT SPECIFIED
0	244	NOT SPECIFIED
11	1	INCENDIARY ACT BY KNOW PERSON
15	8	INCENDIARY ACT BY PERSON(S) UNKNOWN
27	1	SUSPICIOUS ACT, PERSONS UNKNOWN
35	2	HEAD SOURCE TOO CLOSE TO COMBUSTIBLES
36	1	CHILDREN PLAYING WITH HEAT SOURCES
46	1	COMBUSTIBLE PLACED TOO CLOSE TO HEAT SOURCE

IGN_FACT	FREQUENCY	DESCRIPTION
53	15	SHORT CIRCUIT, GROUND FAULT
54	9	OTHER PART FAILURE, LEAK, BREAK
55	1	OTHER ELECTRICAL FAILURE
58	2	WIRES DOWN
62	1	CONSTRUCTION DEFICIENCY
63	1	ITEM CONSTRUCTED TOO CLOSE TO COMBUSTIBLES
66	1	NOT SPECIFIED
71	1	COLLISION, OVERTURN, KNOCKDOWN
73	1	EQUIPMENT UNATTENDED
82	64	EARTHQUAKE CAUSED UNSAFE FACTOR
83	1	HIGH WATER, FLOODS CAUSED UNSAFE FACTOR
92	10	OTHER FACTOR REKINDLED FROM PREVIOUS FIRE

Contributing Factor 1 (CONTRIB_1)

This data field describes other factors not reported in other fields that had bearing on ignition, fire or smoke spread, incident complexity or the existence of hazardous conditions.

The numeric codes used and their descriptions are given below.

CONTRIB_1	FREQUENCY	DESCRIPTION
BLANK	2102	NOT SPECIFIED
202	1	UNDIVIDED ATTIC
206	1	CEILING COLLAPSE
230	2	INSTALLATION DEFICIENCY
300	2	NOT SPECIFIED
302	2	CARELESS ACT
332	6	NOT SPECIFIED
336	1	NOT SPECIFIED
348	1	VANDALISM
399	1	OTHER ACTS OR OMISSIONS
480	3	STORAGE (POOR PRACTICE)
714	1	MALFUNCTION OF ELECTRICAL OR MECHANICAL EQUIPMENT
716	4	OVERHEATING OR ELECTRICAL OR MECHANICAL EQUIPMENT
720	5	RUPTURE OF MECHANICAL EQUIPMENT
724	7	SHORT CIRCUIT OF ELECTRICAL EQUIPMENT
804	38	EARTHQUAKE

Contributing Factor 2 (CONTRIB_2)

This data field describes other factors not reported in other fields that had bearing on ignition, fire or smoke spread, incident complexity or the existence of hazardous conditions. This field is completed only for fires that spread.

The numeric codes used and their descriptions are given below.

CONTRIB_2	FREQUENCY	DESCRIPTION
BLANK	2161	NOT SPECIFIED
223	1	FLOOR COLLAPSE
260	1	WALL COMBUSTIBLE
302	2	CARELESS ACT
330	1	MAINTENANCE INADEQUATE
524	1	DELAY IN DETECTION OF FIRE
804	10	EARTHQUAKE

Material Type First Ignited (TYPE_MAT)

This data field describes the type of material first ignited that had sufficient volume or heat intensity to extend to uncontrolled or self perpetuating fire. The numeric codes that are used in this data field are described below.

TYPE_MAT	FREQUENCY	DESCRIPTION
BLANK	1812	NOT SPECIFIED
0	287	NOT SPECIFIED
1	1	GRASS
5	1	LIVE TREE, BRUSH
11	13	NATURAL GAS
14	1	L.P. - GAS
15	1	ANESTHETIC GAS
23	3	GASOLINE
25	1	CLASS II COMBUSTIBLE LIQUID
39	1	OTHER VOLATILE SOLID, CHEMICAL
41	1	RIGID PLASTIC
43	8	FLEXIBLE PLASTIC
62	8	WOOD
63	8	SAWN WOOD
66	1	FIBERBOARD
67	1	PAPER, UNTREATED, UNCOATED
69	1	OTHER WOOD OR PAPER
71	7	MANMADE FABRIC OR FIBER EXCEPT RAYON
72	10	COTTON OR RAYON FABRIC

TYPE_MAT	FREQUENCY	DESCRIPTION
77	2	PLASTIC OR VINYL FABRIC, UPHOLSTERY
93	6	RUBBISH
99	3	OTHER MATERIAL

Form of Material First Ignited (FORM_MAT)

This data field describes the shape and function of the material first ignited. The numeric codes used in this data field are described below.

FORM_MAT	FREQUENCY	DESCRIPTION
BLANK	1812	NOT SPECIFIED
0	285	NOT SPECIFIED
11	2	EXTERIOR ROOF COVERING
12	3	EXTERIOR SIDEWALL COVERING
13	1	EXTERIOR TRIM, APPURTENANCES
14	2	FLOOR COVERING
15	1	INTERIOR WALL COVERING
17	9	STRUCTURAL MEMBER
19	1	OTHER STRUCTURAL COMPONENT
21	4	UPHOLSTERED SOFA, CHAIR, SEAT
23	2	CABINETRY
26	1	KITCHEN, HOUSEHOLD UTENSILS
31	1	MATTRESS, PILLOW
32	9	BEDDING, BLANKET, SHEET, HEATING PAD
34	1	WEARING APPAREL NOT ON PERSON
41	2	CHRISTMAS TREE
44	1	MAGAZINE, NEWSPAPER, WRITING PAPER
50	1	OTHER SUPPLIES, STOCK
61	10	ELECTRICAL WIRE, CABLE INSULATION
62	1	TRANSFORMER
65	11	FUEL, GAS TANK
72	1	FENCE, POLE, POWER POLES
74	3	GROWING, LIVING FORM
75	5	RUBBISH OR WASTE
79	1	GENERAL FORM
86	6	GAS OR LIQUID ON OR FROM PIPE OR CONTAINER
99	1	OTHER FORM

Equipment Involved in Ignition (EQUIP_TYPE)

This data field describes the type of equipment that fails or brings about the ignition while operating normally. The numeric codes used in this data field are described below.

EQUIP_TYPE	FREQUENCY	DESCRIPTION
BLANK	2044	NOT SPECIFIED
1	1	ROAD TRANSPORT VEHICLES
12	3	WATER HEATER
13	2	FIXED, STATIONARY LOCAL HEATING UNIT
22	1	FIXED, STATIONARY OVEN
41	1	FIXED WIRING
43	1	METER, METER BOX
45	1	SWITCH, RECEPTACLE, OUTLET
46	2	LIGHTING FIXTURE, LAMPHOLDER, BALLAST, SIGN
58	1	PORTABLE APPLIANCE DESIGNED TO PRODUCE HEAT
59	1	OTHER APPLIANCE
98	119	NO EQUIPMENT INVOLVED

Mobile Property Type (MOB_TYPE)

This data field identifies the type of mobile property involved in the incident report. This numeric codes used for this field are described below.

MOB_TYPE	FREQUENCY	DESCRIPTION
BLANK	2166	NOT SPECIFIED
11	4	AUTOMOBILE
14	1	MOTOR HOME
17	4	MOBILE HOME
21	1	GENERAL USE TRUCKS >1 TON
22	1	GENERAL USE TRUCKS <1 TON

Mobile Property Make (MOB_MAKE)

This data field identifies the name of the manufacturer of the mobile property involved in the incident report. This numberic codes used for this field are described below.

MOB_MAKE	FREQUENCY	DESCRIPTION
BLANK	2171	NOT SPECIFIED

MOB_MAKE	FREQUENCY	DESCRIPTION
CHEV	1	CHEVROLET AUTOMOBILE
ESCP	1	EXCAPADE MOTOR HOME
FORD	2	FORD AUTOMOBILE
TOYO	1	TOYOTA AUTOMOBILE
UNK	1	UNKNOWN

Form of Material Causing Spread (FORM_MSPRD)

This field describes the shape and function of the material that causes the fire to spread. The numeric codes used in this data field are described below.

FORM_MSPRD	FREQUENCY	DESCRIPTION
BLANK	2138	NOT SPECIFIED
0	4	NOT SPECIFIED
11	4	EXTERIOR ROOF COVERING
12	3	EXTERIOR SIDEWAL COVERING
14	1	FLOOR COVERING
15	4	INTERIOR WALL COVERING
17	5	STRUCTURAL MEMBER
21	1	UPHOLSTERED SOFA, CHAIR, SEAT
26	1	KITCHEN, HOUSEHOLD UTENSILS
32	1	BEDDING, BLANKET, SHEET
34	1	WEARING APPAREL NOT ON PERSON
44	1	MAGAZINE, NEWSPAPER, WRITING PAPER
51	1	BAOX, CARTON, BAG
61	1	ELECTRICAL WIRE, CABLE INSULATION
65	1	FUEL, GAS TANK
66	1	PAIP, DUCT, CONDUIT, HOSE
75	1	RUBBISH, WASTE
77	1	SIGN
80	1	OTHER SPECIAL FORM
86	1	GAS OR LIQUID ON OR FROM PIPE OR CONTAINER
96	1	NOT SPECIFIED
97	1	MULTIPLE FORM OF MATERIAL IGNITED
98	1	FORM NOT APPLICABLE
99	2	OTHER FORM

Type of Material Causing Spread (TYPE_MSPRD)

This data field describes the type of material that causes the fire to spread. The numeric codes used in this data field are described below.

TYPE_MSPRD	FREQUENCY	DESCRIPTION
BLANK	2138	NOT SPECIFIED
0	4	NOT SPECIFIED
11	7	NATURAL GAS
25	1	CLASS II COMBUSTIBLE LIQUID
36	1	COMBUSTIBLE METAL
39	1	OTHER VOLATILE SOLID, CHEMICAL
43	1	FLEXIBLE PLASTIC
63	11	SAWN WOOD
65	2	HARDBOARD, PLYWOOD
67	1	PAPER, UNCOATED
68	1	CARDBOARD
69	2	OTHER WOOD, PAPER
72	2	COTTON, RAYON FABRIC
93	1	RUBBISH
97	1	MULTIPLE TYPES OF MATERIAL
98	1	TYPE OF MATERIAL NOT APPLICABLE
99	2	OTHER MATERIAL TYPE

Flame Travel Factor (TRVL_FACT)

This data field describes the primary factor in rapid or intense flame spread beyond the room or area of origin. The numeric codes used in this data field are described below.

TRVL_FACT	FREQUENCY	DESCRIPTION
BLANK	2170	NOT SPECIFIED
20	1	INSUFFICIENT INFORMATION TO CLASSIFY
22	1	INADEQUATE FIRESTOPPING
29	1	OTHER STRUCTURAL FACTOR ALLOWING VERTICAL SPREAD
42	1	CONVEYOR OR OTHER MATERIAL HANDLER
44	1	WIND
79	1	UNCLASSIFIED NATURAL ACT
98	1	NO IMPORTANT FACTORS CONTRIBUTE

Avenue of Fire Spread (AVE_FIRE)

This data field indicates the most significant avenue of fire spread. The numeric codes used in this data field are described below.

AVE_FIRE	FREQUENCY	DESCRIPTION
BLANK	2167	NOT SPECIFIED
1	4	CEILING OR ATTIC SPACE
2	1	EXTERIOR OF BUILDING
7	4	HORIZONTAL OPENINGS
9	1	UNCLASSIFIED

Avenue of Smoke Spread (AVE_SMOKE)

This data field indicates the most significant avenue of smoke spread. The numeric codes used in this data field are described below.

AVE_SMOKE	FREQUENCY	DESCRIPTION
BLANK	2126	NOT SPECIFIED
0	2	NOT SPECIFIED
1	6	AIR HANDLING DUCTS
2	1	CORRIDOR
3	1	ELEVATOR SHAFT
4	1	STAIRWELL
5	8	CONSTRUCTION OPENING
6	2	UTILITY OPENING IN WALL OR FLOOR
7	18	DOORWAY, PASSAGEWAY
8	12	NO SIGNIFICANT AVENUE OF SMOKE TRAVEL

Construction Type (CONST_TYPE)

This data field describes the building type of the structure involved in the incident. The numeric codes used in this field are described below.

CONST_TYPE	FREQUENCY	DESCRIPTION
BLANK	2069	NOT SPECIFIED
0	1	NOT SPECIFIED
1	5	TYPE I - NONCOMBUSTIBLE HIGHRISE
2	1	TYPE II - SMALLER NONCOMBUSTIBLE
3	4	TYPE III - NONCOMBUSTIBLE WALLS, COMBUSTIBLE ROOF, FLOOR

CONST_TYPE	FREQUENCY	DESCRIPTION
4	3	TYPE IV - NONCOMBUSTILE LIGHT METAL OR CONCRETE PARKING STRUCTURE
5	94	TYPE V - COMBUSTIBLE, WOOD OR STUCCO

Number of Stories in Structure (FLRS_STRUCT)

The total number of floors above and below ground are given in this data field.

FLRS_STRUC	FREQUENCY	DESCRIPTION
BLANK	1812	NOT SPECIFIED
0	257	NOT SPECIFIED
1	55	ONE STORY
2	33	TWO STORIES
3	16	THREE STORIES
4	3	FOUR STORIES
6	1	SIX STORIES

Number of Floors Involved in the Incident (FLRS_INVLD)

The total number of floors above and below ground that were involved in the incident are given in this data field.

FLRS_INVLD	FREQUENCY	DESCRIPTION
BLANK	1812	NOT SPECIFIED
0	257	NOT SPECIFIED
1	99	ONE FLOOR
2	9	TWO FLOORS

Floor of Origin (FLR_ORIG)

The floor of origin of the fire is given in this data field. The alpha-numeric codes used are given below.

FLR_ORIG	FREQUENCY	DESCRIPTION
BLANK	1812	NOT SPECIFIED
0	260	NOT SPECIFIED
A01	66	GROUND FLOOR
A02	26	SECOND FLOOR
A03	10	THIRD FLOOR

FLR_ORIG	FREQUENCY	DESCRIPTION
A06	1	SIXTH FLOOR
B01	2	FIRST BASEMENT

Type and Effectiveness of Detection System (DET_SYS)

This data field indicates the type of alarm or detection system. The numeric codes used are described below

DET_SYS	FREQUENCY	DESCRIPTION
BLANK	2172	NOT SPECIFIED
2114	1	SMOKE/PHOTOELECTRIC/ELECTRICALLY POWERED, LOCAL ALARM, AUTOMATIC DETECTORS, SATISFACTORY OPERATION
2121	1	SMOKE/PHOTOELECTRIC/ELECTRICALLY POWERED, LOCAL ALARM, AUTOMATIC DETECTORS AND MANUAL SEND, ALERTED OCCUPANTS TO CALL FIRE DEPT
4131	1	SMOKE/IONIZATION/ELECTRICALLY POWERED, LOCAL ALARM, MANUAL SEND, ALERTED OCCUPANTS TO CALL FIRE DEPT
4149	1	SMOKE/IONIZATION/ELECTRICALLY POWERED, LOCAL ALARM, WATCHMAN, EFFECTIVENESS NOT CLASSIFIED
5111	1	IONIZATION/PHOTOELECTRIC, LOCAL ALARM, AUTO DETECTORS, ALERTED OCCUPANTS TO CALL FIRE DEPT

Extinguishing System Type and Effectiveness (EXT_SYS)

EXT_SYS	FREQUENCY	DESCRIPTION
BLANK	2175	NO EXTINGUISHING SYSTEM OR NOT APPLICABLE
21	1	WET PIPE/PARTIAL COVERAGE, NOT FACTOR IN OUTCOME
415	1	WET/COMPLETE COVERAGE, OPERATED BUT NOT EFFECTIVE

Property Management Status (PROP_STAT)

This data field records the property management responsibility and use status of the property. The numeric codes used for this data field are described below.

PROP_STAT	FREQUENCY	DESCRIPTION
BLANK	2066	NOT SPECIFIED
0	1	NOT SPECIFIED

PROP_STAT	FREQUENCY	DESCRIPTION
1	8	PROPERTY MGMT UNDETERMINED, UNINHABITED
11	12	PRIVATE TAX PAYING PROPERTY, UNINHABITED
12	59	PRIVATE TAX PAYING PROPERTY, OCCUPIED
13	12	PRIVATE TAX PAYING PROPERTY, CLOSED AND PERSONNEL ABSENT
14	16	PRIVATE TAX PAYING PROPERTY, OCCUPANT ABSENT
42	1	STATE GOV PROPERTY, OCCUPIED
43	2	STATE GOV PROPERTY, CLOSED AND PERSONNEL ABSENT

Extent of Fire Damage (FIRE_DMGE)

This data field indicates extent of burned or charred area. The numeric codes used are given below.

FIRE_DMGE	FREQUENCY	DESCRIPTION
BLANK	2044	NOT SPECIFIED
0	1	UNDETERMINED
1	49	CONFINED TO OBJECT OF ORIGIN
2	21	CONFINED TO PART OF ROOM OR AREA
3	20	CONFINED TO ROOM
4	2	CONFINED TO FIRE RATED COMPARTMENT OF ORIGIN
5	2	CONFINED TO STORY OF ORIGIN
6	32	CONFINED TO BUILDING OR PROPERTY OF ORIGIN
7	3	EXTENDED BEYOND BUILDING OR PROPERTY
8	1	NO DAMAGE OF THIS TYPE
9	2	NOT CLASSIFIED

Extent of Smoke Damage (SMOKE_DMGE)

This data field indicates the extent of damage caused by the movement of smoke and heat. The numeric codes used are given below.

SMOKE_DMGE	FREQUENCY	DESCRIPTION
BLANK	2044	NOT SPECIFIED
0	3	UNDETERMINED
1	33	CONFINED TO OBJECT OF ORIGIN
2	11	CONFINED TO PART OF ROOM OR AREA
3	14	CONFINED TO ROOM
4	4	CONFINED TO FIRE RATED COMPARTMENT OF ORIGIN
5	4	CONFINED TO STORY OF ORIGIN
6	32	CONFINED TO BUILDING OR PROPERTY OF ORIGIN
7	1	EXTENDED BEYOND BUILDING OR PROPERTY

SMOKE_DMGE	FREQUENCY	DESCRIPTION
8	28	NO DAMAGE OF THIS TYPE
9	3	NOT CLASSIFIED

Extent of Water Damage (WATER_DMGE)

This data field indicates the extent of damage caused by water or other extinguishing agents. The numeric codes used are given below.

WATER_DMGE	FREQUENCY	DESCRIPTION
BLANK	2044	NOT SPECIFIED
0	4	UNDETERMINED
1	33	CONFINED TO OBJECT OF ORIGIN
2	11	CONFINED TO PART OF ROOM OR AREA
3	15	CONFINED TO ROOM
4	1	CONFINED TO FIRE RATED COMPARTMENT OF ORIGIN
5	2	CONFINED TO STORY OF ORIGIN
6	27	CONFINED TO BUILDING OR PROPERTY OF ORIGIN
7	1	EXTENDED BEYOND BUILDING OR PROPERTY
8	35	NO DAMAGE OF THIS TYPE
9	4	NOT CLASSIFIED

Extent of Fire Control Damage (CNTL_DMGE)

This data field indicates the extent of damage done in controlling and extinguishing the fire. The numeric codes used in this data field are given below.

CNTL_DMGE	FREQUENCY	DESCRIPTION
BLANK	2127	NOT SPECIFIED
1	2	CONFINED TO OBJECT OF ORIGIN
2	6	CONFINED TO PART OF ROOM OR AREA
3	9	CONFINED TO ROOM
4	2	CONFINED TO FIRE RATED COMPARTMENT OF ORIGIN
5	1	CONFINED TO STORY OF ORIGIN
6	14	CONFINED TO BUILDING OR PROPERTY OF ORIGIN
7	3	EXTENDED BEYOND BUILDING OR PROPERTY
8	13	NO DAMAGE OF THIS TYPE

Property Loss (PROP_LOSS)

Property loss is the fire department personnel's estimate of the replacement value of property (other than contents) that has been destroyed or damaged during the incident. This number includes water and smoke damage for fires. The loss values are in dollars.

Contents Loss (CONT_LOSS)

Property loss is the fire department personnel's estimate of the replacement value of property (other than contents) that has been destroyed or damaged during the incident. This number includes water and smoke damage for fires. The loss values are in dollars.

Watershed Loss (WSHED_LOSS)

The fire department personnel estimates the number of acres of watershed destroyed by the fire. Any watershed loss of less than one acre is recorded as one acre.

Santa Monica Fire Department. The Santa Monica Fire Department filed 219 incidents on January 17, 1994, 216 of which were filed between 4:31 and 24:00 hours. The records were produced in a format that conforms with the California Fire Incident Reporting System (CFIRS). All 219 incident reports are included in the database that accompanies this report. Selected fields have been retained from the original data, and those fields are described below, along with an explanation of any codes used in the 219 records from January 17, 1994.

A subset of reports covering earthquake-related fire incidents was extracted from the all incident reports of January 17. Any fire that had an ignition related to the earthquake, as specified by the incident report, was included in this list. The list of 15 incident reports is shown in Table 3-2.

Fire Department Identification (FDID1)

This is a unique number assigned by the State Fire Marshal to identify a particular fire department in California. The Santa Monica Fire Department is 19180.

Year (PROYEAR)

The last two digits of the year of the incident, i.e., 94, is in this field.

Incident Number (INCNUM)

A unique number assigned to a single incident.

Exposure Number (INCEXP)

This field indicates that the fire at this location has resulted from exposure to a fire at another location. The fire is reported as a separate fire but is linked to the original fire by this number which ranges from 1 to the total number of exposures for the original fire (which has an exposure number of 0).

A Change or Deletion of a Previous Incident (CORREC)

This field indicates a change or deletion to a previous incident report having the same incident number.

Multi-Agency Incident Number (MULTAGY)

This field is a unique alpha-numeric designation which identifies all incident reports pertaining to a single incident in which two or more fire departments respond. The department in whose jurisdiction the incident occurs assigns the Multi-Agency Incident Number - which consists of the jurisdictional agency's three-letter designation (assigned by the Office of Emergency Services), followed by their incident number for the event.

Incident Date (INCDATE)

This field contains the year, month, and day of the event.

Dispatch Time (DISTIME)

The time of dispatch is the hour and minute when the alarm was dispatched by the fire department alarm center. A 24-hour clock is used.

Arrival Time (ARVTIME)

The arrival time is the actual time when the first responding unit arrived at the incident scene. A 24-hour clock is used.

End Time (ENDTIME)

End time is the time when all, or most, of the equipment at the incident is put back in service and is ready for response to another alarm. A 24-hour clock is used.

First Situation Found (FOUND1)

This field describes the observed conditions when the first emergency unit arrived on the scene. A description of the numeric codes used in this field are given below.

FOUND1	FREQUENCY	DESCRIPTION
11	11	STRUCTURE FIRE
16	1	REFUSE FIRE OUTSIDE
22	1	AIR, GAS RUPTURE
32	6	EMERGENCY MEDICAL CALL
41	50	FLAMMABLE GAS OR LIQUID CONDITION
42	2	TOXIC CONDITION
44	8	ELECTRICAL ARCING, SHORTING
49	9	OTHER HAZARDOUS CONDITION
51	1	PERSON IN DISTRESS
52	8	WATER PROBLEM
53	84	SMOKE, ODOR PROBLEM
55	4	PUBLIC SERVICE ASSISTANCE
56	1	UNAUTHORIZED BURNING
61	1	INCIDENT CLEARED PRIOR TO ARRIVAL
67	18	HAZARDOUS MATERIAL RELEASE INVESTIGATION

FOUND1	FREQUENCY	DESCRIPTION
		WITHOUT ANY FINDING
69	1	OTHER GOOD INTENT CALL
71	4	MALICIOUS, MISCHIEVOUS FALSE CALL
73	1	MALFUNCTION OF ALARM SYSTEM
74	1	UNINTENTIONAL ALARM CALL
79	1	OTHER FALSE CALL
81	3	EARTHQUAKE-RELATED

Second Situation Found (FOUND2)

Subsequent conditions that were observed are noted in this field.

Third Situation Found (FOUND3)

Subsequent conditions that were observed are noted in this field.

Fourth Situation Found (FOUND4)

Subsequent conditions that were observed are noted in this field.

Automatic/Mutual Aid Type (AIDTYPE)

The handling of mutual aid between fire departments is described by this field. The numeric codes used are given below.

AIDTYPE	FREQUENCY	DESCRIPTION
3	3	AID RECEIVED FROM ANOTHER FIRE DEPARTMENT
5	1	AUTOMATIC AID PROVIDED TO ANOTHER FIRE DEPARTMENT
8	212	NO AUTOMATIC/MUTUAL AID RECEIVED OR PROVIDED

Method of Alarm (ALARMTH)

The method of alarm is the first means used to notify the department of an incident. The numeric codes that are used are described below.

ALARMTH	FREQUENCY	DESCRIPTION
1	1	TELEPHONE DIRECT TO FIRE DEPARTMENT
6	1	NO ALARM RECEIVED - NO RESPONSE
7	214	TELEPHONE TIE-LINE TO FIRE DEPARTMENT

Incident Address (INCADDR)

The exact location of the incident, which may be a street address, or directions from a recognized landmark, or an intersection of two roadways is given in this field.

Room, Apartment or Space (INCROOM)

This field adds to the address information by giving a specific room, apartment, office, suite, etc., where the incident occurred.

Incident Zip Code (INCZIP)

The numeric address code assigned by the U.S. Postal Service.

General Property Use (GENERAL)

This field describes the general occupancy of the location. The numeric codes used in this field are described below.

GENERAL	FREQUENCY	DESCRIPTION
BLANK	1	NOT SPECIFIED
11	2	PUBLIC RECREATION USE
13	1	RELIGIOUS USE
16	3	RESTAURANT, FOOD SERVICE, DRINKING ESTABLISHMENT
21	1	PRIMARY- AND SECONDARY-LEVEL EDUCATIONAL USE
22	1	POST-SECONDARY EDUCATIONAL USE
33	2	MEDICAL CARE USE
41	73	ONE- OR TWO-FAMILY RESIDENTIAL USE

GENERAL	FREQUENCY	DESCRIPTION
42	95	MULTI-FAMILY RESIDENTIAL USE
43	2	GROUP LIVING USE
51	4	SALES USE
59	14	BUSINESS, OFFICE USE
62	1	RESEARCH USE
70	1	INDUSTRIAL, MANUFACTURING USE
80	1	STORAGE, WAREHOUSING USE
92	1	PROPERTY UNDERGOING TRANSFORMATION
96	13	MOTOR VEHICLE TRANSPORTATION USE

Specific Property Use (SPECIES)

This field defines the function of a specific space, structure, or portion of a structure, as used by the owner, tenant or occupant of the space. The codes used to described this field are given below.

SPECIES	FREQUENCY	DESCRIPTION
BLANK	124	NOT SPECIFIED
129	1	VARIABLE USE AMUSEMENT, RECREATION PLACES
161	1	RESTAURANT
163	1	TAVERN
213	1	ELEMENTARY SCHOOL
241	1	COLLEGE CLASSROOM BUILDING
410	3	ONE- AND TWO-FAMILY DWELLING
411	27	ONE-FAMILY DWELLING; YEAR-ROUND USE
421	5	APARTMENTS WITH 1 OR 2 LIVING UNITS WITH BUSINESS
422	9	APARTMENTS WITH 3 THROUGH 6 LIVING UNITS WITH BUSINESS
423	19	APARTMENTS WITH 7 THROUGH 8 LIVING UNITS WITH BUSINESS
424	4	APARTMENTS WITH 9 THROUGH 10 UNITS WITH BUSINESS
426	1	APARTMENTS WITH 13 THROUGH 14 UNITS WITH BUSINESS
428	3	APARTMENTS WITH OVER 20 UNITS
430	1	ROOMING BOARDING LODGING HOUSES
442	1	HOTEL, MOTEL WITH LESS THAN 20 UNITS; SEASONAL USE
521	1	CLOTHING STORE
544	1	GIFT, JEWELRY STORE
591	5	GENERAL BUSINESS OFFICE
621	1	CHEMICAL, MEDICAL LABORATORY
882	1	GENERAL VEHICLE PARKING GARAGE

SPECIES	FREQUENCY	DESCRIPTION
929	1	OTHER SPECIAL STRUCTURE
962	2	PAVED PUBLIC STREET
963	3	PAVED PRIVATE STREET

Building Code Occupancy (OCCUPCY)

This field describes the occupancy classification of the building involved in the incident, is defined by the Uniform Building Code. The following codes are used to in this data field.

OCCUPCY	FREQUENCY	DESCRIPTION
BLANK	133	NOT SPECIFIED
A40	1	ICE PLANTS, POWER PLANTS, PUMPING PLANTS, COLD STORAGE AND CREAMERIES
B20	8	DRINKING AND DINING ESTABLISHMENTS HAVING AN OCCUPANT LOAD LESS THAN 50, OFFICE BUILDINGS, PRINTING PLANTS, MUNICIPAL POLICE AND FIRE STATIONS, FACTORIES AND WORKSHOPS, STORAGE AND SALES ROOMS
B30	1	AIRCRAFT HANGARS WHERE NO REPAIR IS DONE, OPEN PARKING GARAGES, HELISTOPS
E10	2	BUILDING USED FOR EDUCATION THROUGH GRADE 12 BY 50 OR MORE PEOPLE
H70	1	OCCUPANCIES WITH TOXIC OR HAZARDOUS MATERIALS
R10	59	HOTELS AND APARTMENT HOUSES
R30	11	DWELLINGS AND LODGING HOUSES

Structure Type (STRUCTP)

This field specifies the type of structure involved in the incident. The codes used in this data field are given below.

STRUCTURE	FREQUENCY	DESCRIPTION
BLANK	133	NOT SPECIFIED
1	81	BUILDING WITH NO SPECIFIC PROPERTY USE
2	1	BUILDING WITH TWO OR MORE SPECIFIC USES
5	1	TENT

Structure Status (STRUCST)

This field gives the state of the structure at the time of the incident. The numeric codes used in this data field are given below.

STRUCTURE	FREQUENCY	DESCRIPTION
BLANK	133	NOT SPECIFIED
1	1	UNDER CONSTRUCTION
2	81	ROUTINELY USED WITH FURNISHINGS IN PLACE
5	1	VACANT PROPERTY BUT SECURED AND MAINTAINED

Occupied at Time of Incident (OCCTIME)

Structures and vehicles are either occupied or unoccupied at the time of the incident. This entry refers to human occupancy, and indicates if people were present in or on the structure or vehicle at the time of the incident.

OCCTIME	FREQUENCY	DESCRIPTION
BLANK	134	NOT SPECIFIED
1	72	STRUCTURE OR VEHICLE OCCUPIED AT TIME OF INCIDENT
2	10	STRUCTURE OR VEHICLE NOT OCCUPIED AT TIME OF INCIDENT

First Type of Action Taken (ACTION1)

This field specifies the initial task performed by the responding fire department personnel. The numeric codes used are given below.

ACTION 1	FREQUENCY	DESCRIPTION
BLANK	204	NOT SPECIFIED
12	1	VENTILATION, EXTINGUISHMENT, SALVAGE AND OVERHAUL
14	1	SALVAGE AND OVERHAUL
15	7	EXTINGUISHMENT
71	3	INVESTIGATE

Second Type of Action Taken (ACTION2)

This field gives the second task performed by the responding personnel. Numeric code(s) used given below.

ACTION 2	FREQUENCY	DESCRIPTION
BLANK	215	NOT SPECIFIED
12	1	VENTILATION, EXTINGUISHMENT, SALVAGE, AND OVERHAUL

Third Type of Action Taken (ACTION3)

This field describes the third type of action taken by personnel at the scene of the incident.

Fourth Type of Action Taken (ACTION4)

This field describes the third type of action taken by personnel at the scene of the incident.

Fire Origin Area (ORGAREA)

This field describes the primary use of the room or space where the fire originated. The numeric codes used in this data field are given below.

ORGAREA	FREQUENCY	DESCRIPTION
0	204	NOT SPECIFIED
5	1	LOBBY, ENTRANCE WAY
14	2	LOUNGE AREA
21	2	SLEEPING ROOM FOR <5 PEOPLE
24	1	KITCHEN, COOKING AREA
62	1	HEATING EQUIPMENT ROOM, WATER HEATER ROOM
71	1	CRAWL SPACE, SUBSTRUCTURE SPACE
76	1	EXTERIOR WALL SURFACE
79	3	OTHER STRUCTURAL AREAS
92	1	ON OR NEAR PUBLIC THOROUGH FARE

Story Level or Fire Origin (ORGLEVL)

This field describes the point where the fire originates in relation to ground level. The alpha-numeric codes used in this data field are given below.

ORGLEVL	FREQUENCY	DESCRIPTION
BLANK	204	NOT SPECIFIED
A01	6	FIRST FLOOR OR GRADE LEVEL
A02	6	SECOND FLOOR
A30	1	THIRD FLOOR

Distance from Origin to Nearest Road (DISTANC)

This field describes the distance from the point of origin of the fire to the nearest edge of the traveled surface of a road, or the nearest outside rail of a railroad right of way.

Form of Heat of Ignition (HEATFRM)

This field describes the form of heat energy that causes the ignition of the fire.

HEATFRM	FREQUENCY	DESCRIPTION
0	205	NOT SPECIFIED
15	1	HEAT FROM NATURAL GAS FUELED EQUIPMENT
17	1	HEAT FROM LIQUID FUELED EQUIPMENT
30	1	HEAT FROM ELECTRICAL EQUIPMENT ARCING OR OVERLOAD
39	1	HEAT FROM OTHER ELECTRICAL EQUIPMENT ARCING OR OVERLOAD
41	1	HEAT, SPARK FROM FRICTION
45	1	REKINDLE, REIGNITION
63	1	HEAT FROM UNDETERMINED SMOKING MATERIAL
66	1	CANDLE, TAPER
69	1	HEAT FROM OTHER OPEN FLAME, SPARKS OR SMOKING MATERIAL
81	2	HEAT FROM DIRECT FLAME, CONVECTION CURRENTS

Ignition Factor (IGNFACTR)

This field describes the act, condition or situation that allowed the heat source to combine with the material first ignited to start a fire.

HEATFRM	FREQUENCY	DESCRIPTION
0	204	NOT SPECIFIED
11	1	INCENDIARY, ARSON, CRIMINAL ACT
14	1	SUSPICIOUS
21	1	RECKLESS, FAILURE TO USE ORDINARY CARE
31	1	ABANDONED, DISCARDED HEAT SOURCE
50	1	MECHANICAL FAILURE, MALFUNCTION
54	2	OTHER PART FAILURE, LEAK, BREAK
82	4	EARTHQUAKE RELATED
92	1	REKINDLED FROM A PREVIOUS FIRE
93	1	EXPOSURE FIRE

Type of Material First Ignited (IGNTYPE)

This field describes the composition of the material that was first ignited by the heat source. This refers to the raw, common, or natural state in which the material exists, such as a gas, flammable liquid, chemical, plastic, wood, paper, fabric, etc. The numeric codes used for this data field are given below.

IGNTYPE	FREQUENCY	DESCRIPTION
0	204	NOT SPECIFIED
11	1	INCENDIARY, ARSON, CRIMINAL ACT
14	1	SUSPICIOUS
21	1	RECKLESS, FAILURE TO USE ORDINARY CARE
31	1	ABANDONED, DISCARDED HEAT SOURCE
50	1	MECHANICAL FAILURE, MALFUNCTION
54	2	OTHER PART FAILURE, LEAK, BREAK
82	4	EARTHQUAKE RELATED
92	1	REKINDLED FROM A PREVIOUS FIRE
93	1	EXPOSURE FIRE

Form of Material First Ignited (IGNFORM)

This field describes the use or purpose of the material that is first ignited in the fire. The numeric codes used in this data field are described below.

IGNFORM	FREQUENCY	DESCRIPTION
0	204	NOT SPECIFIED
12	1	EXTERIOR SIDEWALL COVERING
17	1	STRUCTURAL MEMBER, FRAMING
21	1	UPHOLSTERED SOFA, CHAIR, BENCH
32	1	BEDDING, BLANKET, SHEET, COMFORTER

IGNFORM	FREQUENCY	DESCRIPTION
44	1	MAGAZINE, NEWSPAPER, WRITING PAPER
65	3	FUEL
68	1	FILTER
75	1	RUBBISH, TRASH, WASTE
86	3	GAS OR LIQUID IN OR FROM PIPE OR CONTAINER

Contributing Factor 1 (CONFCT1)

This field describes an additional factor that had an influence on the cause and/or outcome of the incident. The numeric codes used in this data field are described below.

CONFCT1	FREQUENCY	DESCRIPTION
BLANK	214	NOT SPECIFIED
741	2	EARTHQUAKE

Contributing Factor 2 (CONFCT2)

This field describes any additional contributing factor.

Estimated Property Loss (PROLOSS)

The dollar estimate of the current value of the property (excluding contents) is given in this data field.

Estimated Contents Loss (CONLOSS)

The dollar estimate of the current value of contents is given in this data field.

Fuel Model (FUELMOD)

The type of fuel involved in a vegetation fire is described in this data field.

Acres Burned (ACRBURN)

This data field describes the land area, expressed in acres, burned by a vegetation fire.

Equipment Involved in Ignition (EQPTYPE)

This field describes any equipment that provided the heat that caused the ignition of a fire.

Construction Type (CONSTYP)

This field describes the type of building construction used in the structure where the fire occurred. Emphasis is on characteristics that determine the building's ability to withstand exposure to a fire and to limit fire growth. Numeric codes used in this data field are given below.

CONSTYP	FREQUENCY	DESCRIPTION
0	205	NOT SPECIFIED
3	1	TYPE III - EXTERIOR WALLS NON OR LIMITED COMBUSTIBLE MATERIAL; INTERIOR STRUCTURE COMBUSTIBLE
5	10	TYPE V - COMBUSTIBLE, WOOD FRAME BUILDING

Roof Covering (ROOFCVR)

This field describes the type of exterior roof covering on the structure involved in the fire. The numeric codes used in this data field are given below.

ROOFCVF	FREQUENCY	DESCRIPTION
0	205	NOT SPECIFIED
2	6	COMPOSITE SHINGLES
7	6	BUILT-UP

Number of Stories (STORYNO)

The total number of stories above grade in the structure are given in this field

Extent of Flame Damage (FLMDMG)

The size of the fire in terms of how far the flame damage extended is given in this field. The extent of flame damage is the area that was actually burned or charred. It does not include the area that received only heat, smoke, or water damage. The codes that were used in this field are given below.

FLMDMG	FREQUENCY	DESCRIPTION
0	205	NOT SPECIFIED
1	3	CONFINED TO THE OBJECT OF ORIGIN
2	3	CONFINED TO PART OF ROOM OR AREA OF ORIGIN
3	1	CONFINED TO ROOM OF ORIGIN
4	3	CONFINED TO THE FIRE DIVISION COMPARTMENT OF ORIGIN
6	1	CONFINED TO STRUCTURE OF ORIGIN
7	2	EXTENDED BEYOND STRUCTURE OF ORIGIN

Extent of Smoke Damage (SMKDMG)

This field describes the size of the fire in terms of how far smoke and heat damage extended. This includes areas scorched by heat and damaged by smoke, but which do not have flame damage. The numeric codes used in this data field are described below.

SMKDMG	FREQUENCY	DESCRIPTION
0	205	NOT SPECIFIED
1	2	CONFINED TO THE OBJECT OF ORIGIN
2	1	CONFINED TO PART OF ROOM OR AREA OF ORIGIN
3	2	CONFINED TO ROOM OF ORIGIN
4	1	CONFINED TO THE FIRE DIVISION COMPARTMENT OF ORIGIN
5	1	CONFINED TO STORY OR ORIGIN
6	2	CONFINED TO STRUCTURE OF ORIGIN
7	2	EXTENDED BEYOND STRUCTURE OF ORIGIN
8	1	NOT SPECIFIED

Type of Material Generating Most Smoke (SMKTYPE)

The composition or substance of the material that produce the most smoke is given in this data field. The numeric codes used here are described below.

SMKTYPE	FREQUENCY	DESCRIPTION
0	210	NOT SPECIFIED
20	1	FLAMMABLE, COMBUSTIBLE LIQUID
43	1	FLEXIBLE PLASTICS
63	1	SAWN WOOD
67	1	PAPER
71	1	MAN-MADE FABRIC, FIBER, FINISHED GOODS
72	1	COTTON, RAYON, COTTON FABRIC, FINISHED GOODS

Form of Material Generating Most Smoke (SMKFORM)

This data field describes the use or purpose of the material that produced the most smoke. The numeric codes used in this data field are described below.

SMKFORM	FREQUENCY	DESCRIPTION
0	210	NOT SPECIFIED
19	1	OTHER STRUCTURAL COMPONENT OR FINISH
31	2	MATTRESS, PILLOW
33	1	LINEN, OTHER THAN BEDDING
44	1	MAGAZINE, NEWSPAPER, WRITING PAPER
65	1	FUEL

Avenue of Smoke Travel (SMKTRVL)

This data field describes the path or opening that allowed smoke to travel beyond the room or area of origin. The codes used in this data field are given below.

SMKTRVL	FREQUENCY	DESCRIPTION
0	212	NOT USED
5	1	OPENING IN CONSTRUCTION
7	3	DOORWAY, PASSAGEWAY

Type of fire/smoke detector (DETTYPE)

This data field specifies the type of early warning fire/smoke detector(s) installed in the involved structure. Numeric codes use in this data field are described below.

DETTYPE	FREQUENCY	DESCRIPTION
0	214	NOT SPECIFIED
1	1	SMOKE DETECTOR, IONIZATION PRINCIPLE
8	1	NO DETECTOR PRESENT

Detector power supply (DETPOWR)

This field describes the source of power used to operate the fire/smoke detector. The numeric codes used in this field are given below.

DETPOWR	FREQUENCY	DESCRIPTION
0	215	NOT SPECIFIED
1	1	BATTERY OPERATED

Performance of Detector System (DETPERF)

This field describes the detection and performance of detection system equipment. Numeric codes used in this data field are described below.

DETPERF	FREQUENCY	DESCRIPTION
0	215	NOT SPECIFIED
1	1	DETECTOR IN ROOM OF FIRE ORIGIN, AND IT ALERTED OCCUPANTS

Reason for Failure of Detector (DETFAIL)

This field describes the specific reason the detector did not operate.

Type of Extinguishing System (EXTTYPE)

This data field describes the type of automatic extinguishing system present in or near the area of fire origin. This numeric codes used in this data field are described below.

EXTTYPE	FREQUENCY	DESCRIPTION
0	215	NOT SPECIFIED
98	1	NO EXTINGUISHING SYSTEM

Performance of Extinguishing System (EXTPERF)

This data field describes the operation and effectiveness of the automatic extinguishing system.

Reason for Failure of Extinguishing System (EXTFAIL)

This data field describes the condition that prevented the automatic extinguishing system from operating properly. This includes failing to extinguish the fire even though the system operated.

Sprinkler Head Type (SPKLTYP)

The type of sprinkler head used in the automatic sprinkler system existing in the portion of the building affected by the fire is described by this data field.

Number of Sprinkler Heads Activated (SPKLACT)

This data field records the number of sprinkler heads that operated during the fire.

Table 3-1: LAFD INCIDENT REPORTS, JANUARY 7, 1994 (EARTHQUAKE-RELATED FIRES ONLY)

IKEY	AT	SCNE_TIME	TYPE_INC	LOCATION	CEN_TRACT	USE_GEN	AGT_APT_T	KNK_DWN_T	AREA_ORIG	FORM_IGN	IGN_FACT	CONTRIB_1
9401170101	04.36.38	04.42.00	11	1118 W 3RD ST	3202000	41	444	630	26	36	82	399
9401178100	04.53.10	04.53.00	12	15455 N GLENOAKS BL	1064020	41			71	21	82	804
9401178138	04.58.50	05.10.00	11	11742 LUANDA ST	1043000	41			0	0	82	
9401178045	05.08.02	05.10.00	11	21601 SAN JOSE ST	1132130	41	444	449	47	30	82	
9401178172	05.12.36	05.35.56	11	19443 W VENTURA BL	1394000	0	441	520	0	0	82	804
9401170154	05.19.20	05.32.43	11	365 W 47TH PL	2319000	41	455	515	24	14	82	804
9401170180	05.26.08	05.28.37	11	10949 N MCVINE AV	1031000	41	515	525	47	14	82	480
9401178040	05.27.10	05.27.00	11	15445 COBALT AV	1064020	41	505	0	62	14	82	720
9401170227	05.27.30	05.33.00	11	2741 S PALM GROVE AV	2196000	41			71	14	82	720
9401170245	05.46.06	05.50.00	11	7655 N DELIA AV	1222000	41			0	0	82	
9401178273	05.59.54	06.04.00	12	8801 N ETON AV	1132030	41	535	600	25	14	82	206
9401170275	06.13.00	06.30.00	11	8901 N ETON AV	1132030	41			0	0	82	
9401170310	14.27.00	14.31.10	11	5842 W HAROLD WY	1910000	41	535	555	21	21	66	804
9401170315	15.01.22	15.02.22	17	11700 N BALBOA BL	1111000	96	500	700	99	36	82	804
9401170317	15.40.24	15.44.00	11	2324 S CHARITON ST	2703000	41	534	544	14	14	82	804
9401178059	16.12.42	16.20.00	11	20033 N GYPSY LN	1375040	41	532	540	47	14	82	804
9401178027	16.40.24	16.47.00	11	3845 N BOBSTONE DR	1417000	41	538	630	21	36	82	
9401170389	17.22.40	17.27.02	11	7820 W DELONGPRE AV	1944000	41	552	512	14	81	54	804
9401170436	18.26.56	18.36.18	11	1622 N SERRANO AV	1904000	42	610	615	75	33	82	804
9401178009	18.28.04	18.28.00	12	215005 LASSEN ST	1132130	41	604	700	0	0	82	804
9401170480	18.37.10	18.47.00	17	634 W OMELVENY AV	1095000	96	635	800	92	48	82	804
9401177004	19.00.00	08.00.00	11	2400 S BEVERLY DR	2695000	41	632	640	62	15	82	804
9401175006	19.17.48	19.23.10	11	10763 N FORBES AV	1111020	41	630	645	47	14	82	804
9401176013	19.23.06	19.31.50	11	3024 S LIVONIA AV	2697000	42			21	46	82	
9401176022	19.42.26	19.48.52	11	42082 S 10TH AV	2343000	41			21	34	82	
9401176030	19.52.54	20.00.10	11	1340 W EXPOSITION BL	2226000	41	646	700	74	35	82	202
9401175035	20.21.44	20.37.36	11	10630 N LOUISE AV	1113010	41			0	0	82	804
9401176059	21.49.16	21.57.58	11	4230 S 11TH AV	2343000	96			73	0	82	
9401178207	22.11.24	22.23.36	11	9250 OWENSMOUTH AV	1132020	89			41	0	82	
9401176096	22.19.04	22.24.20	11	18111 W NORDHOFF ST	1151020	21	820	845	31	72	82	480
9401178243	22.22.44	22.26.00	11	NORDHOFF / VANALDEN	1152020	41			41	43	82	
9401178110	22.32.38	22.42.26	11	18111 W NORDHOFF ST	1151020	21	915	930	31	72	82	480
9401177080	22.52.34	22.57.22	11	7138 W GREELEY ST	1012000	42			24	46	82	
9401178091	22.55.24	23.00.00	11	1818 S STONER	2672000	42			21	32	82	
9401176129	23.14.52	23.21.44	11	10157 WISNER AV	1096020	41			24	14	82	
9401176134	23.27.06	23.41.48	11	2517 W 54TH ST	2346000	42			14	15	54	804
9401175085	17.32.00	17.37.00	11	9108 W 25TH ST	2697000	41			75	0	82	
9401177098	06.27.00	06.28.00	11	6132 W DE LONGPRE AV	1908000	42	944	1005	62	81	82	804
9401177103	06.52.00	07.41.00	11	2421 N CRESTON WY	1896000	41	1010	1030	21	36	53	804
9401176172	09.18.00	09.25.00	17	18100 W STRATHERN ST	1314000	61	1002	1025	92	17	82	804
9401176181	10.45.00	10.45.00	11	2134 W 54TH ST	2325000	41			24	34	82	
9401176200	12.59.00	13.28.00	11	17609 W VENTURA BL	1395000	59			62	81	82	804
9401175131	06.31.00	06.35.00	11	4500 N WOODMAN AV	1246000	42	1048	1055	24	14	82	804
9401176218	06.37.00	06.45.00	11	14225 W VENTURA BL	1412000	59			51	0	82	
9401176226	06.43.00	06.45.00	17	4618 N SYLMAR AV	1412000	92			94	35	58	804
9401176235	07.09.00	07.12.00	11	12036 W VENTURA BL	1436020	16			25	34	82	
9401176250	08.02.00	08.05.00	11	14569 W BENEFIT ST	1413010	42			24	46	82	
9401177175	08.56.00	09.01.00	11	10885 N JAMIE ST	1041020	88			47	0	82	
9401176257	08.59.00	09.07.00	11	7237 N ANATOLA AV	1319000	41	1203	1205	21	34	82	804
9401177053	09.57.00	10.00.00	11	17515 W ENADIA WY	1319000	41	1233	1250	47	34	82	804

Table 3-1: LAFD INCIDENT REPORTS, JANUARY 7, 1994 (EARTHQUAKE-RELATED FIRES ONLY) (Cont.)

IKEY	AT	SCNE_TIME	TYPE_INC	LOCATION	CEN_TRACT	USE_GEN	AGT_APT_T	KNK_DWN_T	AREA_ORIG	FORM_IGN	IGN_FACT	CONTRIB_1
9401176281	10.07.00	10.15.00	17	8000 N LINDLEY AV	1314000	96			92	0	82	
9401175193	10.32.00	10.42.00	11	17221 W WILLARD ST	1311000	41			0	0	82	
9401170681	10.53.00	11.07.00	11	6660 N RESEDA BL	1327000	59	1435	1435	25	14	82	
9401170721	11.01.00	11.05.00	11	10490 N ILEX AV	1046000	59	1506	1530	38	32	53	804
9401170779	11.11.00	11.15.00	11	9740 N TUNNEY AV	1133010	41	1615	1626	0	0	82	804
9401170832	11.45.00	11.50.00	11	14005 W VENTURA BL	1412000	51			0	0	82	
9401170883	12.02.00	12.06.00	11	154252 W SHERMAN WY	1273000	42	1650	1653	73	32	82	
9401170964	12.45.00	13.08.00	11	14424 W TERRA BELLA ST	1193000	41	1729	1735	21	44	82	
9401171712	06.26.00	06.31.00	11	4360 N VENTURA CANYON AV	1411000	42	1734	1758	47	32	82	804
9401171074	12.30.00	12.31.00	11	7651 N RESEDA BL	1314000	42	1840	1841	22	33	82	724
9401171077	08.46.00	08.49.00	12	154419 HORACE ST	1093000	96			0	0	82	
9401171093	09.28.00	09.40.00	16	15831 W OLDEN ST	1065002	96	1855	1905	92	45	82	
9401171122	09.37.00	10.00.00	11	14037 W VENTURA BL	1412000	79			0	0	82	
9401171145	12.00.00	12.05.00	11	662631 N HAYVENHURST AV	1321000	42	1918	1919	21	46	82	804
9401171155	06.00.00	06.03.00	11	19603 W TURTLE SPRINGS WY	1081001	41			23	65	82	
9401171177	05.33.00	05.37.00	11	566 N KINGSLEY DR	1925000	42			62	14	54	804
9401171186	05.00.00	05.00.00	11	10845 N BURNET AV	1094000	41	2002	2005	74	81	82	720
9401171242	04.40.00	04.40.00	11	1725 N CLEAR VIEW DR	2611023	88	2038	2042	47	14	54	804
9401171345	05.30.00	05.35.00	11	890021 N TOPANGA CANYON BL	1132030	42	2202	2204	24	46	82	804
9401171379	08.50.00	08.54.00	11	184003 W MALDEN ST	1154020	42	2215	2220	14	33	82	804
9401171389	04.37.00	04.35.00	11	17730 W LASSEN ST AV	1151010	42	2226	2245	21	44	82	804
9401171398	08.45.00	08.45.00	11	119 E ANCHORAGE ST	2739000	42	2228	2232	14	32	82	804
9401171411	04.37.00	04.52.00	11	21213 W LASSEN ST	1133020	42			24	33	53	804
9401171436	04.40.00	04.40.00	11	75027 N CANBY AV	1314000	42	2300	2304	21	33	53	804
9401171442	07.55.00	08.00.00	11	7624 N GOODLAND AV	1216000	41	2305	2335	71	30	53	804
9401171467	08.16.00	08.20.00	19	18309 W HALSTED ST	1152010	92	2323	2325	94	33	54	804
9401171483	05.19.00	05.32.00	11	21617 W SATICOY ST	1343010	42	2349	2353	76	32	58	804

Table 3-1: LAFD INCIDENT REPORTS, JANUARY 7, 1994 (EARTHQUAKE-RELATED FIRES ONLY) (Cont.)

TYPE_MAT	FORM_MAT	EQUIP_TYPE	MOB_TYPE	MOB_MAKE	FORM_MSPRD	TYPE_MSPRD	TRVL_FACT	AVE_FIRE	AVE_SMOKE	CONST_TYPE	IKEY	FLRS_STRUCT
72	34	98			12	63			8	5	9401170101	1
11	12	98	17		12	65					9401178100	1
0	0	98			17	63			7	5	9401178138	1
0	0	98								3	9401178045	1
0	50	98			0	0			0	5	9401178172	1
14	86	98			15	69			7	5	9401170154	1
67	44	98			44	67	22	7	5	5	9401170180	1
11	65	98			96	11	44	2	8	5	9401178040	1
11	65	43			0	0			7	5	9401170227	2
0	0	98			99	99			6	5	9401170245	1
66	11	98	17		77	39			7	5	9401178273	1
0	0	98			0	0			0	4	9401170275	1
72	32	98			32	72		1	1	5	9401170310	2
11	86	1			86	11	79	9	8		9401170315	0
11	86	13			17	63		7	7	5	9401170317	1
11	65	12							5	5	9401178059	2
11	65	98			66	11			5	5	9401178027	2
63	17	13							4	5	9401170389	2
43	61	98								5	9401170436	2
0	0	98	17							5	9401178009	1
25	86	98			65	25	42	7	7	5	9401170480	0
63	17	12			11	63			7	5	9401177004	1
0	0	12			15	11				5	9401175006	1
0	0	98								5	9401176013	1
0	0	98								5	9401176022	1
11	17	98			17	11			8	5	9401176030	1
0	0	98			15	63	29	1	1	5	9401175035	1
0	0	98								5	9401176059	1
0	0	98			99	11			8	4	9401178207	1
99	23	98							5	1	9401176096	3
0	0	98								5	9401178243	1
99	23	98							5	1	9401178110	3
0	0	98								5	9401177080	1
0	0	98								5	9401178091	2
0	0	98			15	65			8	5	9401176129	1
69	15	98								5	9401176134	2
0	0	98								5	9401175085	1
62	62	98			26	36			3	5	9401177098	2
93	75	98			75	93			1	5	9401177103	1
11	99	98									9401176172	0
0	0	98								5	9401176181	2
11	65	98					98		8	1	9401176200	3
41	26	98								5	9401175131	4
0	0	98								5	9401176218	2
63	72	98									9401176226	0
0	0	98								5	9401176235	1
0	0	98								5	9401176250	1
0	0	98								5	9401177175	1
71	32	98							7	5	9401176257	1
0	0	98			11	63		1	5	5	9401177053	1

Table 3-1: LAFD INCIDENT REPORTS, JANUARY 7, 1994 (EARTHQUAKE-RELATED FIRES ONLY) (Cont.)

CONTRIB_2	TYPE_MAT	FORM_MAT	EQUIP_TYPE	MOB_TYPE	MOB_MAKE	FORM_MSPRD	TYPE_MSPRD	TRVL_FACT	AVE_FIRE	AVE_SMOKE	CONST_TYPE	IKEY
	0	0	98									9401176281
	11	86	98			11	11			1	5	9401175193
	11	65	98								5	9401170681
	43	61	98							7	5	9401170721
	0	0	98			11	63			5	5	9401170779
	0	0	98			97	97			7	5	9401170832
	62	17	98								5	9401170883
	72	32	46							7	5	9401170964
223	62	17	98			14	63			7	5	9401171712
	71	14	98								5	9401171074
	0	0	98	17		0	0			1		9401171077
	93	75	98									9401171093
	0	0	98			34	72			7	5	9401171122
302	71	32	98							7	5	9401171145
	0	0	98								5	9401171155
	62	17	98								5	9401171177
	11	86	98								5	9401171186
	23	65	98							8	5	9401171242
	99	79	59								5	9401171345
	71	61	98								5	9401171379
	72	32	98							8	5	9401171389
	77	21	98								5	9401171398
	43	61	58								5	9401171411
	71	32	98							2	5	9401171436
524	63	17	98			17	63	20	1	5	5	9401171442
	5	74	98									9401171467
	63	13	98			12	63				5	9401171483

Table 3-1: LAFD INCIDENT REPORTS, JANUARY 7, 1994 (EARTHQUAKE-RELATED FIRES ONLY) (Cont.)

DET_SYS	EXT_SYS	PROP_STAT	FIRE_DMGE	SMOKE_DMGE	WATER_DMGE	CNTL_DMGE	PROP_LOSS	CONT_LOSS	WSHED_LOSS
		12	9	9	9	7	75000	25000	0
		12	6	8	8		3480000	580000	0
		12	6	6	6	6	100000	70000	0
		12	1	1	1		35000	15000	0
		13	6	6	6		200000	50000	0
		12	6	6	6	6	100000	40000	0
		14	6	6	6	6	100000	50000	0
		12	6	8	8	6	1000000	0	0
		12	6	6	6	6	250000	100000	0
		1	6	6	6		100000	0	0
		12	6	6	6		50000	25000	0
		1	6	6	6		50000	0	0
		14	6	6	6	6	10000	0	0
			7	9	9		10000	0	0
		12	6	6	6	6	170000	30000	0
		14	1	6	1		100000	50000	0
		12	6	6	6		350000	50000	0
		12	3	6	3	3	3000	2000	0
		12	2	2	2		2000	0	0
		12	1	1	1	1	100000	40000	0
		11	9	9	9	7	500000	0	0
		12	4	4	4	4	25000	0	0
		13	6	8	8	8	160000	50000	0
		12	1	1	1		1000	0	0
		12	1	1	1		1500	0	0
		12	7	7	7	7	150000	5000	0
		12	7	0	0		150000	0	0
		12	1	1	1		2000	0	0
		12	6	6	9		200000	300000	0
		43	3	5	3	3	40000	10000	0
		11	1	1	1		15000	10000	0
		43	3	5	3	3	40000	10000	0
		12	1	1	1		100	0	0
		12	3	3	3		5000	2000	0
		12	6	6	6		75000	25000	0
		11	1	1	1		200	0	0
		12	1	1	1		5000	0	0
		12	6	6	6	6	50000	10000	0
		14	6	6	6		10000	2000	0
			1	8	8	8	100	0	0
		12	1	1	1		280	0	0
	21	13	3	3	6	3	5000	1000	0
		14	3	3	3	3	1000	500	0
		12	1	1	1		6900	0	0
			1	1	1		1000	0	0
		12	1	1	1		30000	0	0
		12	1	1	1		1	1	0
		12	3	3	3		10000	0	0
		12	3	3	3	8	50000	25000	0
		12	6	6	6	6	80000	25000	0

Table 3-1: LAFD INCIDENT REPORTS, JANUARY 7, 1994 (EARTHQUAKE-RELATED FIRES ONLY) (Cont.)

DET_SYS	EXT_SYS	PROP_STAT	FIRE_DMGE	SMOKE_DMGE	WATER_DMGE	CNTL_DMGE	PROP_LOSS	CONT_LOSS	WSHED_LOSS
			1	1	1		2500	0	0
		12	6	6	6	6	50000	0	0
4149		13	3	8	8	8	3000	0	0
		14	3	6	6		20000	100000	0
		1	6	6	6		30000	15000	0
		13	6	6	6		1500000	750000	0
		14	3	3	3	4	50000	0	0
		14	3	5	3	3	5000	2000	0
		12	6	6	8	8	24000	8000	0
		12	2	3	3		4000	2000	0
		12	6	6	6		30000	0	0
			8	8	8	8	0	0	0
		13	6	6	6		100000	40000	0
		12	2	4	8	8	150	0	0
		12	1	1	1		1000	0	0
		12	2	8	8		300	0	0
		12	2	8	8	2	25000	0	0
		14	2	3	8	8	1000	17000	0
2121		12	2	3	2	2	7000	3000	0
		14	2	3	2	3	500	500	0
		11	2	2	2		10000	0	0
		14	3	3	3	3	20000	15000	0
2114		12	1	2	8	8	450	50	0
4131		12	2	4	2	2	1000	5000	0
		14	6	6	6	6	35000	15000	0
			1	8	8		0	0	0
		11	5	1	5	5	1	0	0

Table 3-2: SANTA MONICA FIRE DEPARTMENT (EARTHQUAKE-RELATED) INCIDENT REPORTS

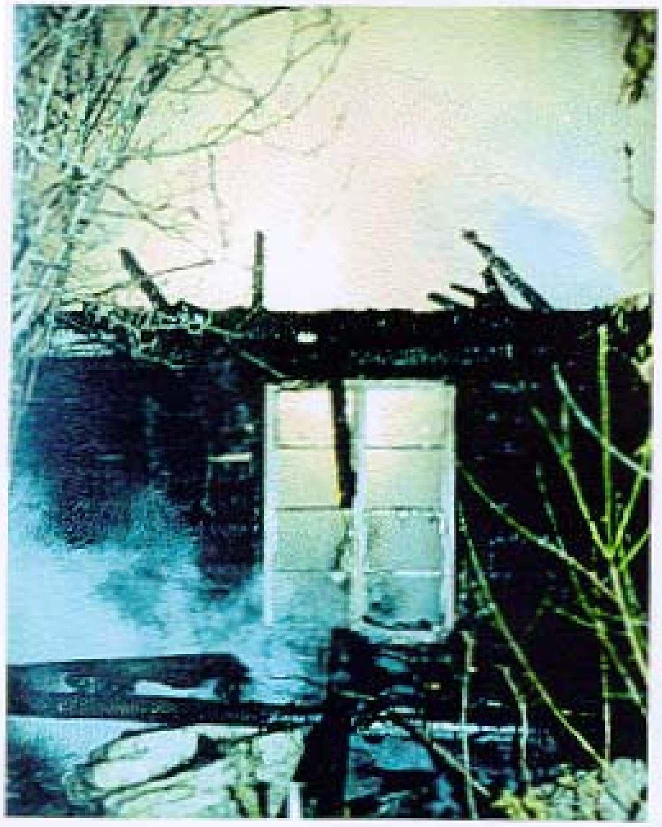
FDID1	PROYEAR	INCNUM	INCEXP	CORREC	MULTAGY	INCDATE	DISTIME	ARVTIME	ENDTIME	FOUND1	FOUND2	FOUND3	FOUND4	AIDTYPE	ALARMTH	INCADDR	INCROOM	INCZIP	GENERAL	SPECIES	OCCUPCY	STRUCTP	STRUCST	FDID1	PROYEAR
19180	94	9400000311	0	1		940117	236	239	400	11				8	7	01255 20TH ST SANTA MONICA		90404	92	929	R10	1	5	19180	94
19180	94	9400000317	1	1		940117	451	455	1030	11				8	7	00914 14 ST SANTA MONICA		90403	42	424	R10	1	2	19180	94
19180	94	9400000317	2	1		940117	451	455	1030	11				8	7	01324 IDAHO SANTA MONICA		90403	42	422	R10	1	2	19180	94
19180	94	9400000317	3	1		940117	451	455	1030	11				8	7	00909 EUCLID SANTA MONICA		90403	42	422	R10	1	2	19180	94
19180	94	9400000317	0	1		940117	451	455	1030	11				8	7	00908 14 ST SANTA MONICA		90403	42	424	R10	1	2	19180	94
19180	94	9400000319	0	1		940117	511	512	636	11				8	7	01446 07 ST SANTA MONICA		90401	42	422	R10	1	2	19180	94
19180	94	9400000361	0	1		940117	801	806	849	11				8	7	00838 09 ST SANTA MONICA		90403	42	422	R10	5	2	19180	94
19180	94	9400000479	0	1		940117	1433	1437	1630	11				8	7	00908 14 ST SANTA MONICA		90403	42	423	R10	1	2	19180	94
19180	94	9400000492	0	1		940117	1545	1546	1550	11				8	7	00457 LINCOLN BL SANTA MONICA		90402	41	411	R30	1	2	19180	94
19180	94	9400000514	0	1		940117	1844	1848	1935	11				8	7	00829 PACIFIC ST SANTA MONICA	2	90405	41	410	R10	1	2	19180	94
19180	94	9400000518	0	1		940117	1913	1918	2000	11				8	7	01339 03 ST SANTA MONICA		90401	59	591	B20	1	2	19180	94
19180	94	9400000519	0	1		940117	1955	1958	2041	16				8	7	03400 PICO BL SANTA MONICA		90405	96	962				19180	94
19180	94	9400001500	0	1		940117	330	331	345	11				8	6	02030 WILSHIRE BL SANTA MONICA		90403	16	163	B20	1	1	19180	94
19180	94	9400001118	0	1		940117	1200	1203	1230	11				8	7	03232 BROADWAY SANTA MONICA		90404	42	424	R10	1	2	19180	94

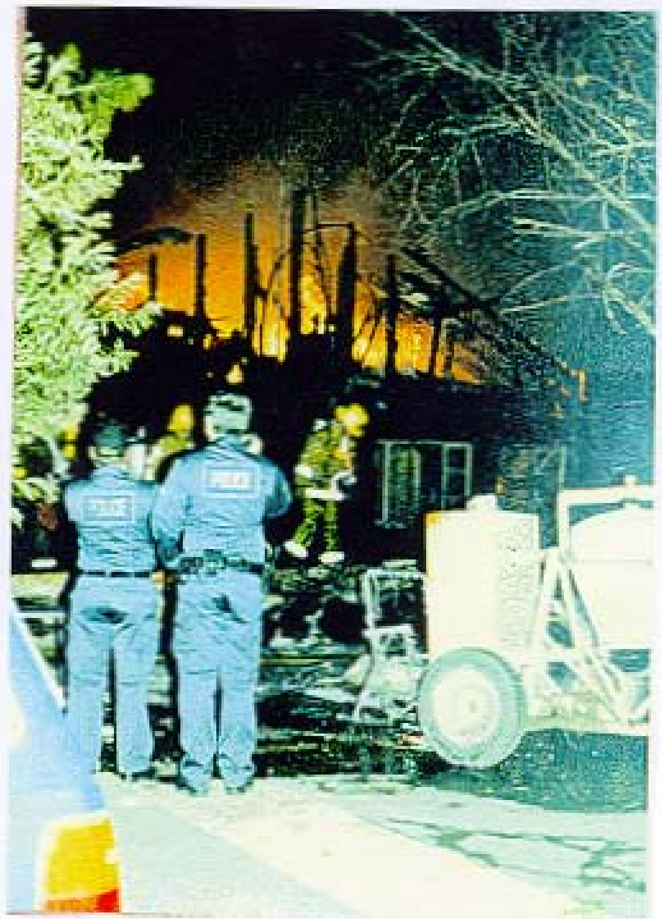
Table 3-2: SANTA MONICA FIRE DEPARTMENT (EARTHQUAKE-RELATED) INCIDENT REPORTS

INCNUM	OCCTIME	ACTION1	ACTION2	ACTION3	ACTION4	ORGAREA	ORGLEVL	DISTANC	HEATFRM	IGNFACTR	IGNTYPE	IGNFORM	CONFCT1	CONFCT2	PROLOSS	CONLOSS	FUELMOD	ACRBURN	EQPTYPE	CONSTYP	ROOFCVR	STORYNO	FLMDMG	SMKDMG	SMKTYPE	SMKFORM	SMKTRVL	DETTYPE	DETPOWR	DETPERF	DETFAIL	EXTTYPE	EXTPERF	EXTFAIL	SPKLTYP	SPKLACT
9400000311	2	12				21	A02	0	63	31	71	21			0	0		0	0	5	2	2	4	6	72	31	5	0	0	0	0	0	0	0	0	0
9400000317	2	15				76	A02	0	81	93	63	12			10000	2000		0	0	5	2	2	3	5	0	0	0	0	0	0	0	0	0	0	0	0
9400000317	2	15				76	A01	0	81	93	63	12			10000	2000		0	0	5	2	2	3	5	0	0	0	0	0	0	0	0	0	0	0	0
9400000317	2	15				76	A01	0	81	93	63	12			10000	2000		0	0	5	2	2	4	5	0	0	0	0	0	0	0	0	0	0	0	0
9400000317	2	15				79	A02	0	81	82	11	86			400000	100000		0	0	5	7	2	7	7	0	0	0	0	0	0	0	0	0	0	0	0
9400000319	1	15				71	A01	0	41	82	11	65			90000	50000		0	0	5	7	1	6	6	63	19	0	0	0	0	0	0	0	0	0	0
9400000361	1	15				21	A02	0	39	54	11	65			10000	5000		0	0	5	7	2	4	4	43	31	0	0	0	0	0	0	0	0	0	0
9400000479	2	15				79	A01	0	45	92	63	17			0	0		0	0	5	7	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0
9400000492	2	14				24	A01	0	17	54	11	86	741		20000	100		0	0	5	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
9400000514	1	71	12			14	A02	0	66	21	71	32			300	50		0	0	5	2	2	2	3	71	33	7	1	1	1	0	0	0	0	0	0
9400000518	2	15				62	A30	0	30	50	50	68			250	0		0	0	3	7	3	1	8	0	0	0	8	0	0	0	98	0	0	0	0
9400000519		15				92	A01	10	0	14	67	75			0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9400001500		71				5	A01	5	69	11	20	65			100	0		0	0	5	2	1	1	1	20	65	7	0	0	0	0	0	0	0	0	0
9400001118	1	71				14	A02	0	15	82	67	44	741		1000	500		0	0	5	2	2	2	3	67	44	7	0	0	0	0	0	0	0	0	0

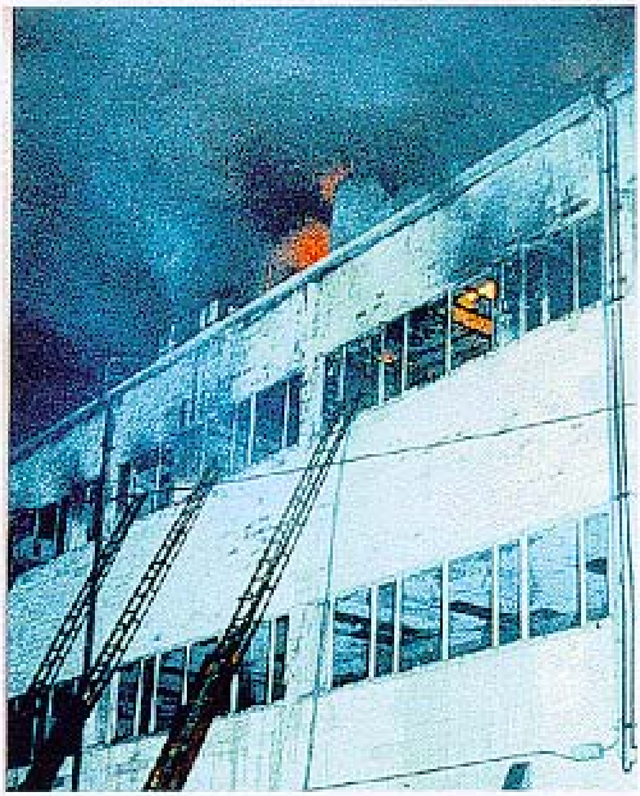
3.3 PHOTOGRAPHS

A selection of photographs pertaining to earthquake-related fires and fire department operations is given in the following section. All photographs are courtesy of the City of Los Angeles Fire Department.





3-1 (left) and 3-2 (right): Fire in wood-frame dwelling (location unidentified)



3-3 (top) and 3-4 (bottom):

Commercial office building fire, Ventura Blvd., Sherman Oaks

3-5: Multiple structure fire spread, 18110 Andrea Circle North, North San Fernando Valley. (Loss: 17 units, 3 buildings, ~ $500,000; cause: gas meter damage)

3-6: Broken water and gas mains on Balboa Boulevard in an area of extensive ground failures possibly caused by faulting. The broken gas main (foreground) ignited and caused a fire that burned down five houses and damaged several more.

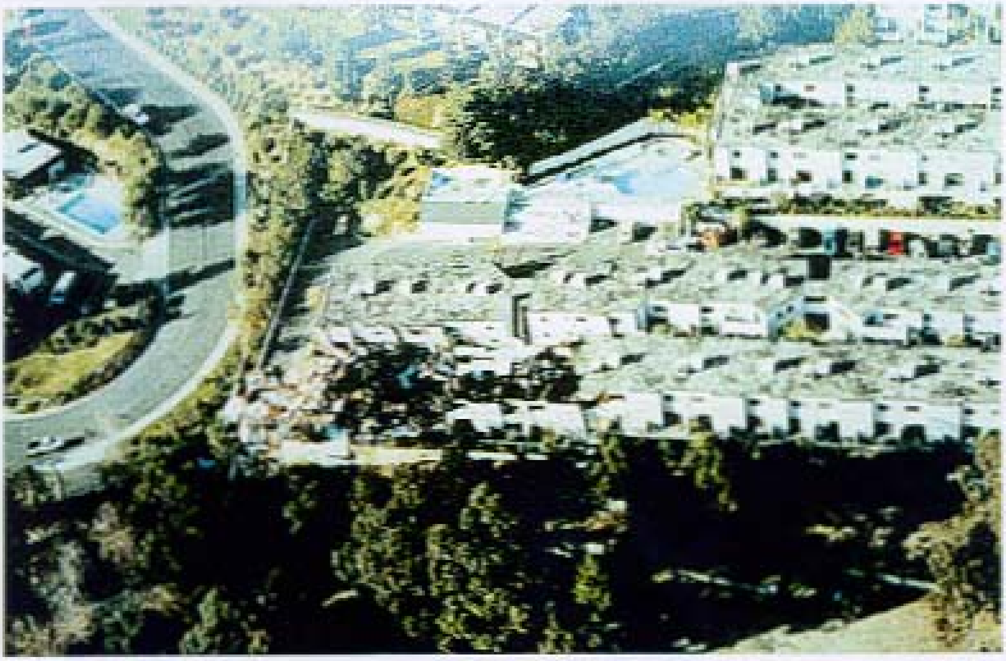
3-7: This fire on Balboa Boulevard in Granada Hills destroyed several homes and was caused by an unusual sequence of events. Adjacent water and gas mains broke because of ground failure (possible faulting). According to eyewitness, the truck stalled because of the flooding, and when the driver attempted to restart the vehicle, the leaking gas was ignited.

3-8: Burning gas main on Balboa Boulevard, Granada Hills, January 18, 1994.

3-9: The remains of a few of the homes destroyed by the fire on Balboa Boulevard.

3-10: Collapsed 2-story condominium with fire in debris, 11611 Blucher Ave., Granada Hills.

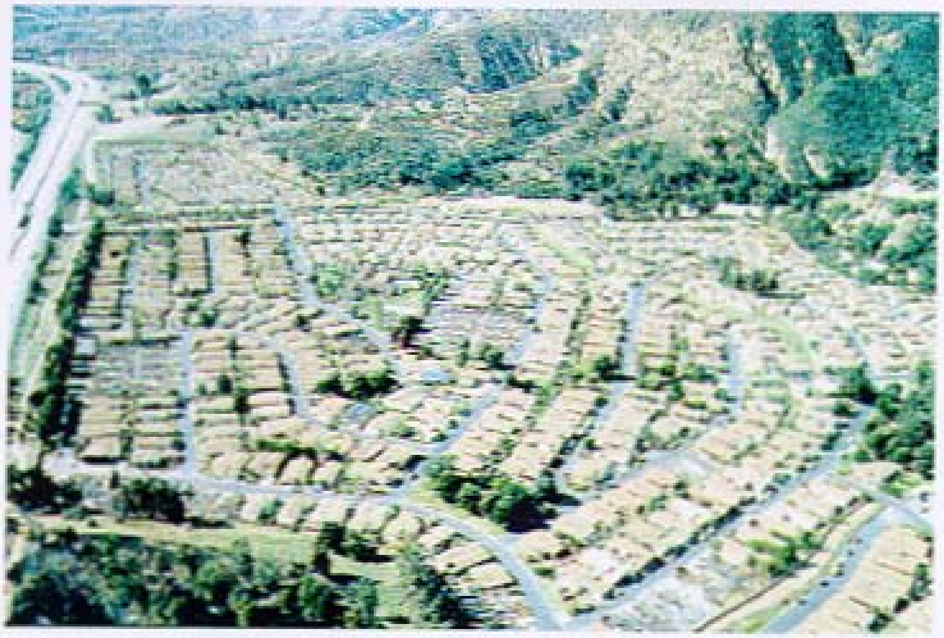
3-11: Roof area of collapsed condominium, Granada Hills.



3-12: Aerial view, collapsed condominium, Granada Hills.

3-13: Total collapse of end units of condominium, Granada Hills.

3-14: Structure fire, California State University, Northridge, Science Building



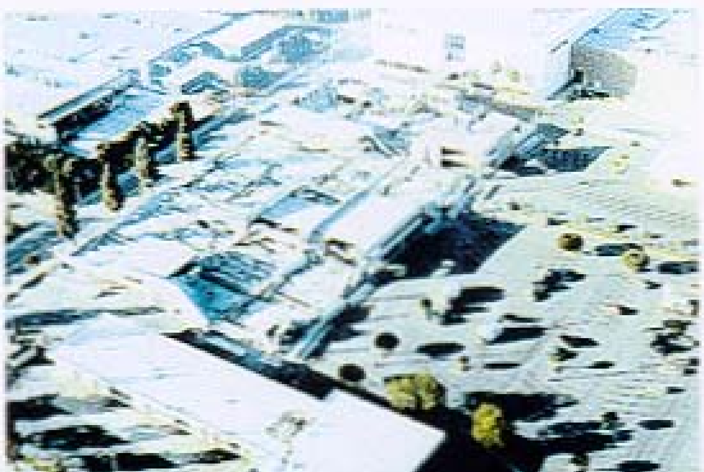
3-15: The large mobile home in San Fernando had at least five separate fires, all caused by mobile homes coming off of their foundations and severing gas lines. The rate of ignitions in mobile home parks was much higher than for housing developments. The rate is higher because in some mobile home parks, as many as 95% of the homes collapsed off their supports.

3-16: The remains after a fire in a mobile home development that destroyed at least 36 homes, 15445 Glen Oaks Blvd.

3-17: Residential fire in 18500 block of Strathern St., Reseda, approximately 11AM January 19 (two days after the earthquake). Fire fighters were still hampered by lack of water in the neighborhood to fight the fire. The only water available to fight this fire was from water tenders (tanker trucks) supplied by the Riverside County Fire Department. (Photo: S.P. Harris, EQE)

3-18: 9565 Reseda Blvd., Northridge Meadows Apartment, briefing Urban Search and Rescue Teams

3-19 (top) and 3-20 (bottom): Northridge Meadows Apts. collapse of structure from soft first story parking garage. Three story building, 16 killed, hundreds rescued, 9565 Reseda Blvd.



3-21 (top) and 3-22 (bottom): 9301 Tampa Avenue, Northridge Fashion Center three-story parking structure—rescue of one trapped person.

3-23A (top) and 3-23B (bottom): Train derailment at Tampa and Nordhoff.

3-23C: Train derailment at Tampa and Nordhoff, 20 cars, one leaked 1,500 gallons of sulfuric acid

3-23D: These tank cars containing sulfuric acid derailed during the earthquake. Only one leaked.

4. ANALYSIS

4.1 INTRODUCTION

This section presents selected results from analyses of the data compiled in this project and presented in the previous section.

4.2 GEOGRAPHIC AND TEMPORAL DISTRIBUTION OF IGNITIONS

Los Angeles FD

The Northridge earthquake reportedly caused or was a contributing factor in 77 fires in the LAFD service area. These earthquake-related fires are located on the map in Figure 4-1. The 77 fires were among a total of 161 fires that occurred on the day of the earthquake.

The time line in Figure 4-2 shows all calls for assistance with fires on the day of the earthquake. Earthquake-related fires predominate the calls for the first three hours. During the remainder of the day, the earthquake is a factor in almost one half of the fires. The presence of aftershocks, the shifting of damaged structures, and the turning off and on of utilities as a result of the initial shock had apparently caused new fires to occur.

Santa Monica Fire Department

As previously stated, the city of Santa Monica suffered a relatively large number of earthquake-related fires. Fifteen fires were reported after 4:31 AM on January 17, and, according to the incident reports, four of these fires were directly caused by the earthquake. The map in Figure 4-1 shows the location of these fires. The major fire that resulted in almost half of the property loss for all SMFD fires ($1.2 million by the fire department's estimate) was an apartment house fire that spread to adjacent buildings. The cause of the fire was reported to have been the ignition of natural gas escaping from lines ruptured by the movement and partial failure of the building. A photograph of the damage is shown in Photo 4-1.

A time line of incident reports on the day of the earthquake is shown in Figure 4-5, from 4:31 until midnight. The large number of dispatches at mid morning were mostly hazardous condition calls due to the reported leakage of natural gas. Hazardous condition dispatches and other public service assistance account for over 75% of the dispatches. The breakdown of the day's calls into dispatches categories is shown in Figure 4-6. Note that Emergency Medical Service (EMS) accounts for only 3% of all dispatches.

4.3 PATTERNS OF IGNITION - SOURCES AND LOCATIONS

Structural fires predominate (86%) the LAFD earthquake-related fires, Figure 4-7. As noted above, each report of a mobile home fire may actually involve multiple structures, since a single report may have been written for an entire mobile home park consisting of multiple burn sites. Fires classified as "outside" include the incident on Balboa Boulevard in Granada Hills where ground movement broke gas and water mains beneath the street, igniting the escaping gas and causing fires in five surrounding homes (an aerial photograph of the burned area is shown in Photo 3-12).

More than 70% (66) of the earthquake-related fires occurred in single- or multiple-family residences, as might be expected from the building stock that is typical in the San Fernando Valley. The general property use for locations that suffered earthquake-related fires is given for all 77 locations in Table 4-1.

The area of origin of the earthquake-related fires could be identified in 66 of the cases. The more common locations shown in Figure 4-8 are typical for the residential building stock of buildings that was effected.

The types of spark, heat or flame that started the fires are described in Table 4-2. The major cause of ignition was electric arcing as the result of a short circuit, although gas flame from an appliance is also a recurring source of ignition.

The material that first ignites is identified in Table 4-3. Where identification could be made, escaping natural gas (presumably from a broken gas line is the single most common ignition material.

4.4 IGNITION RATE

A very important parameter in the analysis of post-earthquake fires is the earthquake-related ignition rate. Data from LAFD was combined with estimates of MMI and building inventory (EQE, 1995) to correlate normalized post-earthquake ignition rate as a function of MMI. Post-earthquake ignition rate is normalized by total building inventory floor area, since floor area serves as a good proxy for both ignition sources and available fuels. The resulting ignition rates are presented in Figure 4-9, for both (I) all data, and (ii) non-zero data only (in many analyses of post-earthquake ignition rates, it has been customary to only regress non-zero data). The resulting rates are comparable to prior US earthquakes (Natural Disaster Coalition, 1993).

4.5 IGNITIONS VERSUS NON-FIRE DEMANDS

While the fire department responded to fires that have occurred, they also received a massive influx of calls for other forms of assistance that were largely related to the earthquake. Los Angeles City Fire Department Operations Control Dispatch Section (OCD) logged over 7,000 calls on the day of the earthquake, which is almost three times their average daily volume of calls. The calls were screened and 2,177 incident reports were created. Department resources were allocated in response to 1,307 of these calls. The frequency of the calls is reflected in the time line of incident reports shown in Figure 4-3. The graph shows the number of reported calls on a half-hourly basis.

By appropriately screening calls, LAFD was able to reach most locations rapidly. The elapsed time from dispatching resources until arrival at the scene of the incident is termed "roll time". This response time varied throughout the day, and varied most during the initial few hours after the earthquake shock. However, LAFD was able to maintain a median roll time of about 6 minutes, even in the first three hours following the event.

Dispatches for fires were only 12% of the total number, as can be seen in Figure 4-4. Even though calls were screened before dispatching personnel and equipment, almost 1/3 of the dispatches were false alarms or were "good intent call" that were not real problems. LAFD reports indicate initial estimate of fire-related damage to property and building contents for the 77 earthquake related fires totaled $12.4 million.

Table 4-1

PROPERTY USE FOR 77 LAFD EARTHQUAKE-RELATED FIRES, 4:31 TO 24:00 HRS, JANUARY 17, 1994

General Property Use	Frequency
One or Two Family Residential	35
Multi-Family Residential	20
Public Roadway	6
Office	4
Primary/Secondary School	2
Vacant Property	2
Restaurant	1
Commercial	1
Power Production/Distribution	1
Other	4
Unknown	1

Table 4-2

FORMS OF HEAT IGNITION FOR 77 LAFD EARTHQUAKE-RELATED FIRES, 4:31 TO 24:00 HRS, JANUARY 17, 1994

Form of Heat Ignition	Frequency
Gas Appliance Flame	13
Short Circuit, Mechanical Damage	6
Short Circuit, Insulation	6
Short Circuit, Other	5
Normal Electrical Equipment Heat	5
Spark from Equipment	4
Direct Spread	4
Heat from Gas Appliance	2
Escaping Wood/Paper Ember	2
Overloaded Electrical Equipment	2
Faulty Electrical Contact	2
Electric Lamp	2
Spontaneous	2
Liquid Fuel Appliance Heat	1
Discarded Hot Ember	1
Rekindle	1
Catalytic Converter	1
Match/Lighter	1
Unknown	17

Table 4-3

MATERIAL FIRST IGNITED FOR 77 LAFD EARTHQUAKE-RELATED FIRES, 4:31 TO 24:00 HRS, JANUARY 17, 1994

Material First Ignited	Frequency
Natural Gas	13
Sawn Wood	5
Man-Made Fabric	5
Wood	4
Cotton Fabric	4
Flexible Plastics (i.e., wire insulation)	3
Rubbish	2
Tree/Brush	1
L.P.-Gas	1
Gasoline	1
Class II Combustible Liquid	1
Rigid Plastics	1
Fiber Board, Wood Pulp	1
Paper	1
Other Wood	1
Plastic/Vinyl Fabric	1
Other	3
Unknown	29

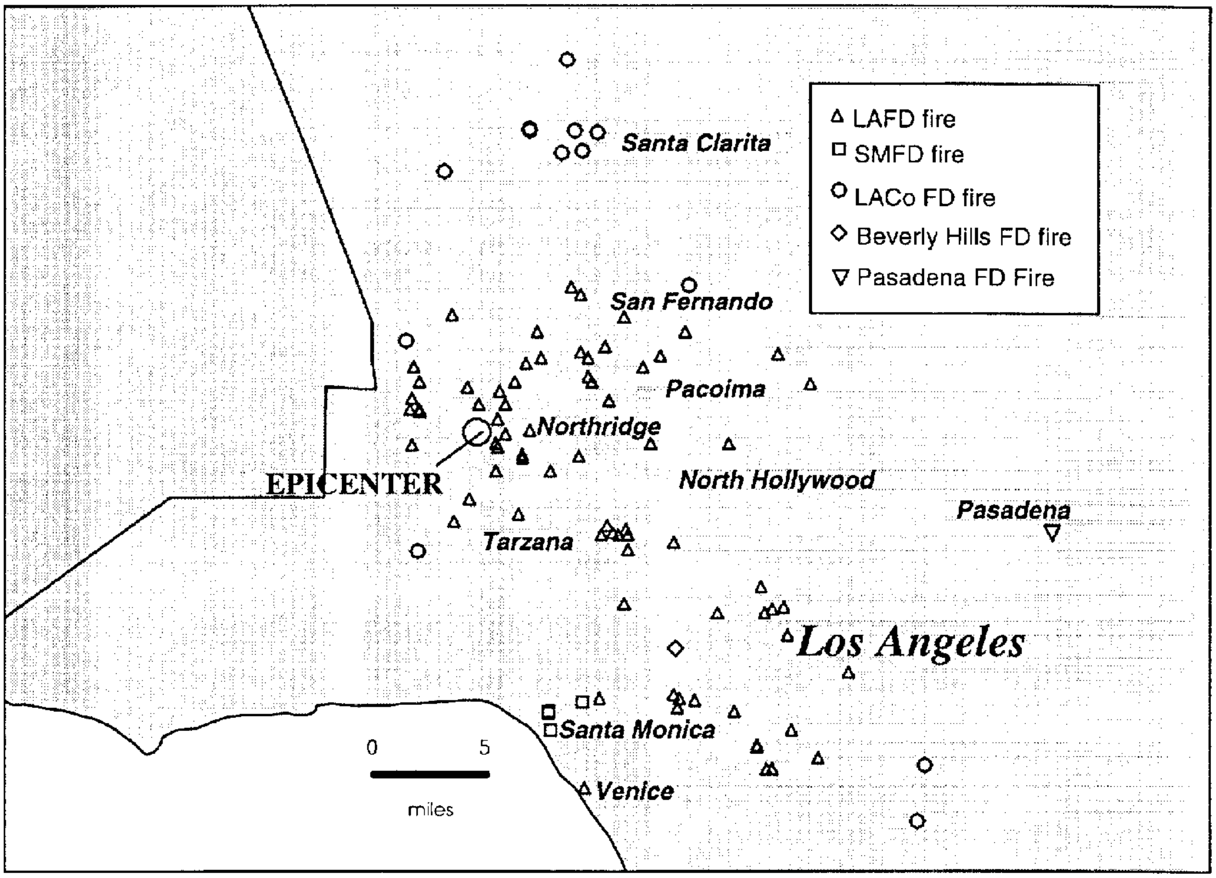


Figure 4-1: Distribution of Fire-related Incidents, January 17, 1994 Northridge earthquake

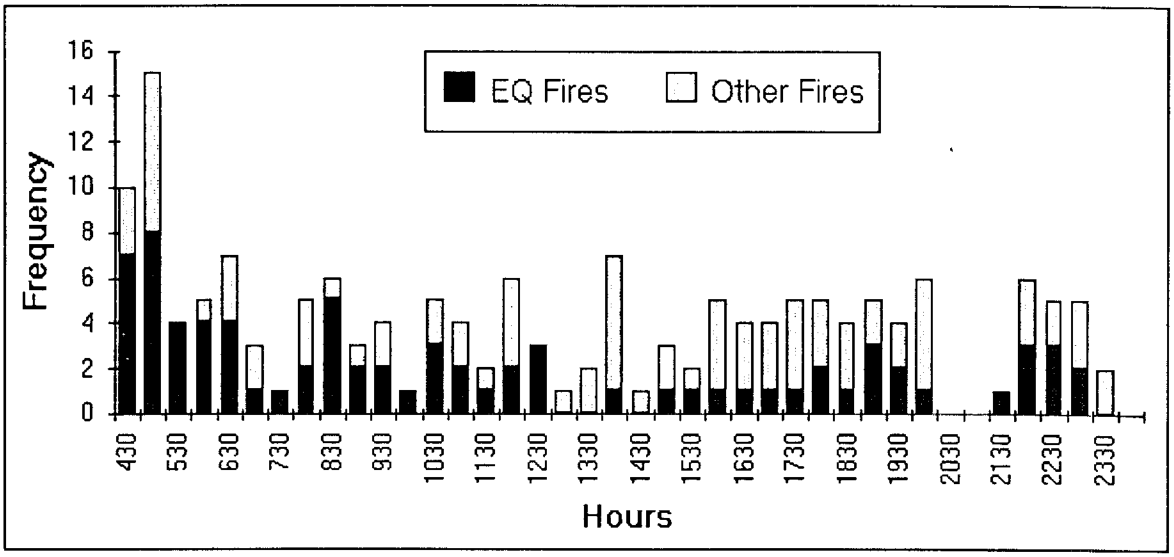


Figure 4-2: LAFD Fires, 4:31 to 24:00 hrs, January 17, 1994.

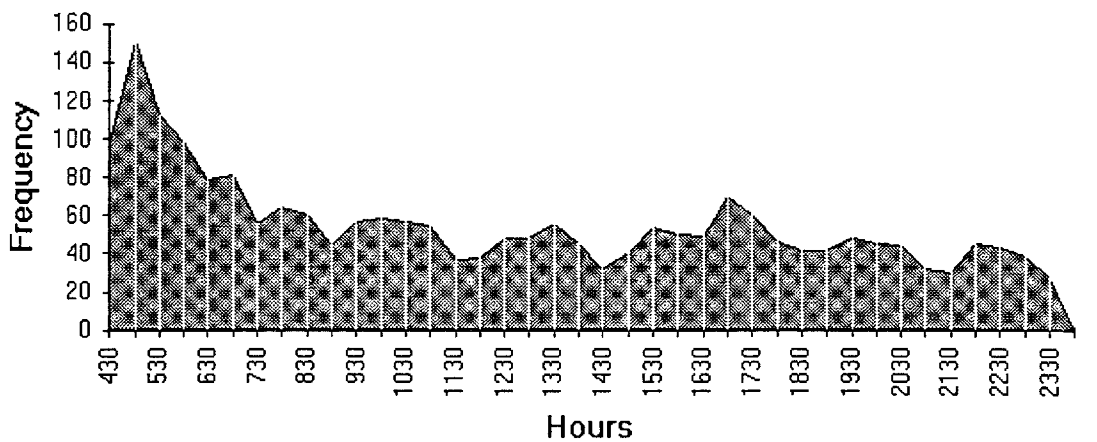


Figure 4-3: LAFD Incident Reports, 4:31 to 24:00 hrs, January 17, 1994

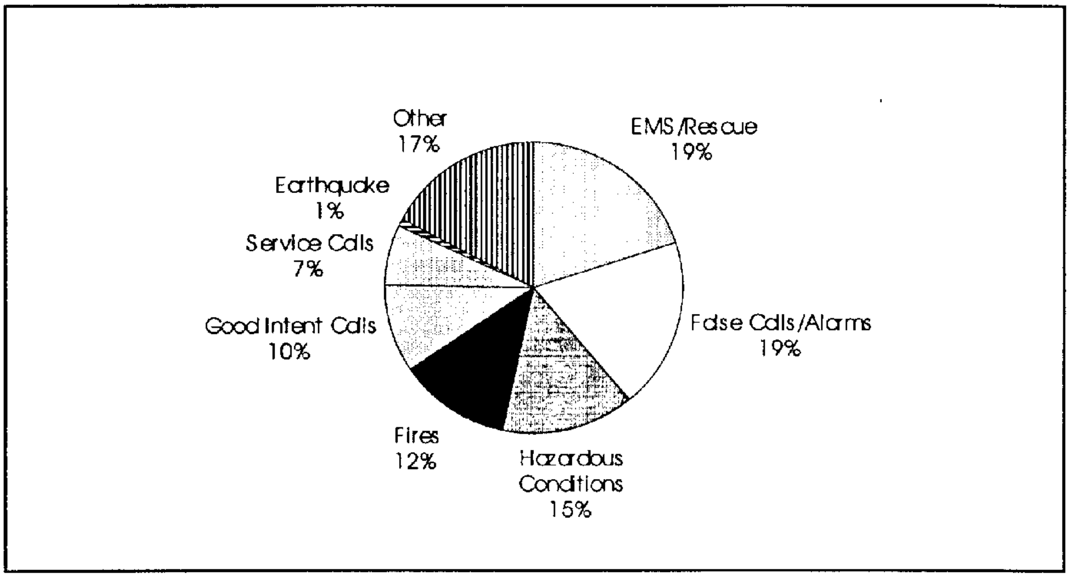


Figure 4-4: LAFD Incident Response Types, 1308 Incidents, 4:31 to 24:00 hrs, January 17, 1994.

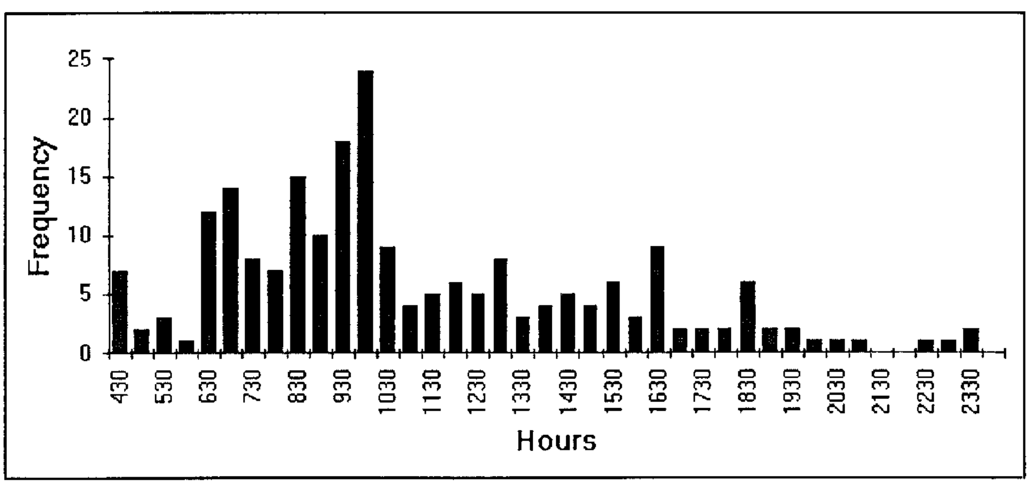


Figure 4-5: SMFD Incident Reports, 4:31 to 24:00 hrs, January 17, 1994.

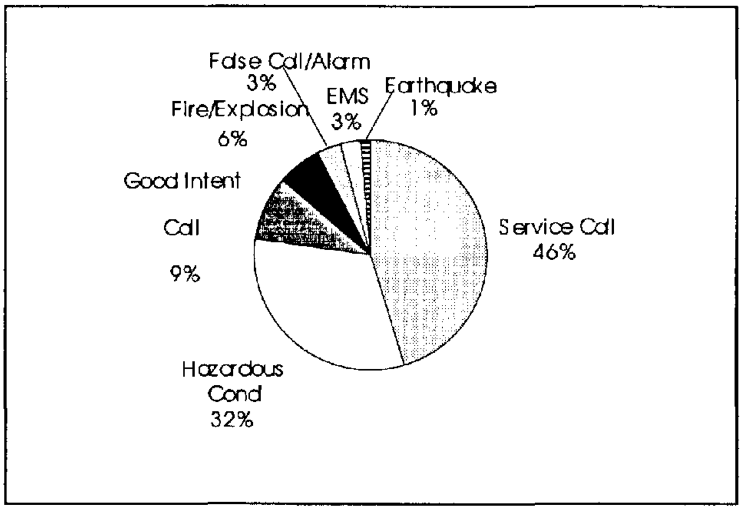


Figure 4-6: SMFD Incident Response Types, 216 Incidents, 4:31 to 24:00 hrs, January 17, 1994.

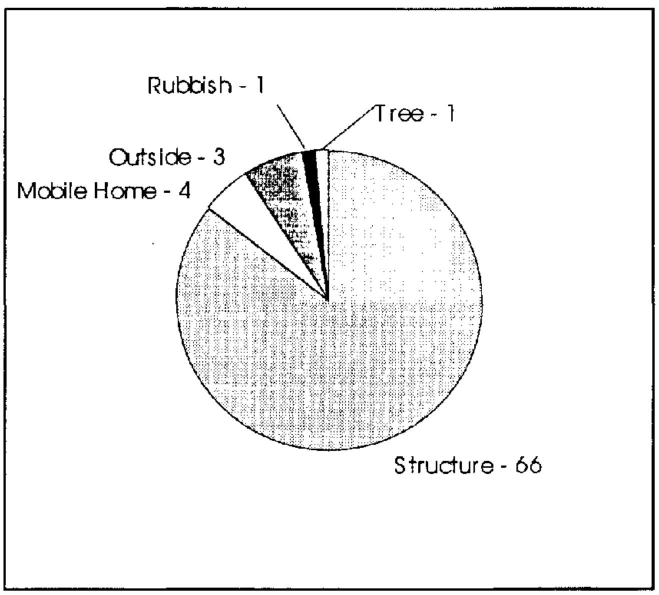


Figure 4-7: LAFD Earthquake-Related Fires, 4:31 to 24:00 hrs, 4:31 to 24:00 hrs, January 17, 1994.

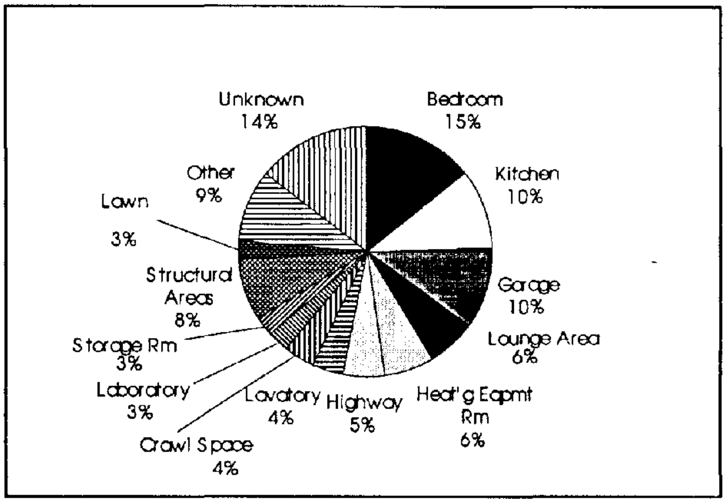


Figure 4-8: Area of Ignition, LAFD Earthquake-Related Fires, 4:31 to 24:00 hrs, January 17, 1994.

Post-Earthquake Ignition Rate
Northridge Earthquake (LAFD only)

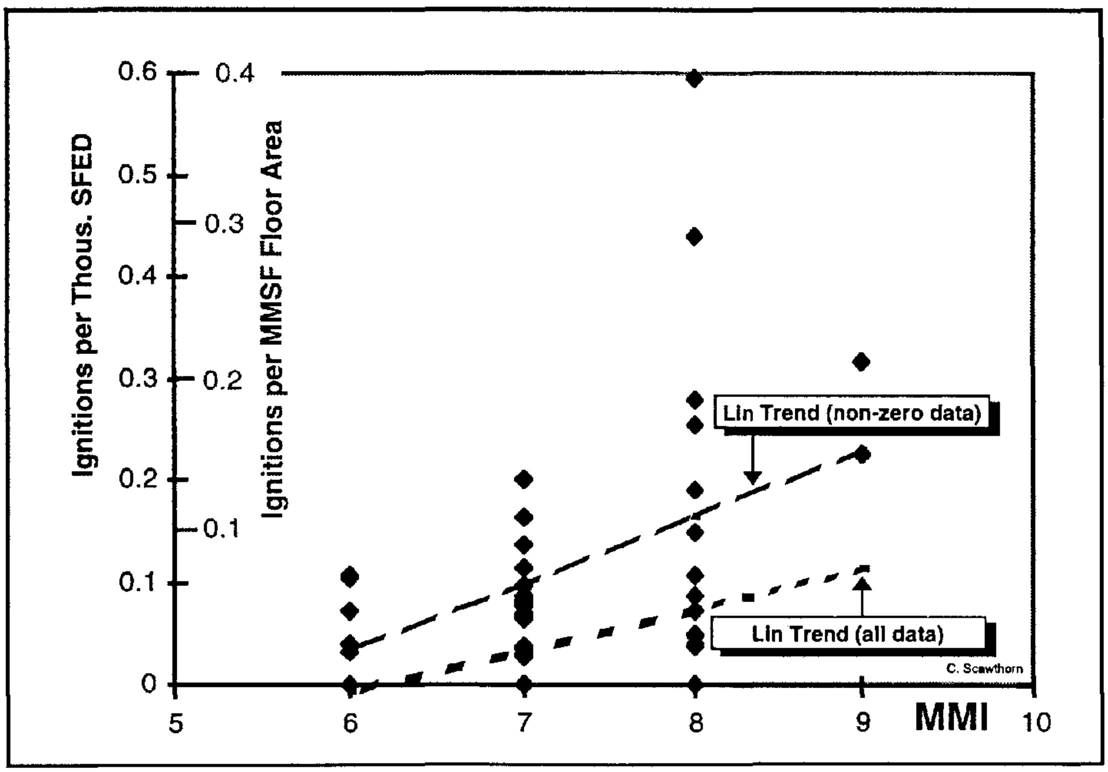


Figure 4-9: Post-Earthquake Ignition Rate, Northridge Earthquake, LAFD Data only

5. OPERATIONS AT SELECTED FIRES

5.1 INTRODUCTION

This section provides details of fire department operations at five selected fires occurring during the Northridge earthquake:

- Balboa Blvd. Fire
- Tahitian Mobile Home Park Fire
- Oakridge Mobile Home Park Fire
- Los Olivos Mobile Home Park Fire
- Cal State Northridge Fires

The criteria for selection of these incidents included size (all were multiple structure fires), problems of water supply, and potential for insights regarding urban conflagration (the fires occurring in mobile home parks are indicative of dense urban settings).

A vital aspect of firefighting is water supply - for each of these incidents, we have attempted to estimate total water required for control of the fire. The basis for these estimates has been records and reports of incident commanders and fire department personnel at the fireground, as to the times and types of apparatus employed, and typical water required for various apparatus, as detailed in Table 5-1.

5.2 NO. BALBOA BLVD. FIRE

<u>Site Description</u>

This fire scene is located in the Granada Hills area of the San Fernando Valley. It is a residential area with one- and two-story wood-frame single-family dwellings, many with swimming pools, on Balboa Blvd. between Halsey and Lorilland Streets. A 56-inch water main under the street was broken, flooding the street and front yards of the homes.

Location/Ignition/Cause

A broken 20-inch gas main under Balboa Boulevard was ignited by the driver of a nearby stalled pick-up truck who was attempting to start the vehicle. Electric arcing in the ignition system ignited a large gas cloud, creating a fireball and igniting two dwellings on the east side of Balboa and three on the west side. Radiant heat from the gas fire was a major factor in the spread of fire. Wind was 15 to 20 mph from the northeast. Ignition occurred about 20 minutes after the earthquake struck. A total of five homes were destroyed, with minor damage to four others.

Fire Department Operations

Report

Fire fighters from Engine 8 and Engine 18 were out on district survey, saw the fire, and responded. Engine 74 responded to a radio request for assistance from Engine 8.

Response

Fire fighters from Engine 8 arrived first and found Balboa Boulevard impassable due to the water flowing from the broken water main. Captain Rust took Engine 8 around the streets parallel to Balboa Boulevard (Paso Robles and McLennan Avenues) and cross streets (Lorilland and Halsey) to check the fire hydrants for water. They were dry. Engine 8 fire fighters entered the alley west of Balboa to protect the structures on that side of the fire. They located a swimming pool behind a home on Paso Robles and used it as a water source. Water from this swimming pool was also supplied to Engine 18 at the south end of the alley. Engine 18 fire fighters entered the alley west of Balboa and set up to protect the homes at the south end. The heat from the fires was intense and forced fire fighters to operate from protected areas.

A Los Angeles County brush fire hand crew arrived on the scene as a mutual aid resource and was directed to cut and remove combustible shrubs, trees, fences, etc. around homes exposed to the fire.

Fire fighters from Engine 74 arrived on the scene, checked the hydrants on the north side of the fire, found them dry, and entered the alley east of the fire. The alley was impassable due to debris from collapsed block walls. Resident volunteers removed the debris, and Engine 74 fire fighters proceeded south to use a swimming pool for a water source. Engine 74 fire fighters extinguished a fire in the attic of an exposed one-story dwelling and continued to direct water streams on the exterior of this building.

A group of local citizen volunteers formed a "bucket brigade" on the northeast side of the fire using a swimming pool for a water source. They protected the house exposed to the fire at that location.

Engine companies 8, 18, and 74 pumped water between 1 1/2 and 2 hours during the firefighting operation. It took about 2 hours for the natural gas leak fire to be reduced in size such that it presented a minimal threat from radiated heat.

The Incident Commander at the scene, Captain Rust, directed operations on the west side between his company and Engine 18, and coordinated efforts with Engine 74 on the east side. Heavy radio traffic use made radio communications very difficult.

An aerial photograph of the scene after the structure fires were extinguished is shown in Photo 3-8. Note that the ruptured gas main is still burning.

Water-related Aspects

Breaks in the water mains rendered all surrounding fire hydrants inoperative. Fortunately, several homes in the area had swimming pools that were used as water supply sources. Engine 8 and Engine 74 fire fighters used their 1 1/2-inch siphon ejectors to draw water into their tanks. The 1 1/2-inch siphon ejector can supply water at 92 to 115 gpm. The swimming pools provided approximately 70 minutes of water flow. Hose layout and water sources used are shown in the table below and in Figures 5-1 (a) through (d).

Table 5-1. Water Usage, Balboa Blvd. Fire

Engine 8	■ One 1 1/2-inch siphon ejector in pool supplying approx. 100 gpm
	■ One 1 1/2-inch supply line laid to Engine 18 for their water source
	■ One 1 1/2-inch tip line with spray tip - 125 gpm ■ TOTAL: 8,750 gallons
Engine 18	■ One 1 1/2-inch supply line in to fill tank
	■ One 1-inch line with spray tip - 25 gpm ■ TOTAL; 1,750 gallons
Engine 74	■ One 1 1/2-inch siphon ejector in pool supplying approx. 100 gpm ■ Two 1-inch lines/spray tips 50 gpm ■ TOTAL: 3,500 gallons
TOTAL ESTIMATED WATER EMPLOYED TO CONTROL/EXTINGUISH FIRES: 14,000 GALLONS	

5.3 TAHITIAN MOBILE HOME PARK FIRE

Site Description (15445 Cobalt Street)

This fire scene is located in the Sylmar area of the San Fernando Valley. The Tahitian Park has 236 mobile home units within an 800 by 1,050 foot area. Units located in the west side of the park are older, are more closely spaced, and are surrounded by large trees. Mobile home units are generally 24 feet wide and 60 feet long. Some are 12 by 60 feet, separated by narrow driveways that are approximately 10 feet wide, see Photo 3-15.

Location/Ignition/Cause

Soon after the earthquake struck at 0431 hours, multiple fires were ignited in three different locations within the park. The first fire company, Engine 75, found 30 to 40 mobile homes burning at 0455 hours. The initial shaking caused many mobile homes to slide off their supports, crushing or severing utility connections. Electrical arcing or open flame caused may fires. Sources ignited and fed natural gas, which escaped from broken supply pipes under or adjacent to the units. The fires spread from ignition points by a 15 to 20 mph north wind, which spread the fire to adjacent structures. A broken high-pressure natural gas manifold also ignited a large fire within the park.

The fires in the park burned 53 of the 236 units.

Fire Department Operations

Report

Engine 75 fire fighters were out on district survey and saw numerous fires in the darkness. The fire at the Tahitian Park was the largest, so they responded, arriving about 25 minutes after the earthquake.

Response

Engine 75 fire fighters arrived first at 0455 hours and found 30 to 40 mobile homes burning in three locations. Working alone, they laid a 3 1/2-inch supply line from a hydrant on Cobalt Street into the park. Initial pressure was 60 psi. They began attacking the fire, protecting exposed units with one 1 3/4-inch and one 1 1/2-inch line and their wagon battery. Within minutes the hydrant pressure dropped to zero. Fire fighters were forced to withdraw, using 500 gallons in their tank for protection. Captain Simms, the Incident Commander, then made sure that the park residents evacuated to a safe area.

Engine 75 left the area at 0540 hours for another assignment. Between 45 and 60 minutes later, Engine 75 was dispatched back to the Tahitian Park with mutual aid engine companies from the Los Angeles County Fire Department. Engine 75 was assisting one Los Angeles County engine to gain access to the park's swimming pool for water supply. About 45 to 50 mobile homes were burning at this time when Los Angeles City Battalion Chief Bowie (Battalion 12) arrived and became the incident commander. He directed a Los Angeles County battalion chief with five engines to the northeast side of the park. Additional Los Angeles City companies were deployed to the west and south areas in a downwind position for firefighting and exposure protection.

At this time, the wind speed was down to about 5 mph and the water had returned to the hydrants registering approx. 30 psi. Engine companies were sent into the park and down various streets using water from the hydrants and small hand lines (mainly 1 3/4 and 1 1/2 inches) to attack fires.

By 1100 hours, 10 fire companies gained control of the fires.

Fifty three of the 236 units burned. Figure 3-16 is a photograph of a portion of the park after fires were extinguished.

Water-related Aspects

When Engine 75 first arrived and connected to a hydrant on Cobalt Street. The hydrant had 60 psi but water only flowed for one to three minutes. The hydrants around the park at this time had no water. The park had one swimming pool containing approximately 12,000 gallons, but access to the pool by fire apparatus was difficult.

Water was available later in the hydrants at reduced pressures (approx. 30 psi). Fire companies used water as required from hydrants on Cobalt Street and Bradley Avenue.

Water for firefighting operations flowed for about two hours. Total estimated water employed during this time was 275,000 gallons (approx.)

Hose layouts and water sources are shown in the table below and in Figures 5-2 (a) through (e).

Table 5-2. Water Usage, Tahitian Mobile Home Park Fire

Engine 75	■ Laid supply line from hydrant initially and set up wagon battery, (one) 1 3/4-inch line, (two) 1 1/2-inch lines ■ Total gpm = 950 ■ Total gallons = 1,500
Engine 75	■ Laid 2 1/2-inch supply line from Engine 220 and used (one) 1 3/4-inch line, (two) 1 1/2" lines ■ Total gpm = 450 ■ Total gallons = 54,000
Los Angeles County Engine 1	■ Supplied by Engine 220 used (two) 1 1/2-inch lines ■ Total gpm = 250 ■ Total gallons = 30,000
Engine 220 with Truck Company 20	■ Laid 3 1/2 supply line from Cobalt Street, supplied Engine 75, Los Angeles Co. Engine 1, and Engine 19 ■ Used (two) 1 3/4-inch lines, (two) 1 1/2-inch lines. Total gpm = 650 ■ Total gallons = 78,000
Los Angeles County Engine 2	■ Supplied by Los Angeles Co. Engine 5, used (two) 1 1/2-inch lines. ■ Total gpm = 250 ■ Total gallons = 30,000
Los Angeles County Engine 3	■ Supplied by Los Angeles Co. Engine 5, used (two) 1 1/2-inch lines. ■ Total gpm = 250 ■ Total gallons = 30,000

Los Angeles County Engine 4	■ Used (one) 1 1/2-inch line ■ Total gpm = 125 ■ Total gallons = 15,000
Engine 19	■ Laid 3 1/2-inch line supplied by hydrant, used (two) 1 1/2-inch lines ■ Total gpm = 250 ■ Total gallons = 22,500
Los Angeles County Engine 5	■ Hooked up to hydrant on Bradley Ave. and supplied Los Angeles County engines in the park
Engine 53	■ Laid long suction 3 1/2 inches into park from hydrant on Cobalt St., used (two) 1 1/2-inch lines ■ Total gpm = 250 ■ Total gallons = 15,000
Engine 26	■ Hooked up to hydrant on Cobalt St. and supplied Engines 53 and 19, used (one) 1 1/2-inch line ■ Total gpm = 125 ■ Total gallons = 3,750
TOTAL GALLONS USED TO CONTROL FIRE: 279,750	

5.4 OAKRIDGE MOBILE HOME PARK FIRE

Site Description (15455 Glen Oaks Boulevard)

This fire scene is located in the Sylmar area of the San Fernando Valley. The Oakridge mobile home park is approximately 2,000 by 4,000 feet and contains 600 mobile homes. Units are closely spaced with narrow roads and landscaped with large trees and shrubs, see Photos 3-15 and 3-16. Brush-covered foothills are located north of the park.

Location/Ignition/Cause

Multiple fires were ignited in several locations. Many mobile homes slid off their supports, crushing or severing utility connections. Many fires were caused by electrical arcing or open flame sources igniting natural gas, which escaped from broken supply pipes under the mobile homes. Fires spread from ignition points to adjacent structures as a result of a 15 to 20 mph north wind that dissipated later that morning. At that time, some of the brush north of the park ignited from the fire in the nearby mobile homes. A total of 55 mobile homes burned.

Fire Department Operations

Report

Engine 91 fire fighters left their quarters after the earthquake on a district survey and saw the fire in Oakridge Park. At approximately 0437 hours, they responded to the fire.

Response

Captain Kaplan, Engine 91, entered the park and noticed a broken water pipe. Engine 91 fire fighters took a position on Colt Street and began fire attack on several small fires around the mobile homes, using their 500-gallon tank and 1 1/2-inch hose. The wind at this time was northeast at 15 to 20 mph. Fire fighters then moved to another location, hooking up to a hydrant in the park, and laid a 3 1/2-inch supply line to attack a fire, which was now burning five mobile homes. A 2 1/2-inch hand line helped knock down the fire when water was lost from the hydrant. They used their remaining 500 gallons in the tank, picked up their hose, and assisted evacuating occupants. The fire department dispatch center was notified of the situation, and Engine 91 left to continue a survey of a nearby hospital. This action was based on the number of fires, lack of water, and no additional assistance from other fire engines.

Engine 81 fire fighters were out on earthquake survey when notified by radio to respond to Oakridge. They arrived on scene at 0520 hours and began fire attack, working with Los Angeles County Engine 12 fire fighters. They supplied Engine 81 through a 2 1/2-

inch line. At this time, limited water flow returned to the hydrants. Engine 81 had to use three 1 1/2-inch lines on six mobile homes, as leaking natural gas continued to feed the fires.

At approximately 0545 hours, Engine 91 returned to Oakridge to find engine companies from the United States Forest Service (USFS), additional Los Angeles County engines, and a Los Angeles County water-dropping helicopter operating at the incident. Engine 91 set up for firefighting with a USFS engine.

The helicopter dropped water on the fire that spread to nearby grass and brush and on some of the perimeter mobile homes that were burning.

When the Battalion Chief of Battalion 12 arrived to survey the Oakridge Park at 0645, the fires were well under control and mop-up operations (overhaul) were underway.

Fifty-five of the 600 mobile homes burned. Photo 3-?? is a photograph of some of the burned area in the park.

Water-related Aspects

When Engine 91 fire fighters began pumping operations from a hydrant, a limited amount of water was available. Within 10 to 15 minutes, the hydrant ran dry. Fire fighters accessed water from one swimming pool located near the center of the complex. It is interesting to note that water pressure returned to the hydrant system, as it did in other fire situations at that time. The earthquake had caused widespread power outages affecting the water supply pumps in this area. Possibly, water pressure returned when auxiliary power sources were used.

Engine companies responding with Engine 81 were later able to obtain limited water from the hydrants within the park.

Hose layout and water sources used are shown in the table below and in Figures 5-3 (a) through (e).

Table 5-3. Water Usage, Oakridge Mobile Home Park Fire

Engine 91	■ Initially used 500-gallon tank on engine and (one) 1 1/2-inch line ■ Total gpm = 125 ■ Total gallons = 1,875
Engine 91	■ one 3 1/2-inch supply line to hydrant ■ 2 1/2-inch hand line with 1 1/4-inch tip ■ Total gpm = 325 ■ Total gallon = 4,875
Engine 81	■ one 2 1/2-inch supply line to Los Angeles County Engine 12, used (three) 1 1/2-inch lines ■ Total gpm = 375 ■ Total gallons = 30,000
Los Angeles County Engine 12	■ Laid supply line 2 1/2-inch to hydrant ■ Supplied engine 81 though 2 1/2-inch line. ■ Used (two) 1 1/2-inch lines ■ Total gpm =250 ■ Total gallons = 22,000
Engine 91	■ Supplied by USFS engine through 1 1/2-inch line ■ Used (one) 1 1/2-inch line ■ Total gpm = 125 ■ Total gallons = 7,500

U.S. Forest Service Engine 1	■ Supplied by water from hydrant, provided water to Engine 91 though 1 1/2-inch line ■ Used (one) 1 1/2-inch line and (one) 1-inch line ■ Total gpm = 150 ■ Total gallons = 9,000
U.S. Forest Service Engine 2	■ Supplied by hydrant, provided water to USFS Engine 3 ■ Used (one) 1 1/2-inch line ■ Total gpm = 125 ■ Total gallons = 7,500
U.S. Forest Service Engine 3	■ Supplied by USFS Engine 2 ■ Used (one) 1 1/2-inch and (one) 1-inch line ■ Total gpm = 150 ■ Total gallons = 7,000
Los Angeles County Engines 1 and 2	■ Supplied by hydrant each used one 1 1/2-inch line ■ Total gpm = 250 ■ Total gallons = 22,000
Los Angeles County Helicopter	■ Water tank capacity = 365 gallons ■ Estimated 10 water drops ■ Total gallons = 3,650
TOTAL GALLONS USED TO CONTROL FIRE: 115,400	

5.5 LOS OLIVOS MOBILE HOME PARK FIRE

Site Description (15831 Olden Street)

This fire scene is located in the Sylmar area of the San Fernando Valley. The Los Olivos mobile home park has 81 units located in an area of 1,200 by 270 feet. When compared to the Tahitian and Oakridge parks, this park is smaller and newer.

Location/Ignition/Cause

As in the Tahitian and Oakridge fires, collapsing supports under mobile homes, damaged utilities, and leaking natural gas contributed to multiple fire. Wind speed was estimated at 10 to 15 mph from the northeast. Exposures outside the park was not a problem. Twenty two mobile homes burned.

Fire Department Operations

Report

Battalion Chief Bowie, Battalion 12, made an initial survey and found several homes burning. He had no resources available until he obtained Los Angeles County Fire Department mutual aid assistance.

Response

The initial fire response to the Los Olivos Park was handled by Mutual Aid Strike Team 1101. A strike team consists of one battalion chief and command vehicle, and five engine companies. It is estimated that Strike Team 1101 arrived at this fire at 0530 hours, where they were confronted with multiple fires on the east side of the park. Wind conditions were similar to the area at that time, 10 to 15 mph northeast.

Five engines were deployed to the park to contain the fire and protect exposed homes. Since all five engines arrived together with their leader, a coordinated initial attack could be made.

The engines found that the hydrants were not working, so initial attack was made using water from the engine tanks, and small hand lines, i.e., 1 and 1 1/2 inches. Later, water returned to the hydrants and the engines were able to supply more lines on a prolonged firefighting operation.

Water-related Aspects

Similar conditions were again found with water pressure returning to the hydrant system later. Engines initially used their tanks using minimal amounts of water until a hydrant supply was obtained. One swimming pool in the park at the north end was used to fill apparatus tanks with siphon ejectors.

Hose layouts and water sources are shown in Figures 5-4 (a) through (d).

Table 5-4. Water Usage, Los Olivos Mobile Home Park Fire

Los Angeles County Strike Team 1101 Engines 1, 2, 3, 4, and 5	■ Initial attack using 1 1/2- and 1-inch hand lines from tank ■ Total gpm = 657 ■ Total gallons = 4,000
Los Angeles County Strike Team 1101 Engines 1, 2, 3, 4, and 4	■ Supplied by hydrant system from Olden Street and private hydrants within the park with limited quantity ■ Handheld fire attack lines 1- and 1 1/2-inch increased ■ Total gpm = 1,050 ■ Total gallons = 63,000
TOTAL GALLONS USED TO CONTROL FIRE: 67,000	

5.6 CAL STATE NORTHRIDGE FIRES (DRAWN FROM BURMESTER (1994))

Site Description (18111 Nordhoff St)

This fire scene is located in the Northridge area of the San Fernando Valley. The Cal State Northridge campus is a flat parklike setting approximately one mile square, with low- and mid-rise buildings distributed throughout and typically well separated. A number of buildings on campus sustained serious structural damage, including the main library, and a parking structure on the east side of the campus, which collapsed.

Location/Ignition/Cause

Several fires occurred in the science buildings complex, on the east side of the campus. Causes are discussed below but are likely due to chemical reactions.

Fire Department Operations

Response

Battalion Chief William Burmester responded at 0755 with three Tac Team engine companies to the Cal State Northridge campus. He found three science laboratories, each approximately 400 ft. by 50 ft. three story buildings, with smoke showing on the third floor of Bldgs. 1 and 2. Chief Burmester noted that all three buildings were placarded with the number "4" in each section of the diamond (indicating hazardous and flammable materials). Engine 90 surveyed Building 1 and found a small fire, while Engine 10 directed handlines with limited success on the larger and rapidly spreading fire in Building 2. However, Engine 10 withdrew when approximately 30+ explosions began occurring Building 2 laboratories. At 0845 the fire in building 1 was effectively knocked down (later determined to be due to either heating devices or reaction of spilled chemicals), but a small amount of smoke began to show in Building 3. From 0900 to 0915 Task Force and Squad 39 and other units arrived and assisted, including development of a continuous water supply using a relay from an operable hydrant 800 ft. away, and a 1,000 ft. relay from pumps operating from draft in swimming pools at the north end of the campus. Wagon batteries were positioned to protect exposures and, at

0918 Engine 16 found a fire on the third floor of Building 3, which was attacked and controlled. However, for approximately 40 minutes, heavy streams from wagon batteries were applied into Building 2, until that fire was knocked down at about 0944. By 1000 water supply was relatively plentiful and, after having plotted chemical locations by conference with teachers, doctors and students, interior attack of Building 2 was accomplished, using blowers ventilating ahead of them. The fires in Building 2 were extinguished - Task Force and Squad 39 remained on-scene to wait for the County Health Department and secure the scene.

Water-related Aspects

Hydrants in the immediate area had no water. Adequate water was obtained relay from an operable hydrant 800 ft. away, and a 1,000 ft. relay from pumps operating from draft in swimming pools at the north end of the campus. Accurate estimate of water usage is difficult, but a minimum of 84,000 gallons was likely employed (this estimate is based on 2 hours of at least 2 handlines, at 200 gpm, and 1 hour for 2 master streams, at 500 gpm).

Table 5-5

GPM FLOWCHART

Apparatus		Water Flow (typ)
■ Wagon battery		500 gpm
■ 2 1/2-inch hose - 1 1/4-inch tip		325 gpm
■ 1 3/4-inch hose/spray tip		200 gpm
■ 1 1/2-inch hose/spray tip		125 gpm
■ 1-inch hose/spray tip	75 psi 200 psi	23 gpm 50 gpm
■ 1 1/2-inch siphon ejector		115 gpm (max.)

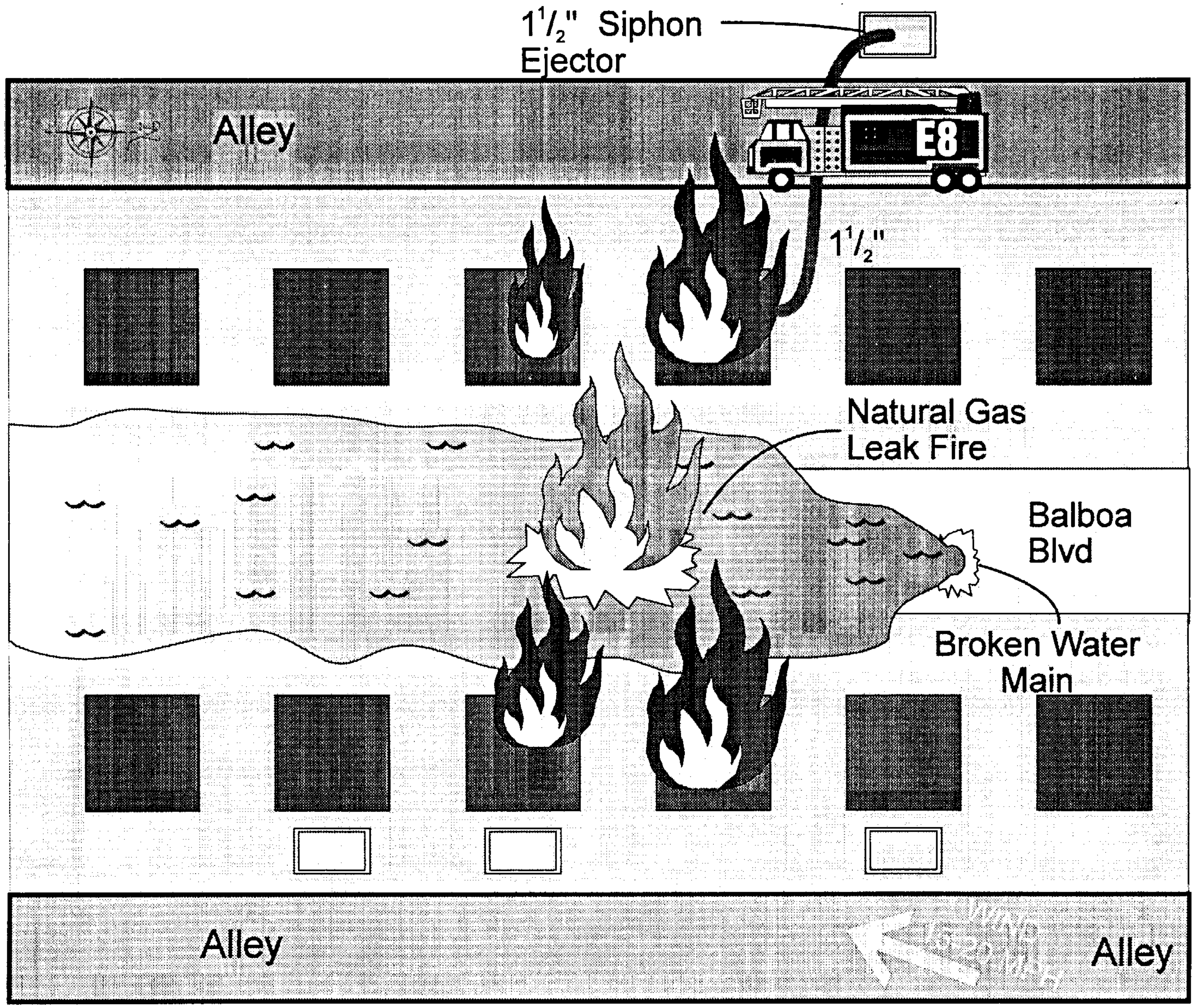
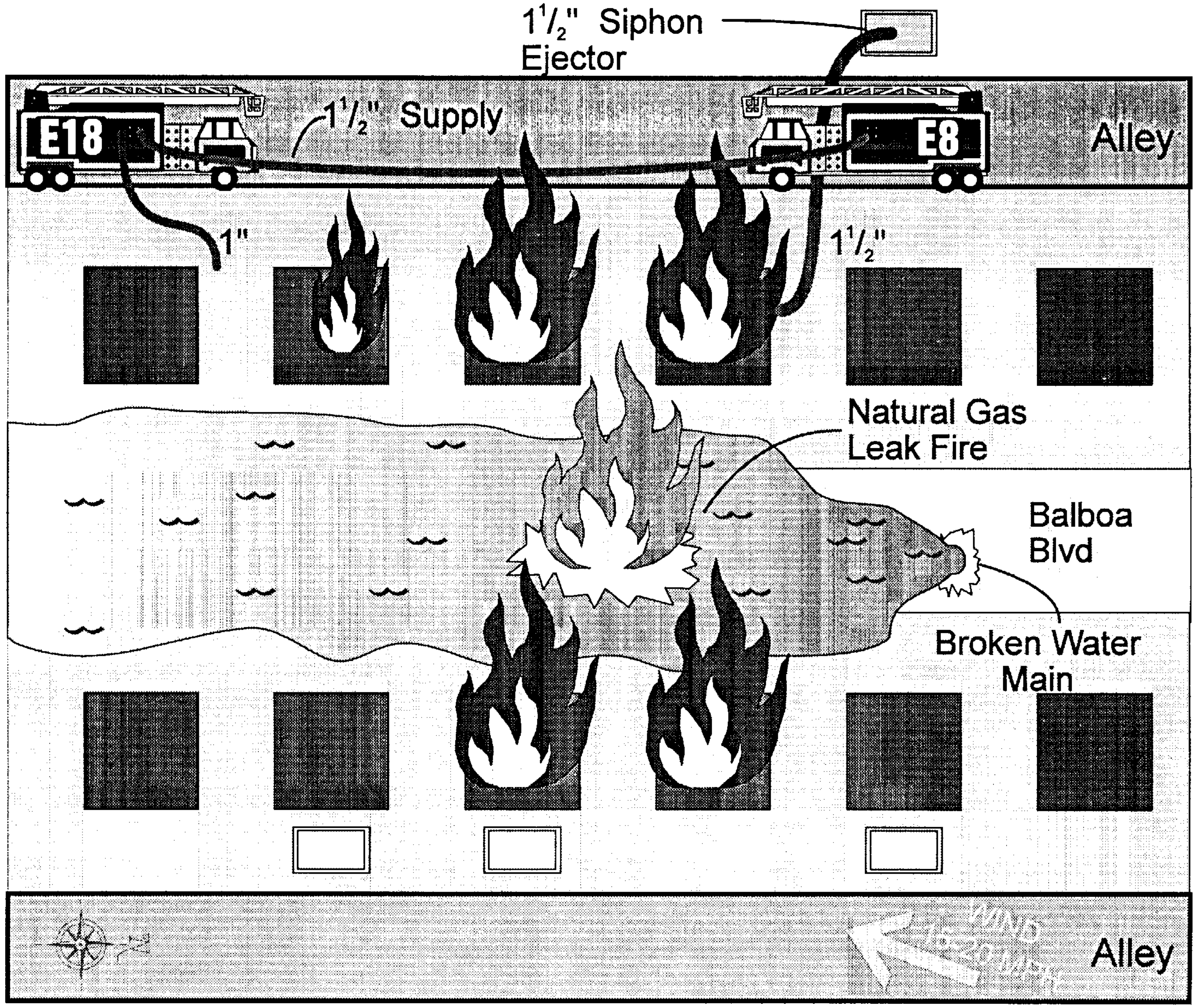


Figure 5-1a: Balboa Boulevard fire scene at 4:50 A.M.



time0505.cdr 52010.01 3/96

Figure 5-1b: Balboa Boulevard fire scene at 5:05 A.M.

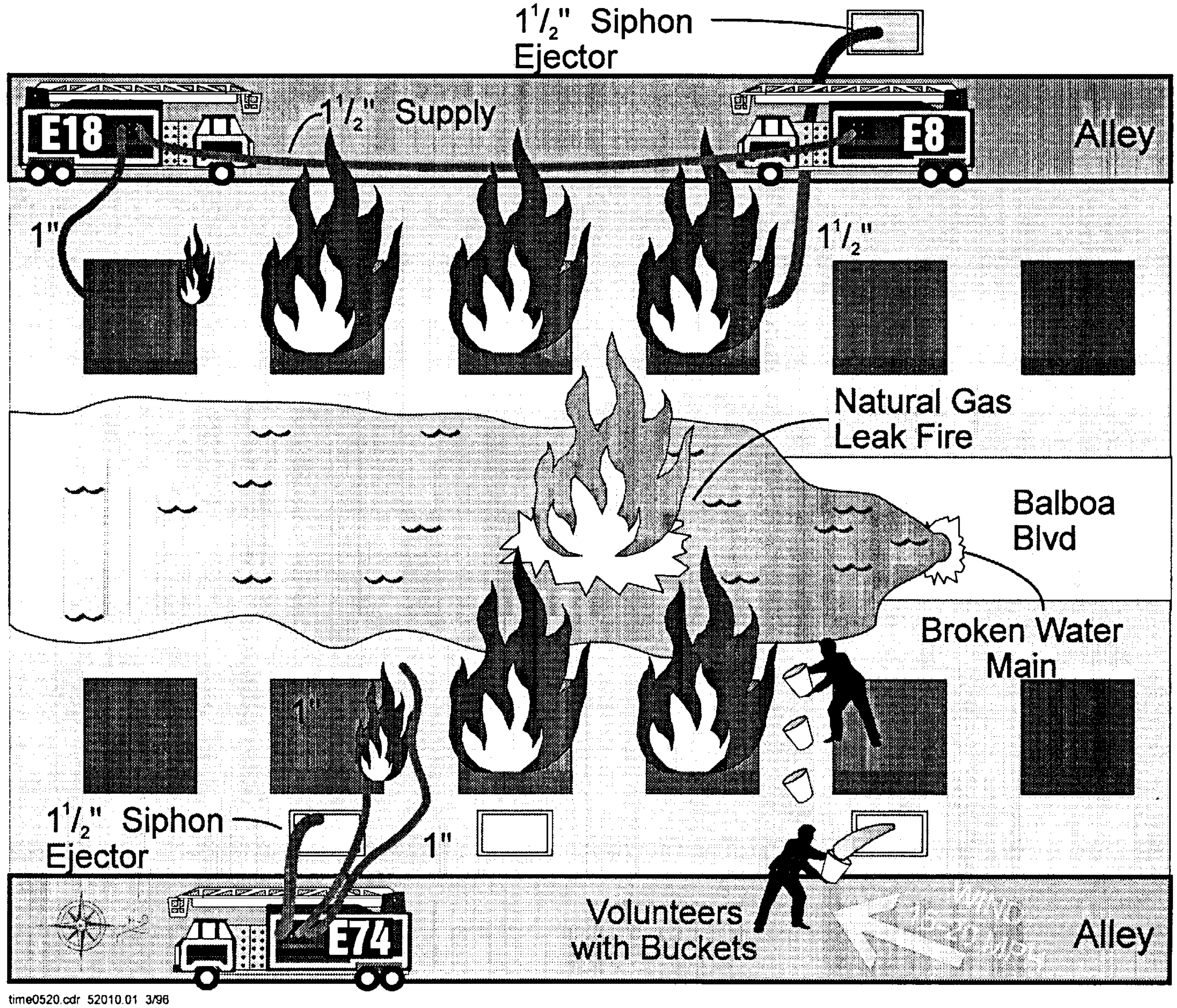


Figure 5-1c: Balboa Boulevard fire scene at 5:20 A.M.

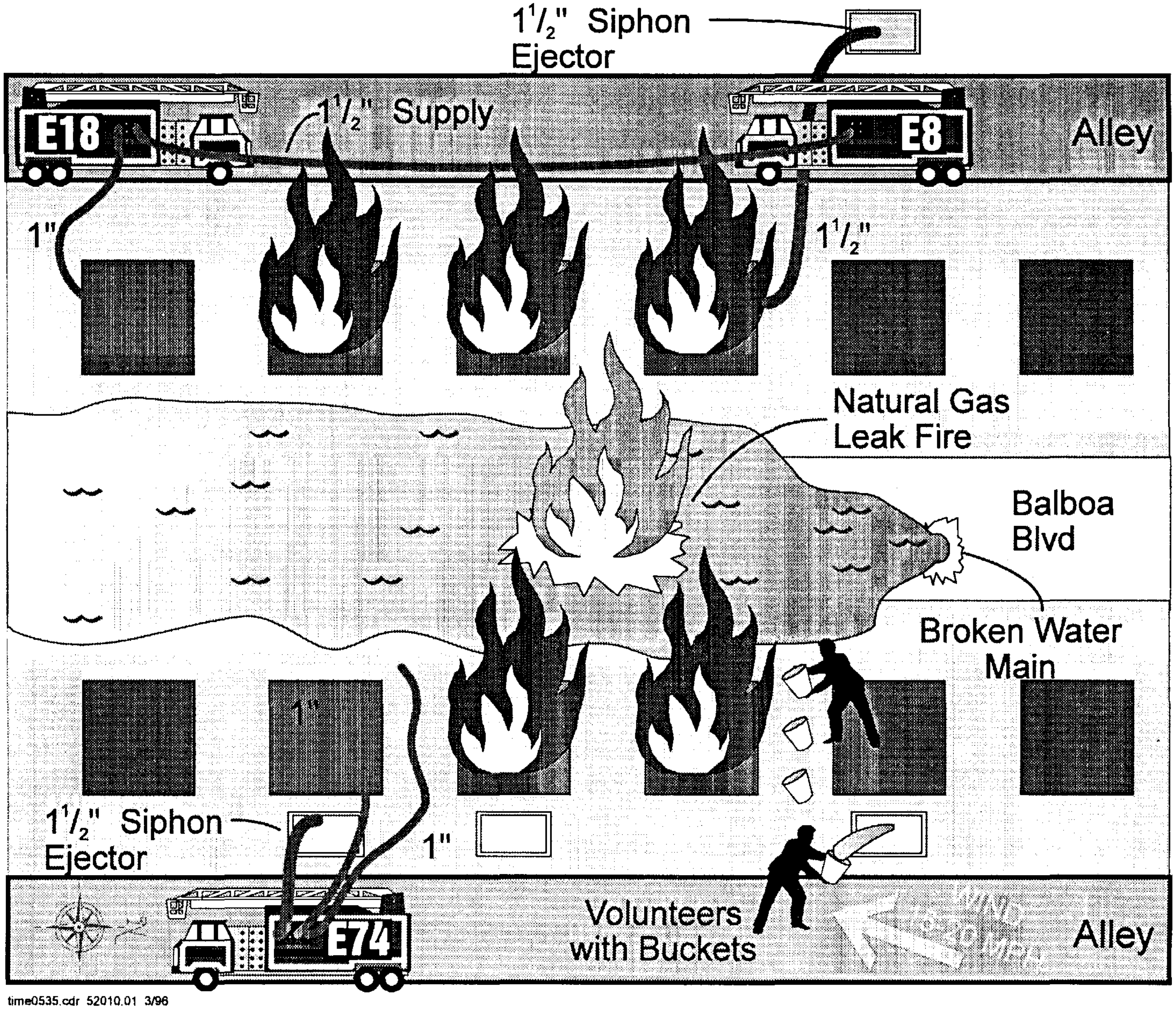


Figure 5-1d: Balboa Boulevard fire scene at 5:35 A.M.

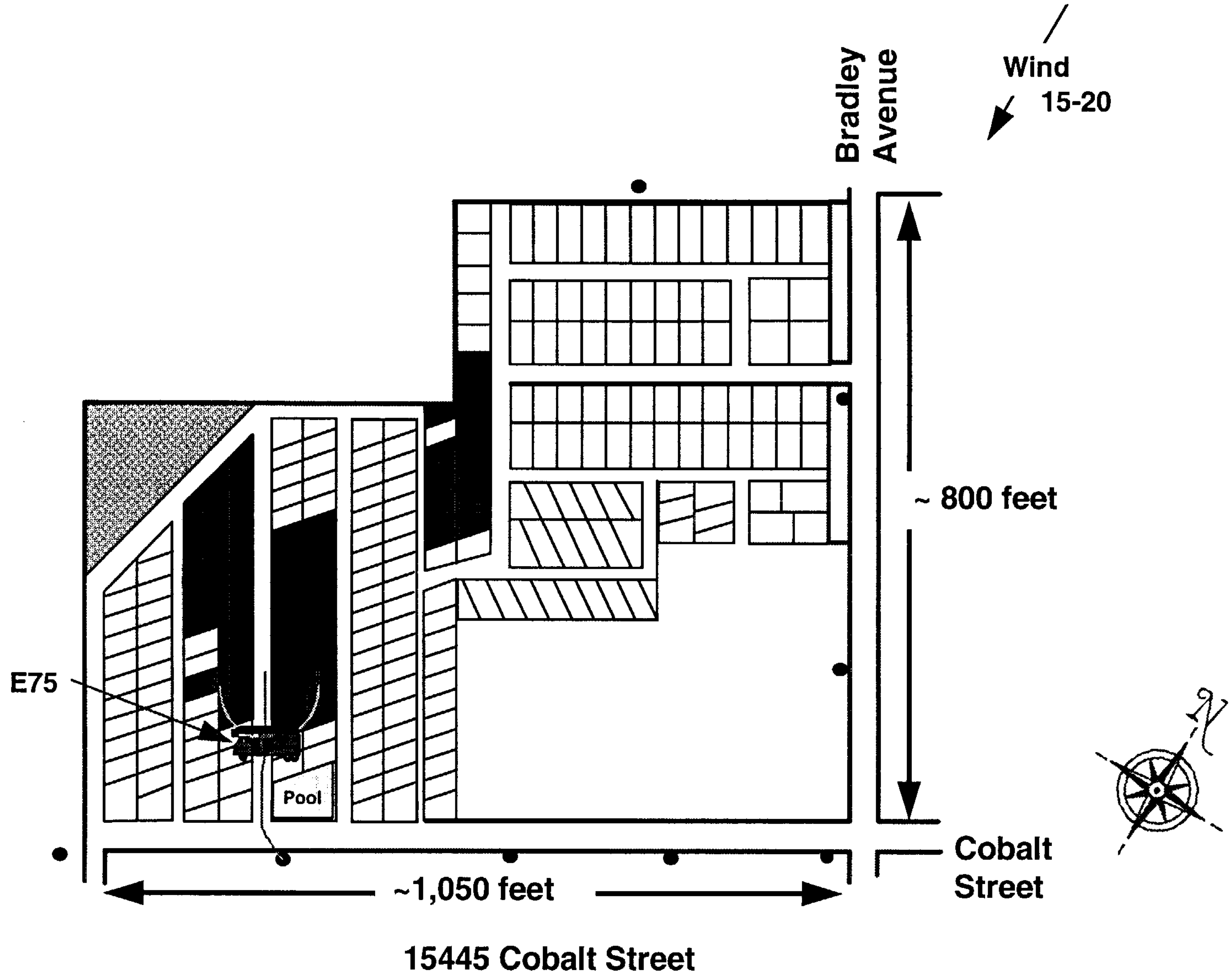


Figure 5-2a: Tahitian Park fire scene at 4:55 A.M.

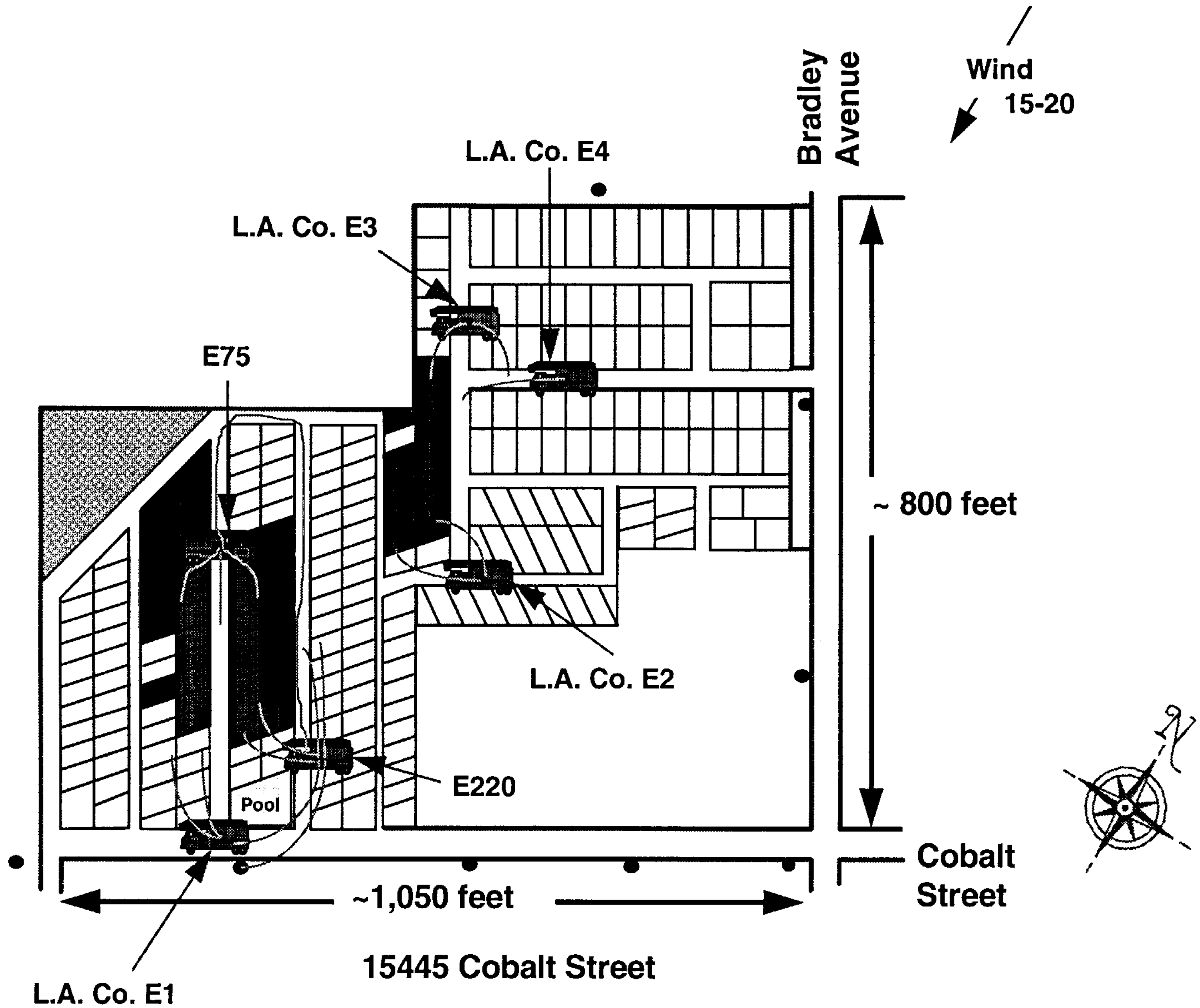


Figure 5-2b: Tahitian Park fire scene at 6:30 A.M.

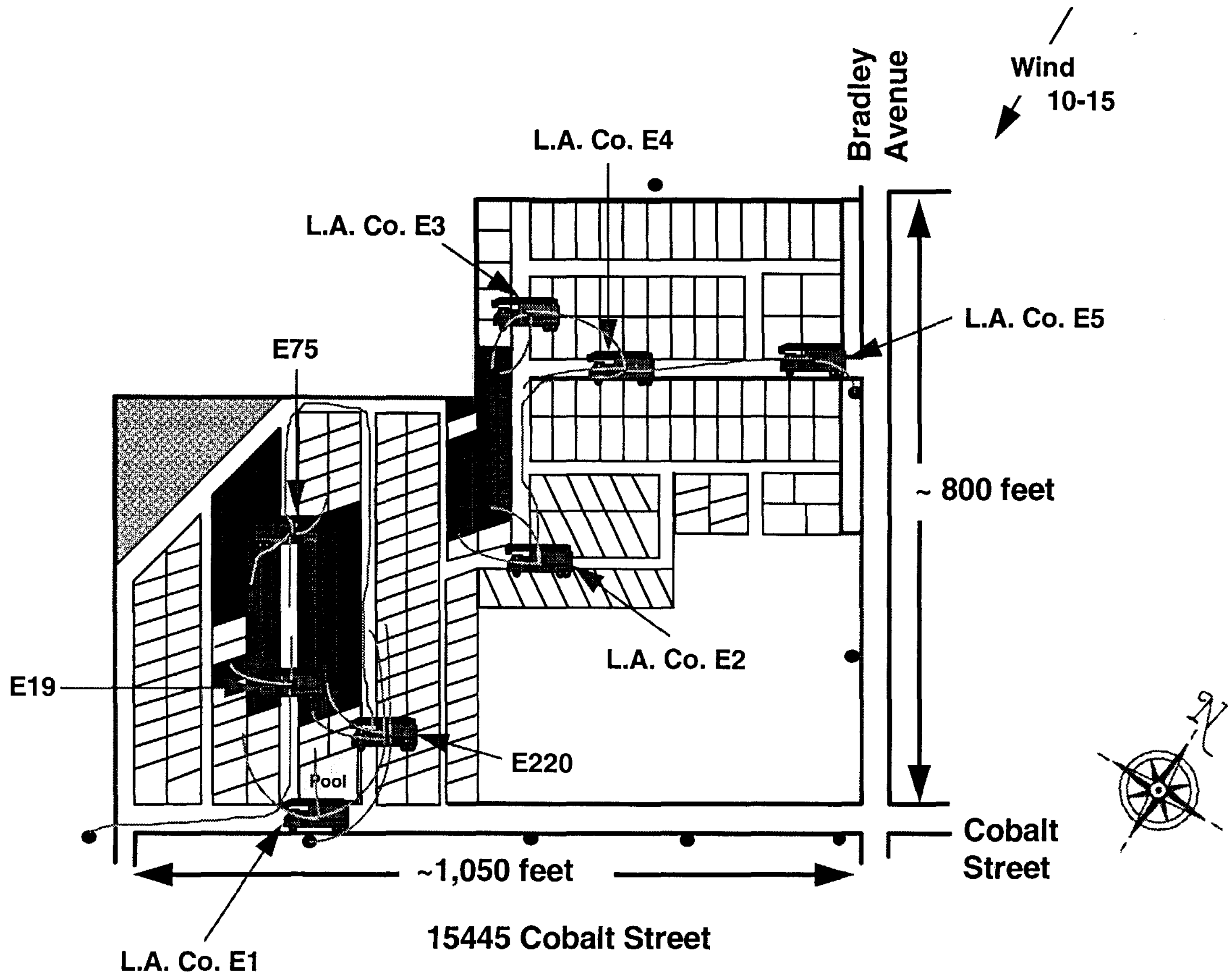


Figure 5-2c: Tahitian Park fire scene at 7:00 A.M.

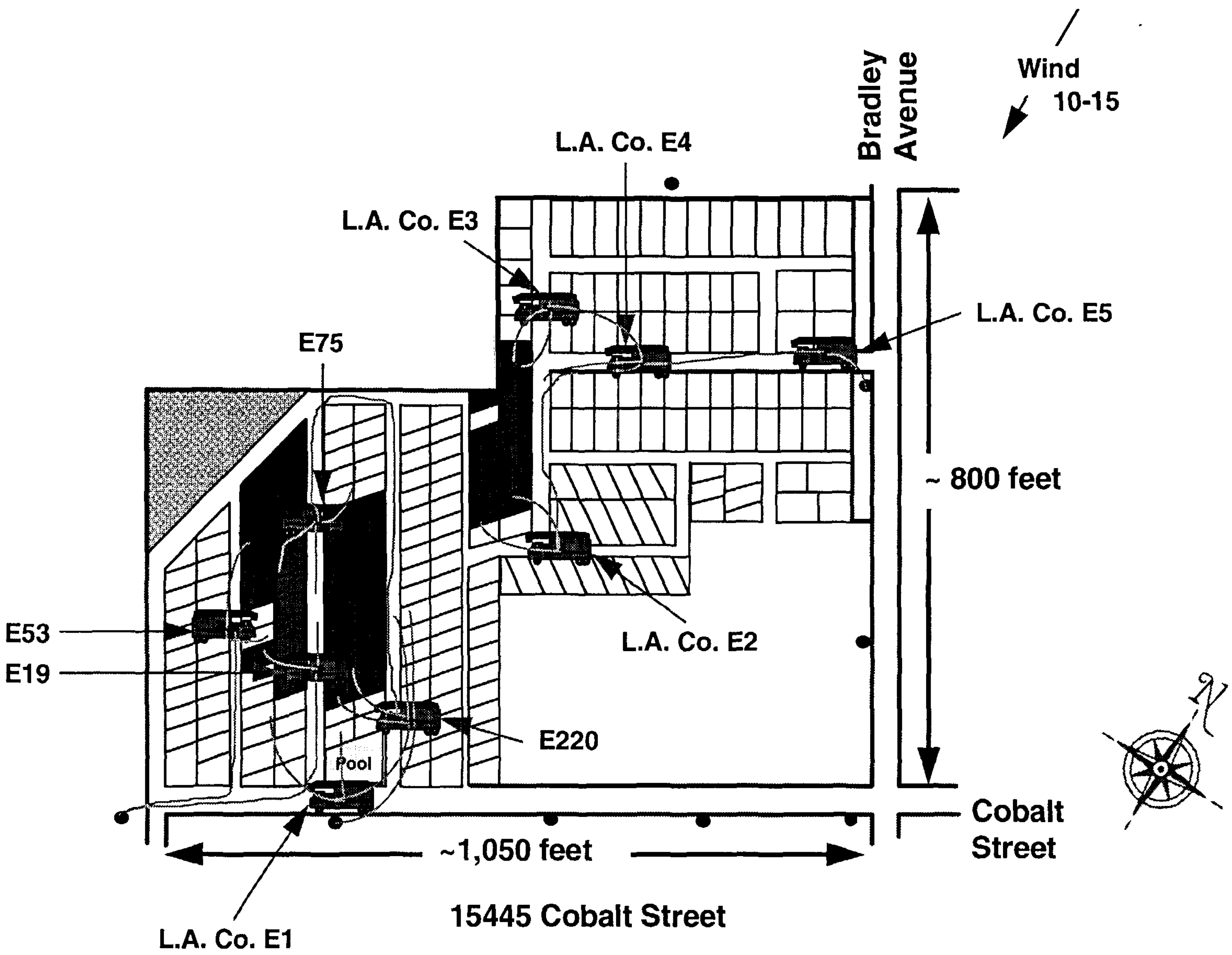


Figure 5-2d: Tahitian Park fire scene at 7:30 A.M.

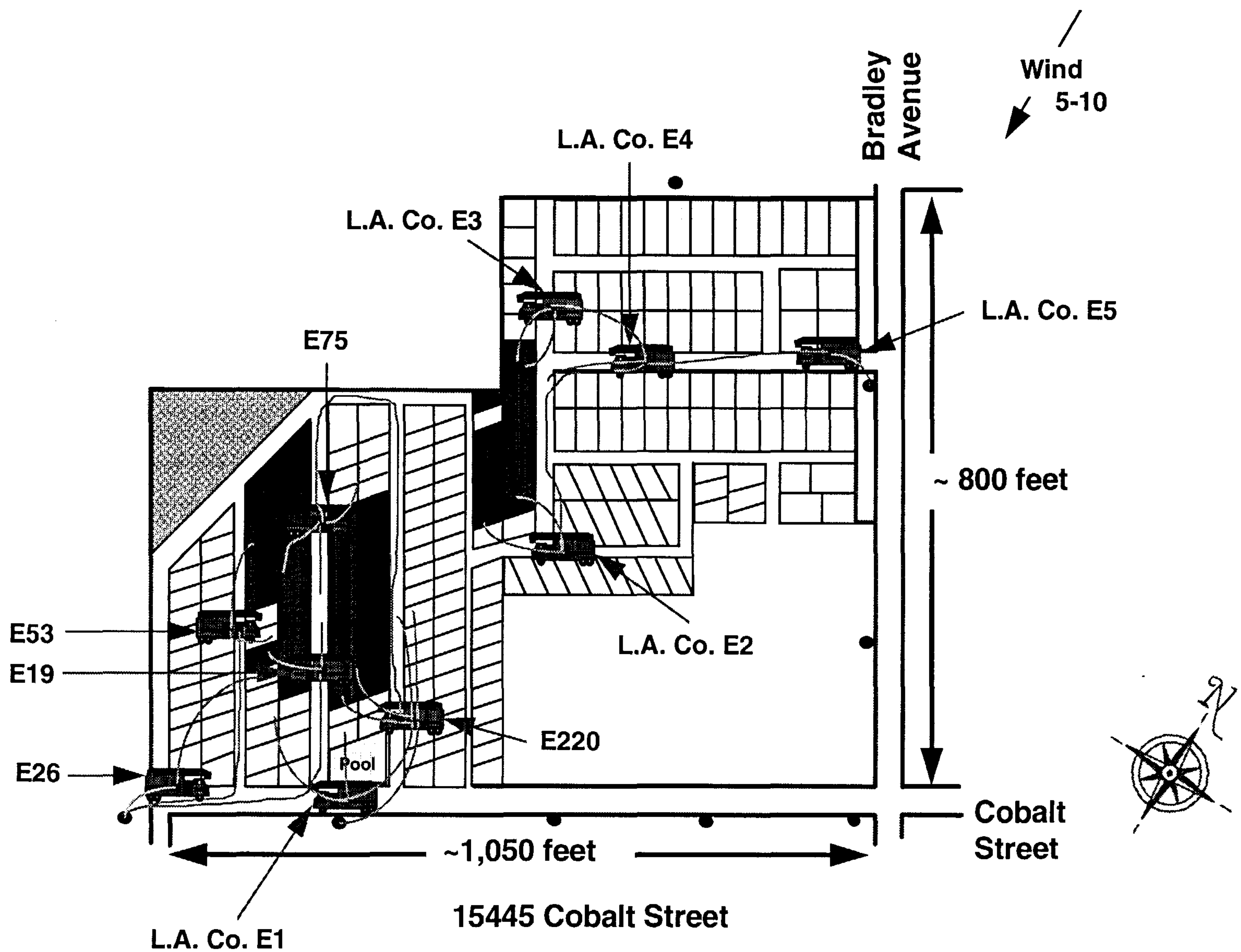


Figure 5-2e: Tahitian Park fire scene at 8:00 A.M.

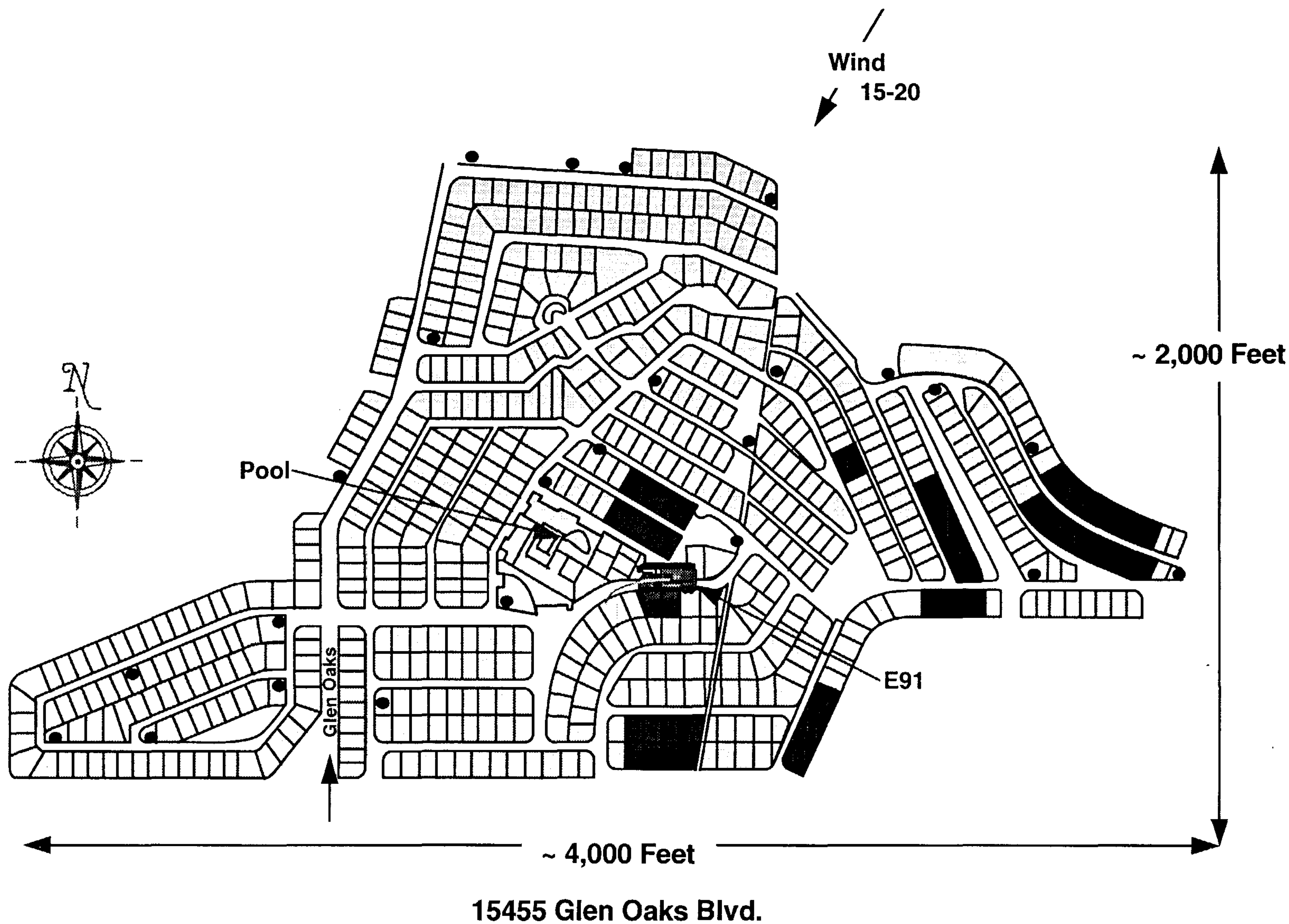
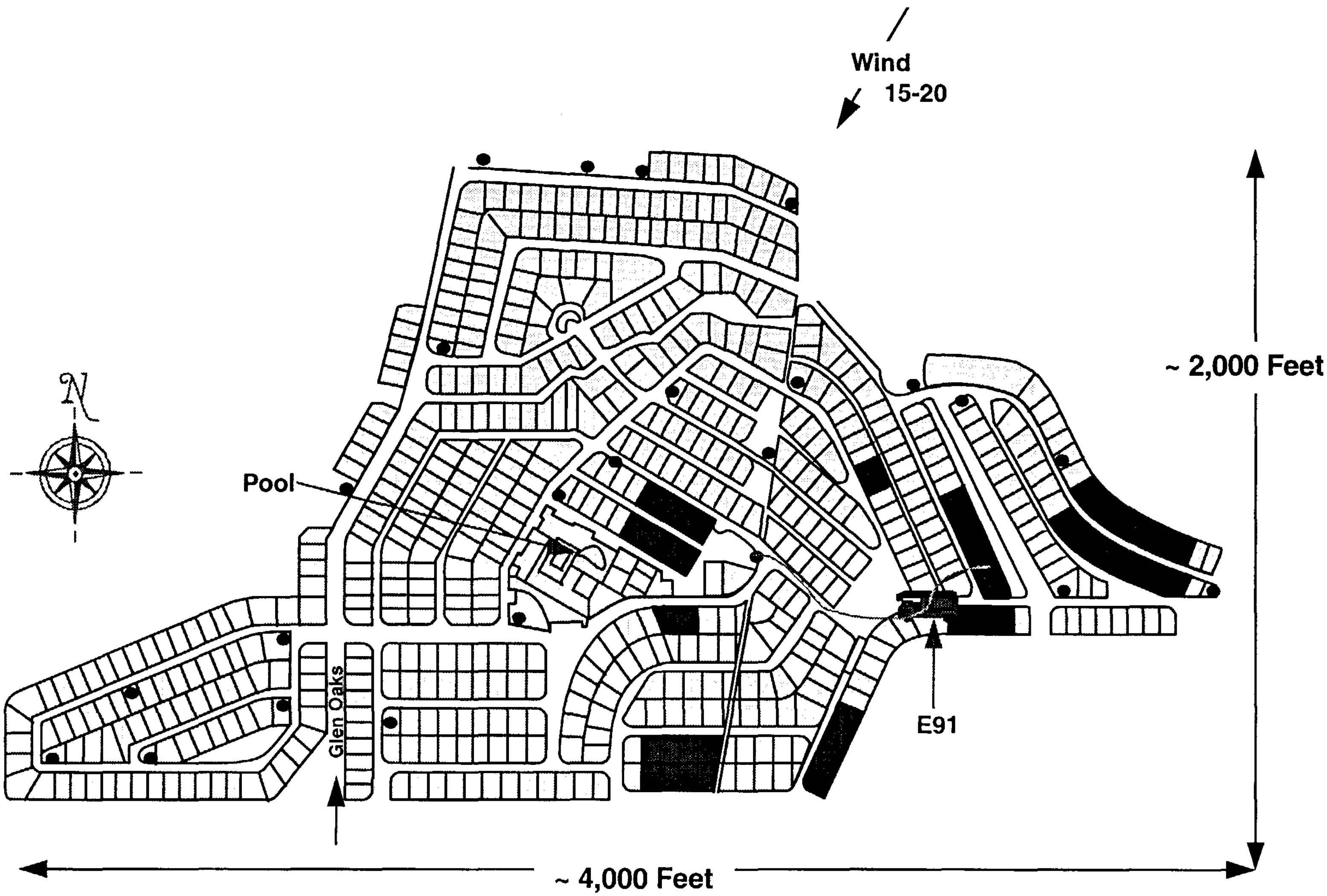


Figure 5-3a: Oakridge fire scene at 4:40 A.M.



15455 Glen Oaks Blvd.

Figure 5-3b: Oakridge fire scene at 5:00 A.M.

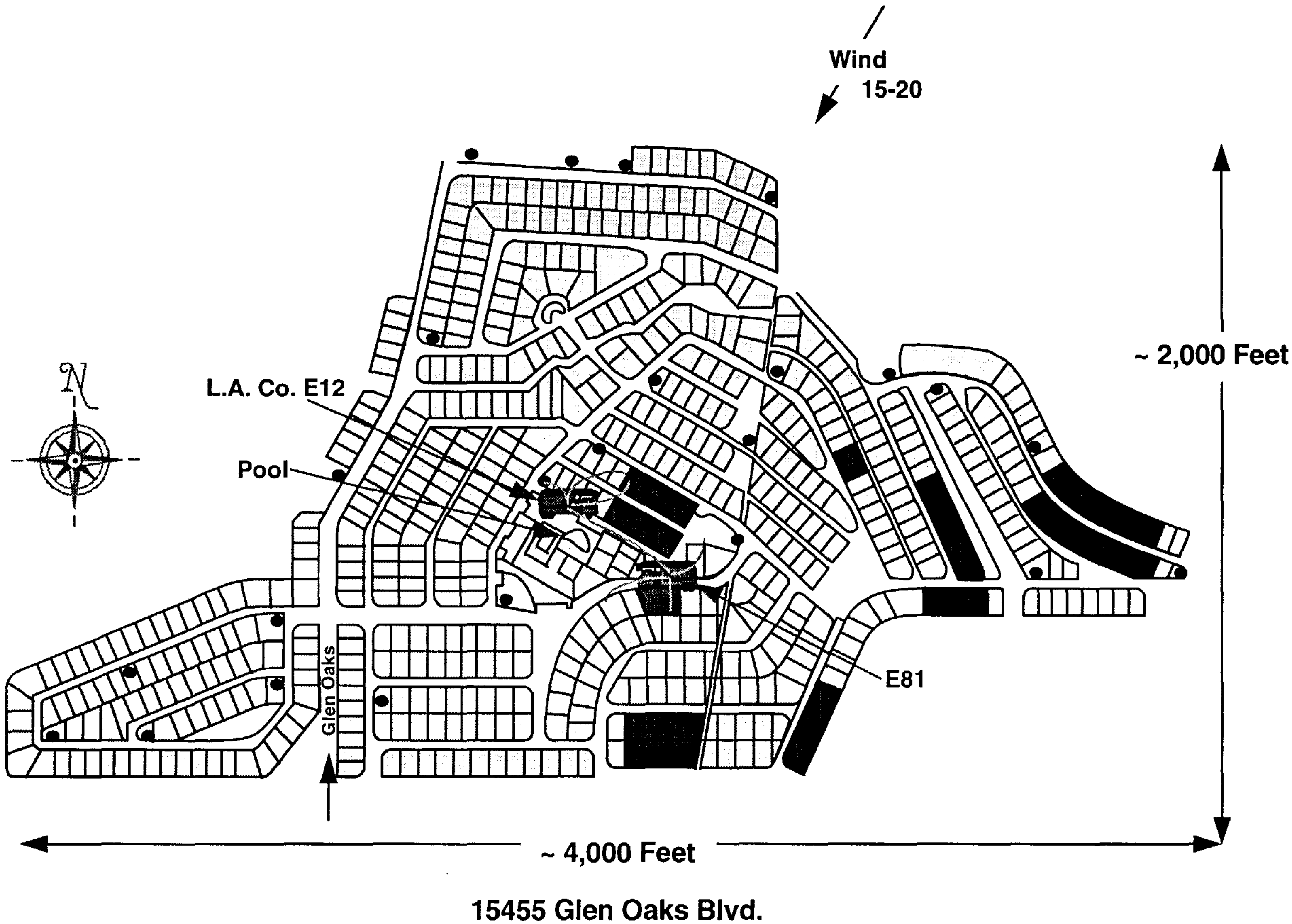


Figure 5-3c: Oakridge fire scene at 5:20 A.M.

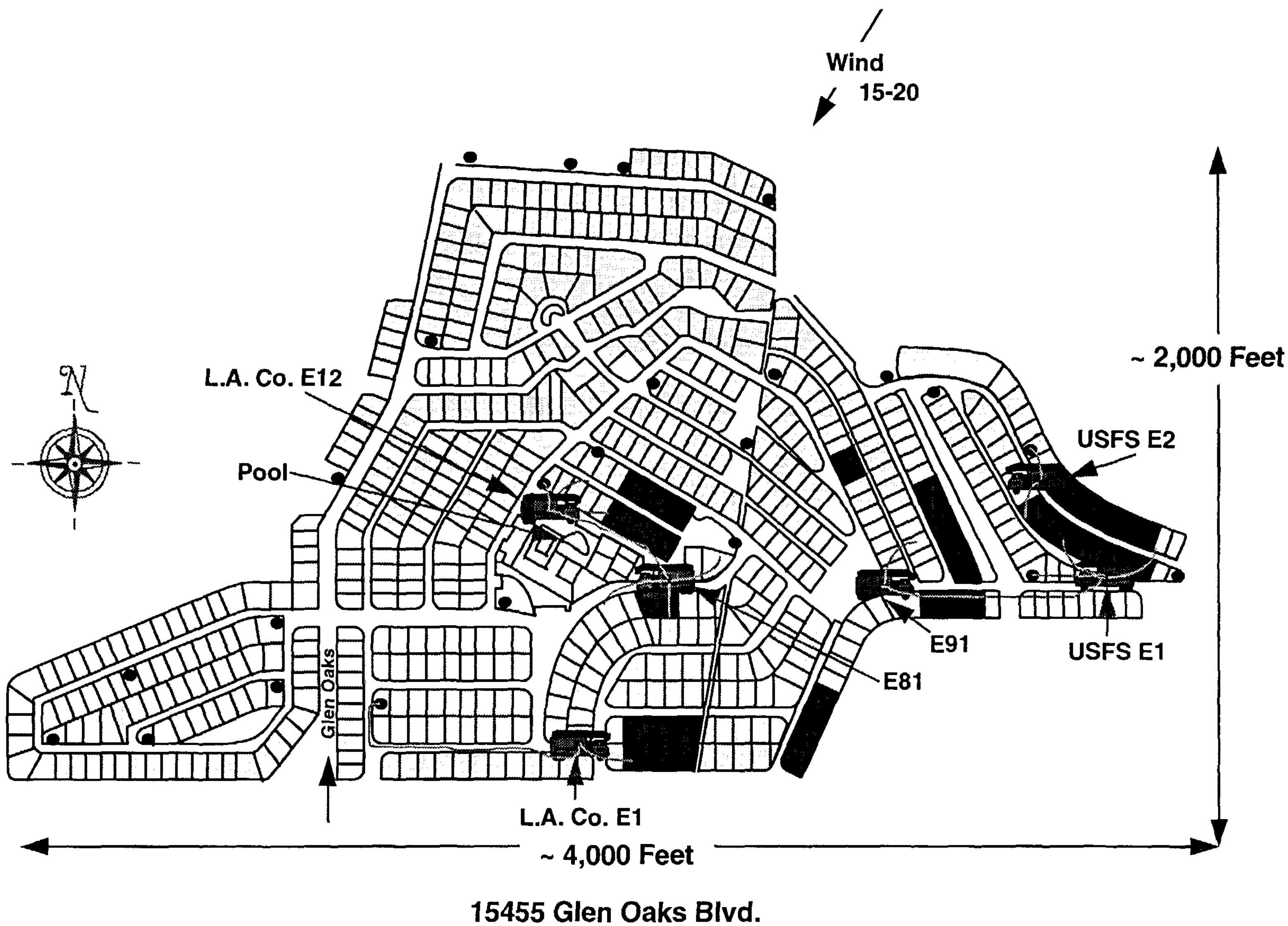
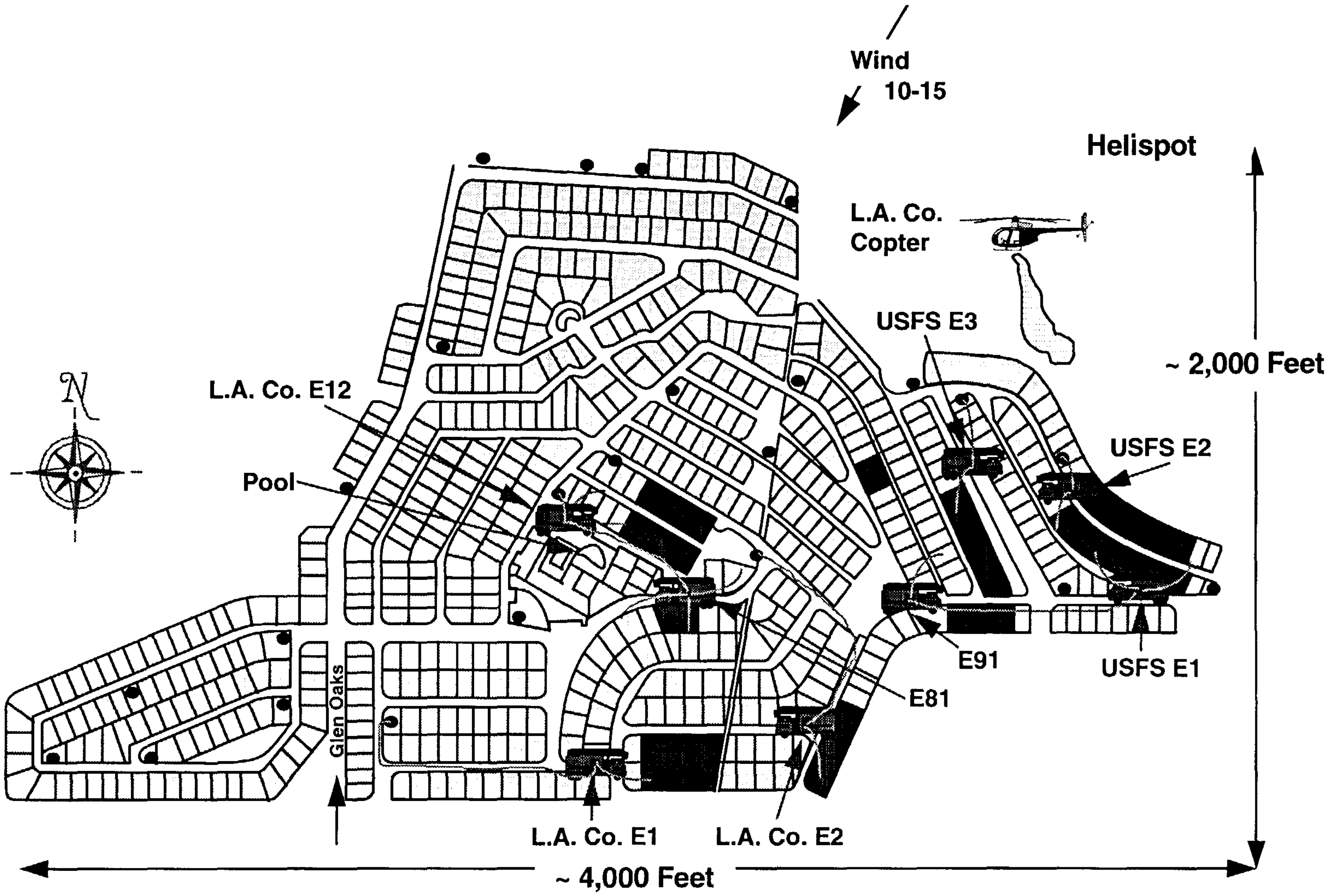
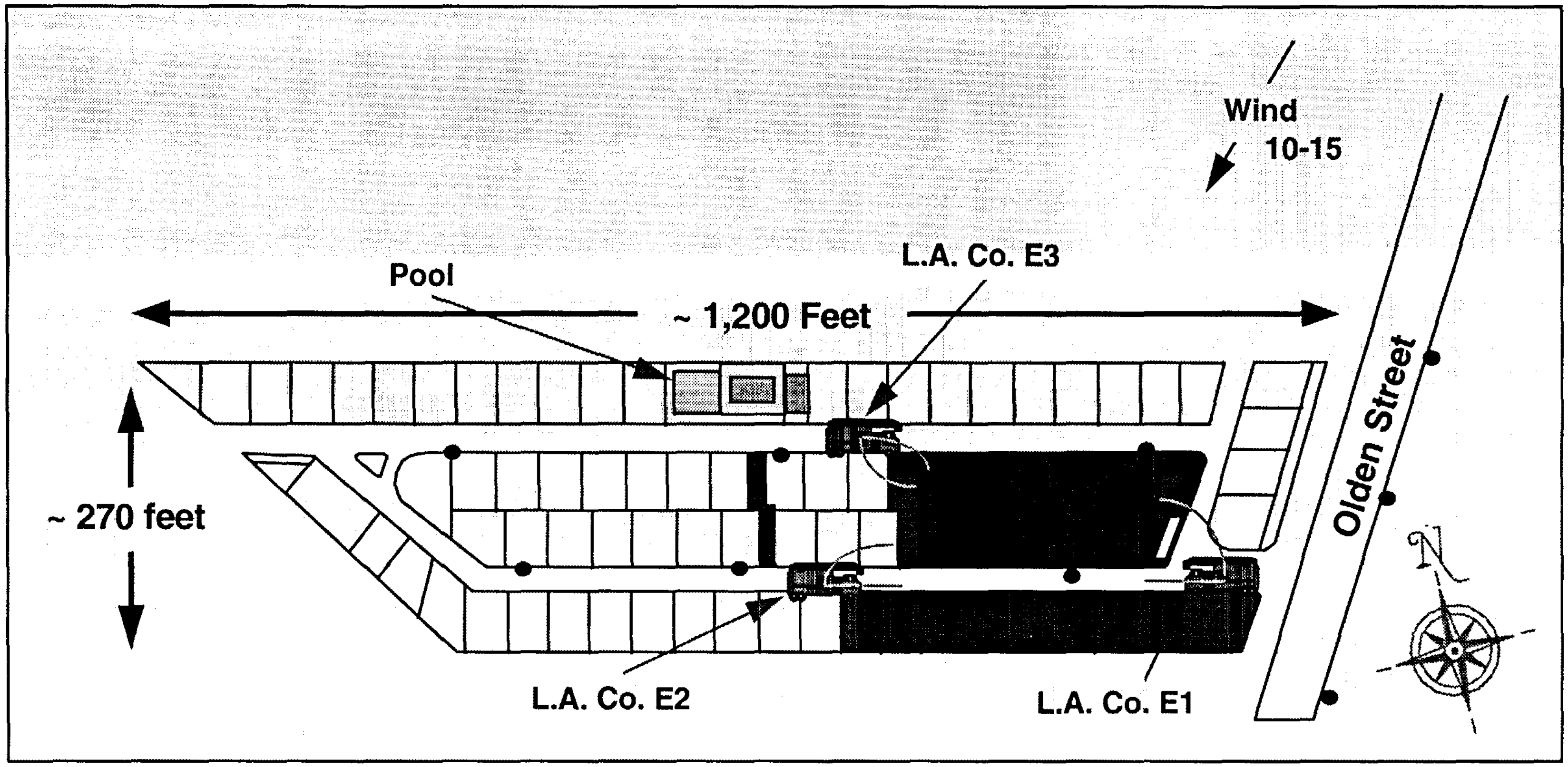


Figure 5-3d: Oakridge fire scene at 5:40 A.M.



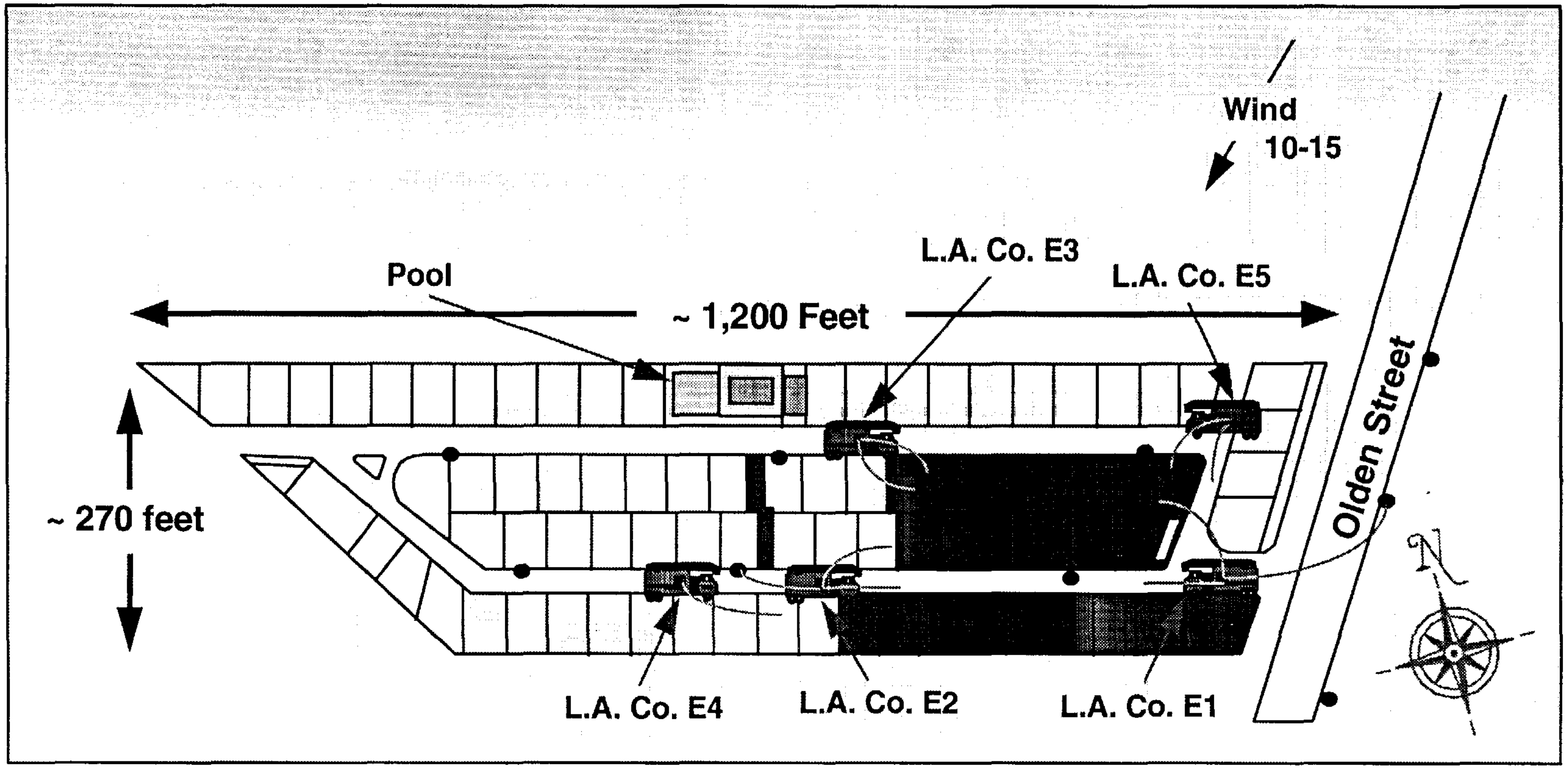
15455 Glen Oaks Blvd.

Figure 5-3e: Oakridge fire scene at 6:00 A.M.



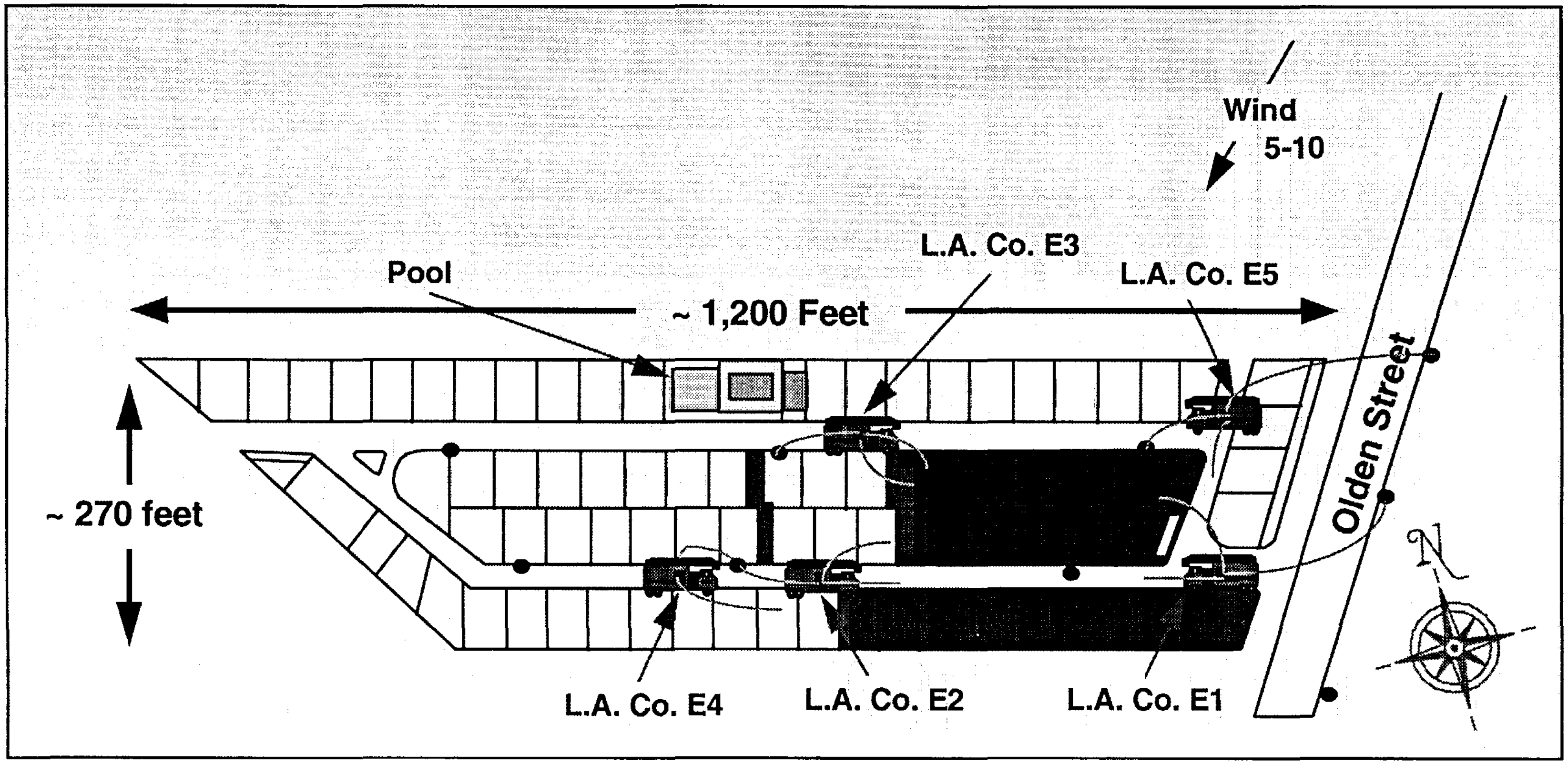
15831 Olden Street

Figure 5-4a: Los Olivos fire scene at 5:30 A.M.



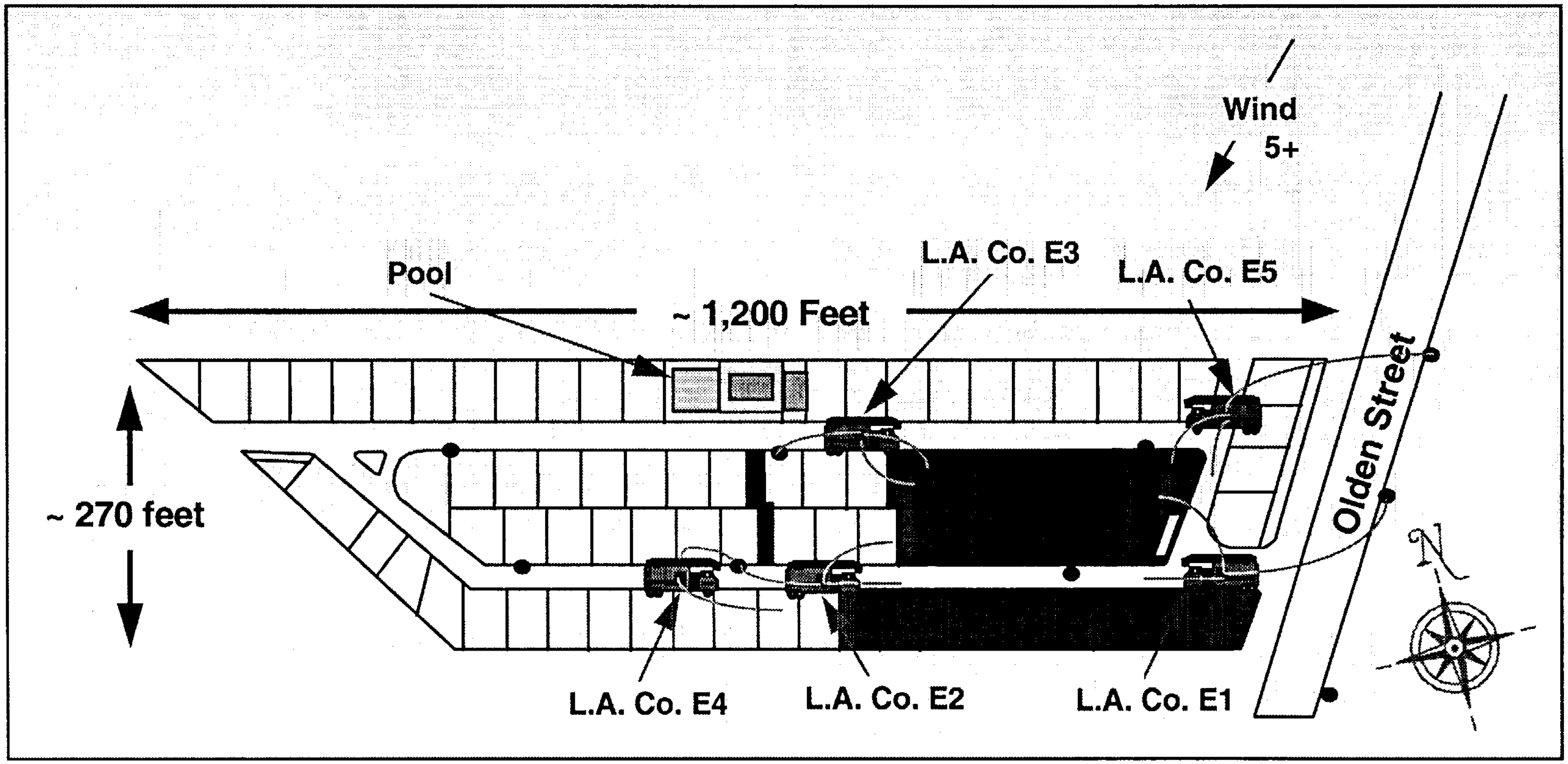
15831 Olden Street

Figure 5-4b: Los Olivos fire scene at 5:45 A.M.



15831 Olden Street

Figure 5-4c: Los Olivos fire scene at 6:00 A.M.



15831 Olden Street

Figure 5-4d: Los Olivos fire scene at 6:15 A.M.

6. LESSONS AND OBSERVATIONS

This section presents useful lessons and observations with regard to fire following earthquake, that can be drawn from the Northridge earthquake data and analyses presented above.

6.1 INTRODUCTION

The purpose of this research was to collect and document fire-related data and aspects of the Northridge earthquake, and record observations based on this experience, regarding the potential for major fires in future earthquakes. While a full analysis of the collected data was beyond the scope of the present project, the analyses of the data presented in section 4, and the detailed accounts of selected fireground operations presented in section 5, permit a number of useful observations and the identification of selected lessons which can be beneficial with regard to mitigating the problem of fire following earthquake. Additional insights on the Northridge earthquake can also be gained by comparison with other events - in particular:

- the 6:00 A.M. February 9,1971 M_w 6.7 San Fernando earthquake, also occurring in the San Fernando valley, with an epicenter approximately 15 km. northeast of the Northridge earthquake epicenter (the two events in fact had overlapping aftershock zones)

- the 5:46 A.M. January 17, 1995 M_w 6.9 (JMA M7.2) Hanshin (official name: Hyogo-ken Nambu), centered under the northern tip of Awaji island near Kobe, in the Kansai region of Japan.

Comparisons of these two events with the Northridge earthquake are discussed below.

6.2 THE NORTHRIDGE EARTHQUAKE

While the Northridge earthquake resulted in extremely strong shaking, widespread damage and record economic losses, relatively few buildings actually collapsed, and loss of life was relatively small. This is emphasized when the Northridge earthquake event is contrasted with the Hanshin (Kobe) earthquake of exactly one year later - both of similar magnitude and occurring in advanced industrialized urban regions early in the morning, the loss of life in Northridge earthquake was 57, while the Kobe event's death toll is estimated at more than 6,000.. Due to the relatively few collapses and resulting light search and rescue (SAR) demands, local fire departments were relatively free to respond to fires, and LAFD and other departments coped in general very well with the fires that resulted. LAFD, for example, reported that all fires were under control by 9:45 A.M. of January 17 (Tierney et al, 1995).

6.3 FIRE DEPARTMENTS

Facilities

In general, fire department facilities (fire stations, communications, etc) performed well - several stations were damaged, but not severely, and the damage did not significantly impede response. However, LAFD had had all stations reviewed for earthquake safety in previous decades, and other jurisdictions may not have. Therefore, all existing fire stations should be reviewed for earthquake safety and functionality.

In regard to communications, which are vital for efficient utilization of fire department resources, the Northridge earthquake highlighted several problems. LAFD central dispatch's loss of power might have been critical, if the demands had been even higher. Therefore, all existing fire department communications and dispatch facilities should be reviewed for post-earthquake functionality.

Planning

While overall fire department earthquake emergency planning was proven satisfactory in this event, several important observations emerged. Several fire departments affected by this earthquake have an earthquake emergency plan that, given a major earthquake, delegates the responsibility to battalion commanders for all emergency operations and control within their geographic areas, including the dispatching of their resources. This planning is based on several assumptions, including anticipation of communications problems and recognition that significant numbers of fires and other emergencies will not be reported to the central dispatch center, due to overload or failure of the telephone system. The January 17 earthquake, however, was an incident of intermediate size, such that, in several departments, the decision was made not to fully implement the earthquake emergency plan. That is, management of local resources was not relinquished to the battalion level, so that dispatch control was retained by the central dispatch center. While this appears to have resulted in generally satisfactory response, it is now recognized that conditions for full implementation of an earthquake emergency plan need better definition. That is, one of the reasons for localized command and control is the recognition that significant numbers of fires and other emergencies will not be reported to the central dispatch center, due to overload or failure of the telephone system. However, it was observed during the January 17 event that the central dispatch centers are not able to reliably determine whether they are receiving full telephone service. If some emergency reports are being received, even though this may be a large number of reports, it may constitute only a fraction of the actual emergencies at the time. Central dispatch centers have no way of determining this and, furthermore, are often too burdened to even be considering this question. Future earthquake emergency planning should include well-defined, measurable, conditions under which the responsibility for all emergency operations and control within geographic areas, including the dispatching of resources, is delegated to local commanders.

6.4 IGNITIONS AND FIRE SPREAD

A number of observations emerge from the January 17 earthquake, concerning fire ignitions and response. Firstly, while there were a significant number of earthquake-related fires, these were all brought under control within several hours of the earthquake. Furthermore, the resources of the Los Angeles region were sufficient to deal with all fire ignitions, as well as other emergencies, such as search and rescue, hazardous materials releases, etc. This is an excellent response, and is due to the large well-equipped fire service in the Los Angeles region, which has dealt with a large number of fires and other emergencies in the last several years. However, this earthquake was actually only a relatively intermediate-sized event which, combined with the time of day, only caused a fraction of the ignitions that a larger earthquake is capable of*. Wind, humidity and other conditions were also favorable, and not a problem. While firefighting water supply failed in the heavily affected area, firefighters were able to avail themselves of alternative sources (e.g., backyard swimming pools). Such alternative sources would likely not suffice should conflagrations have developed.

Response

Fire department response was very good, even though impeded by communications problems and lack of water due to damage to the water system. A perennial lesson in fire service planning is the need for alternative water supplies. Backyard swimming pools sufficed at Balboa Blvd. and some other locations in the Northridge earthquake, but other regions may not have these. Therefore, research is needed in innovative materials and techniques, or alternatives, to water for fire suppression, such as:

- foams, for example, can increase the effectiveness of water manyfold.
- aerial attack has been suggested for large urban conflagrations, and it was used to a very limited extent in the Northridge earthquake. However, its effectiveness in urban firefighting remains to be demonstrated - structural fires are primarily *internal* fires, so that wetting of fuels by external aerial attack is problematic, with the exception for example of wood shake roofs. In southern California, shrubbery and vegetation are a major factor in fire spread, so that aerial attack can be beneficial, in selected situations.
- portable water systems, using large diameter hose to create above-ground water mains are another alternative for delivery of large amounts of water over mid-range distances (e.g., 1 to 10 km) at short notice. These have been developed and extensively employed in the San Francisco Bay Area, including very effective applications during the 1989 Loma Prieta earthquake and 1991 East Bay Hills fire (Scawthorn and Blackburn, 1990; Scawthorn, 1992).

* See for example, Scawthorn et al (1994) NFPA J. , where more than 500 ignitions are projected for a large earthquake on the Newport Inglewood fault zone in west-central Los Angeles.

Observations from Specific Incidents

Review of the specific incidents discussed in section 5 provides a number of observations, including (the incident which suggested the specific lesson is identified parenthetically):

Water

- Preplan alternate water sources (Balboa)
- Use water efficiently. One can do a lot with a limited amount if properly directed on exposed surfaces. (Balboa)
- Consider the use of shallow water draft (12" - 18") equipment. (Balboa)
- When hydrants are being tested for water, the water should be released for a longer period of time. (Tahitian)
- The engine company water tank capacity of 500 gallons was very beneficial when used sparingly. (Los Olivos)
- Evaluate use of water-dropping helicopters for fire control of structures (Oakridge)

Planning

- Pre-incident evacuation plans by residents worked well. (Tahitian)
- Properly directed civilian volunteers can be very effective. (Balboa)
- Allocate available radio frequencies to those geographic areas with the highest number of incidents. (Balboa)
- Evaluate the effectiveness of implementing a command system (Incident Command System) that is used by multiple responding fire departments (Los Angeles City, Los Angeles County, and USFS) (Oakridge)

Operations

- Safety and teamwork are essential to working in areas with multiple hazards, including the hazard of earthquake aftershocks. (Balboa)

- Response priorities for the Sylmar area were made by the Los Angeles City Battalion Chief for that area according to an established earthquake response plan (Los Olivos)

- Immediate mutual aid response was very effective, especially considering that the Sylmar area is on the northeast edge of the city of Los Angeles. (Los Olivos)

Mobile Home Park Design

- Review and improve mobile home park safety design (Tahitian)

- Redesign utility hookups to accommodate structure movement.

- Provide accessible central shutoff for natural gas. This shutoff should control the entire park.

- Improve seismic support and bracing of mobile homes.

- Provide clearer space between units.

<u>Incendiary Fires</u>

The problem of arson immediately following an earthquake is a major concern. As in past earthquakes, however, arson immediately following the Northridge earthquake was not a major problem. The first three days following the Northridge earthquake resulted in 11 incidents (both structure fires and mobile fires) that have been judged or may be judged as incendiary by the Los Angeles Fire Department. This compares with an average daily occurrence of about 10 incendiary fires.

Problems with incendiary fires do exist long after the initial earthquake damage, however. Buildings that are vacated and may still contain valuables are attractive nuisances. Furthermore, vacant buildings may be occupied by vagrants or homeless persons. Unauthorized entrance or occupation increases the likelihood of fire ignition. The vacant nature and damaged state of the building also makes fire fighting dangerous and more difficult. In the months following the Northridge earthquake, LAFD reports a number of incendiary fires in vacated buildings. In response to this problem, LAFD has initiated a program of inspection and pre-fire planning for vacant buildings, so that responding firefighters will at least be familiar with the buildings.

6.5 COMPARISON WITH OTHER EVENTS

Northridge versus the 1971 San Fernando Earthquake

With regard to fire-related aspects, it is of interest to note the striking similarities of the 1994 Northridge earthquake to the 1971 San Fernando earthquake. This may not be surprising, in that the two events are of similar magnitude (M_W 6.7 for the 1971 event, versus M_W 6.7 for the 1994 event) in relatively the same locations, and occurring at similar times of day and year (0600 February 9 vs. 0431 January 17). Not only is the total number of earthquake-related fires almost identical, but the distribution is quite similar, as shown in Table 6-1. The description of the 1971 event provided by Steinbrugge et al (1971) could almost be used word for word for the 1994 event. Broken gas mains on Balboa Blvd. resulting in large flares, as shown in Photo 3-16 of this report, are almost identical to photographs of flares due to broken gas mains on Glenoaks Blvd. in 1971, as shown in Figure 5 of Olson (1973).

Northridge versus the 1995 Hanshin (Kobe), Japan Earthquake

The 5:46 AM January 17, 1995 M_W 6.9 (JMA M7.2) Hanshin (official name: Hyogo-ken Nambu) earthquake was centered under the northern tip of Awaji island near Kobe, in the Kansai region of Japan. The event resulted in Modified Mercalli Intensity (MMI) shaking intensities greater than MMI VIII over approximately 400 square km of the Kobe-Ashiya-Nishinomiya-Amagasaki area, with a total population of 2.46 million. The Kobe Fire Department (KFD) protects 1.5 million persons, and is a modern, well-trained fire response agency, with 1,298 uniformed personnel, two helicopters, two fireboats, and 196 vehicles. Approximately 100 fires broke out within minutes of the earthquake, primarily in densely built-up, low-rise areas of the central city, which comprise mixed residential-commercial occupancies, predominantly of wood construction. Within 1 to 2 hours, several large conflagrations had developed. Modes of fire reporting were unclear as of this writing, and fire response was hampered by extreme traffic congestion, and collapsed houses, buildings, and rubble in the streets. Because of the numerous collapses, many areas were inaccessible to vehicles. The final burned area in Kobe was estimated at 1 million square meters, with 50% of this in the Nagata Ward. Kobe sustained approximately 1,750 breaks in its underground water distribution system. Water for fire-fighting purposes was available for 2 to 3 hours, including the use of underground cisterns. Subsequently, water was available only from tanker trucks. KFD attempted to supply water with a fireboat and relay system, but this was unsuccessful due to the relatively small hose used by KFD. Several observations emerge from these two earthquakes, which are summarized in Table 6-2. Specifically:

- **Ignitions:** The total number of ignitions is comparable - 110 for the Northridge event, versus 108 for Kobe City. Considering population affected, the ignition rate is also comparable.

- **Response:** In Northridge, ignitions were all brought under control within several hours of the earthquake. Furthermore, the resources of the Los Angeles region were sufficient to deal with all fire ignitions, as well as other emergencies, such as search and rescue, hazardous materials releases, etc. The fire service in Los Angeles equates to approximately 1 firefighter per 1,338 population, while in Kobe this ratio is about 1/1,138, or quite similar. However, Los Angeles region is significantly larger than Kobe, so that Los Angeles had more than four times the total resources of Kobe, a significant difference.

- **Weather Conditions:** Wind, humidity and other conditions were favorable in both cases and not a major problem.

- **Water Supply:** In Los Angeles, while firefighting water supply failed in the heavily affected portions of Northridge, firefighters were able to avail themselves of alternative sources (e.g., backyard swimming pools). In Kobe, due to the more than 2,000 breaks in the underground water distribution system, the fire department was without water within several hours, and found it difficult to relay or otherwise obtain water for firefighting purposes. As a result, fire spread in Kobe was significantly greater than in Northridge, resulting in the destruction of perhaps 5,000 buildings in Kobe.

6.6 UTILITY SYSTEMS

Water Supply

The Northridge earthquake significantly affected the water supply for portions of the San Fernando Valley, forcing fire departments to resort to alternative water supplies, which were not always effective. As discussed above, more effective alternatives to existing water supplies and fire-department dependencies are required. Additionally, water supply agencies can significantly improve the situation by enhancing the seismic ruggedness of their systems, through identification of seismic vulnerabilities, enhanced redundancies in system configuration, rapid seismic shut-off valving and other measures (Scawthorn, 1993; 1996).

Power and Gas Systems

Electricity and gas were clearly identified in section 4 as major contributors to fire ignitions following earthquake. Seismic shut-off gas valves appear to have functioned effectively. While no comparable seismic shut-off device appears to be on the market for electric services, their development should be considered.

Table 6-1

COMPARISON OF FIRES FOLLOWING THE

1994 NORTHRIDGE AND 1971 SAN FERNANDO EARTHQUAKES

Community	Number of Earthquake-Related Fires 1994	Number of Earthquake-Related Fires 1971
Los Angeles City	77	64
Los Angeles County	~15	25
Ventura County	~10	
Santa Monica	4	
Burbank	0	7
Pasadena	1	2
Glendale	0	9
South Pasadena	0	
Beverly Hills	1	
Culver City	0	
Fillmore	2	
TOTAL	**~110**	**109**

Source for 1971 data: Steinbrugge et al (1971)

Table 6-2

HANSHIN AND NORTHRIDGE EARTHQUAKES: COMPARATIVE ANALYSIS

Aspect	Factor	Northridge	Hanshin
Event	Magnitude (M_W)	6.7	6.9
	Date (winter)	Jan 17	Jan 17
	Time	0431	0546
Region	Population (MMI 8)	1.2 million	2 million
	Area (sq. km)	781	40
	Density (pop/sq km)	1,536	50,000
Ignitions	Number (total)	110	108
	Structural Fires	86%	97%
	Rate (MMI 7) **Ign/pop:**	14,719	13,676
Response	FD Communications	manual dispatch	
	Resources (ff/popul):	1,338	1,540
	Stations	104	26 (Kobe)
	Traffic Congestion	Minor	Major
	Mutual Aid	Available - not needed	after 10 hrs
Water	Water System Damage	Some	Total?
	Cisterns	Swimming Pools	946, mostly 40 tons (10 mins)
Wind		Calm	Minor
Gas	Automatic Shut-offs	? few %	78% - ineffective due to structl collapse
Spread		Minor	Major: 5,000 bldgs

7. CONCLUDING REMARKS

The Northridge earthquake is the most damaging earthquake, at least from a property point of view, to have occurred in the US since the 1906 earthquake. In modern times, the only disaster to rival it in terms of property loss has been Hurricane Andrew in the US, and the Kobe earthquake in Japan. While Andrew caused comparable monetary loss, the Hurricane actually caused comparatively little damage to larger buildings. In contrast, the Northridge event is typical of earthquakes in that larger, multi-story buildings are not immune from major structural damage and even collapse. Such damage poses severe challenges to firefighters responding to post-earthquake fires and/or search and rescue emergencies.

7.1 FIRE FOLLOWING EARTHQUAKE

Viewed in the context of the 1971 earthquake, the 1991 East Bay Hills fire, the 1992 Los Angeles Civil Disturbances, the 1993 Southern California wildfires, the 1995 Kobe earthquake, and projections for larger US earthquakes (Natural Disaster Coalition, 1993), the 1994 Northridge earthquake and associated fires reinforces the following points:

- earthquakes in urban areas continue to cause multiple simultaneous ignitions, and degrade emergency response due to impaired communications, transportation and water supply
- these events are replicable, as shown by comparison of the 1971 and 1994 events, providing some validation for simulation modeling and projections for larger events
- under adverse conditions, large conflagrations are possible in California cities, as shown by the 1991 and 1993 events
- the California fire service and mutual aid systems are capable of effective response to multiple simultaneous ignitions, as shown by the 1971, 1993

and 1994 incidents (although the approximately 500 ignitions for the 1994 Civil Disturbances were spread over three days)

- projections for larger earthquakes in Los Angeles indicate perhaps 500 ignitions within several hours

This accumulation of experience leads to the conclusion that the potential exists for large conflagrations following a major earthquake in an urban area. Under adverse meteorological and other conditions, these conflagrations may burn for several days, replicating the events of 1906 in San Francisco. The California mutual aid system will be able to mobilize large resources in response, but the deployment of these resources will be hampered by transportation difficulties and, perhaps most tellingly, failure of firefighting water supplies. Improvements in planning and infrastructure are absolutely required to forestall this potential.

7.2 ADDITIONAL RESEARCH

The magnitude and importance of the fire following earthquake problem has been emphasized in the above, and by the events of January 17, 1994. In order to mitigate this problem, a number of actions are required, which can be facilitated by the following suggested areas for research:

- improved understanding is required with regard to factors contributing to overall loss, including

  - **ignitions** - what are the primary sources; what devices, or education, might reduce the number

  - **fire spread** - rates of building - building spread as a function of wind, exposure distance, building materials, and protection measures are required, for improved simulation and to identify areas for mitigation

  - **communications** - problems, both hardware, software and operational, continue to exist. How can fire departments be provided with adequate communications bandwidth during a high intensity event like a major earthquake? More hardware alone is not the solution, as decision-making overload may prove to be the bottleneck. What planning, decision-making software or other aids might contribute to easing the decision-making load?

— **water supply** - inadequacies continue to be a problem - we have discussed alternatives above (section 6), and emphasize here again the need for both water alternatives, and for rapidly-deployable high-volume water transport apparatus.

- additional analysis of Northridge earthquake data - while the database for ignitions has been compiled and presented in this project, and some limited analyses performed, there are still substantial analyses to be performed, including: (a) more refined statistical work with regard to ignitions, spread, and response, (b) modeling to attempt to replicate the Northridge earthquake experience, (c) further comparison of the Northridge earthquake with other events - the limited comparisons herein, with the 1971 San Fernando and 1995 Kobe events are very enlightening.

- modeling of the overall problem of fire following earthquake needs to be continued and extended. Simulation modeling of the phenomena has been performed by the first author of this report (Natural Disaster Coalition, 1993), but significantly more work remains to be done. Additionally, a user-friendly generic model of the phenomena needs to be developed and provided to fire departments in seismic areas, for the planning and training purposes.

8. REFERENCES

AIRAC (1987) Fire Following Earthquake, Estimates of the Conflagration Risk to Insured Property in Greater Los Angeles and San Francisco, Report prepared for the All-Industry Research Advisory Council by C. Scawthorn, All-Industry Research Advisory Council, Oak Brook, IL.

Callahan, J. (1987) A Report by The Los Angeles City Fire Department on the Whittier Narrows Earthquake of October 1, 1987.

Dewey, J.W., B.G. Reagor, L. Dengler, and K. Moley (1995) Intensity Diestribution and Isoseismical Maps for the Northridge, Calfornia, Earthquake of January 17, 1994, U.S. Geological Survey Open-File Report 95-92.

Eguchi, R. et al (1996) Analyzing Economic Impacts and Recovery from Urban Earthquakes, draft of paper for *Analysing Economic Impacts and Recovery from Urban Earthquakes: Implications from Research on the Northridge Earthquake,* conference sponsored by the Earthquake Engineering Research Institute and Federal Emergency Management Agency, Pasadena, Oct.

EQE (1995) The Northridge Earthquake of January 17, 1994: Report of Data Collection and Analysis, Part A: Damage and Inventory Data, prepared by EQE International, Inc. And The Geographic Information Systems Group of the Governor's Office of Emergency Services, for Governor's Office of Emergency Services, State of California, May.

Hall, J.F. (1996) Wood Buildings, in section in *Northridge Earthquake of January 17, 1994 Reconnaissance Report, Vol. 2,* Tech. Editors J. F. Hall, Earthquake Spectra, Supplement C to Vol. 11, January

Holzer, T.L. et al (1996) Causes of Ground Failure in Alluvium during the Northridge , California, Earthquake of January 17, 1994, Proc. 6th US-Japan Workshop on Earthquake Resistant Design of Lifeline Facilities and Countermeasures against Earthquakes, Waseda University, Tokyo, June.

Los Angeles Fire Department (1994) 1994 Northridge Earthquake, After-Action Report (Draft)

Lund, L. et al (1995) Lifelines, section in *Northridge Earthquake of January 17, 1994 Reconnaissance Report, Vol. 1, Tech.* Editor J. F. Hall, Earthquake Spectra, Supplement C to Vol. 11, April.

Natural Disaster Coalition (1993) Fire Following Earthquake, Estimates of the Conflagration Risk to Insured Property in Greater Los Angeles,San Francisco, Seattle and Memphis Areas, Report prepared for the Natural Disaster Coalition by C. Scawthorn and M. Khater, available from the Insurance Institute on Property Loss Reduction, Boston MA.

Olson, R.A. (1973) *Individual and Organizational Dimensions of the San Fernando Earthquake*, in San Fernando, California, Earthquake of February 9, 1971, NOAA, US Dept. of Commerce, Washington.

Scawthorn, C., M. Khater and C. Rojahn, 1993. A Model Methodology for Assessment of Seismic Vulnerability and Impact of Disruption of Water Supply Systems , Proc. 1993 National Earthquake Conference, Memphis TN.

Scawthorn, C., K.A. Porter and F. T. Blackburn, 1992. Performance of Emergency Response Services After the Earthquake, USGS Prof. Paper 1551-F, The Loma Prieta, California Earthquake of October 17, 1989 - Marina District, T.D. O'Rourke, ed., Strong Ground Motion and Ground Failure, T.L. Holzer, Coord.

Scawthorn, C., Frank T. Blackburn. 1990. "Performance of the San Francisco Auxiliary and Portable Water Supply Systems in the 17 October 1989 Loma Prieta Earthquake." Proceedings 4th U.S. National Conference on Earthquake Engineering, Palm Springs, CA.

Scawthorn, C., T.D. O'Rourke. 1989. "Effects of Ground Failure on Water Supply and Fire Following Earthquake: The 1906 San Francisco Earthquake." Proceedings, 2nd U.S. - Japan Workshop on Large Ground Deformation, July, Buffalo.

Scawthorn, C., F.T. Blackburn and J. Neil. 1989. "Earthquake Preparedness for Fire Departments--Anticipating a Major Disaster." Firehouse Magazine, December, New York.

Scawthorn, C., M. Bouhafs and F. T. Blackburn. 1988. "Demand and Provision for Post-earthquake Emergency Services: Case Study of San Francisco Fire Department." Paper presented at the 9th World Conference of Earthquake Engineering, Tokyo and Kyoto.

Scawthorn, C. and Donelan, J. (1984) Fire-Related Aspects of the Coalinga Earthquake, Chapter in the Earthquake Engineering Research Institute report on the Coalinga Earthquake of May 2, 1983.

Scawthorn, C., Bureau, G., Jessup, C., and Delgado, R. (1985) Fire-related Aspects of 24 April 1984 Morgan Hill Earthquake, Earthquake Spectra, v. 1, n. 3, 1985.

Scawthorn, C. (1992) Conflagrations: The Forgotten Disaster. Proc. 1992 Annual Forum, National Committee on Property Insurance, Boston MA.

- (1996) Reliability-based design of water supply systems, Proc. 6th US-Japan Workshop on Earthquake Resistant Design of Lifeline Facilities and Countermeasures against Earthquakes, Waseda University, Tokyo, June.

- (1989) "Fire Following Earthquake in High-rise Buildings." Chapter in Topical Volume on Fire, Council on Tall Buildings and Urban Habitat, Bethlehem.

- (1987) "Fire Losses From Earthquakes: State of the Art." Paper presented at the 3rd International Conference on Soil Dynamics and Earthquake Engineering, Princeton.

- (1986a) Use of Damage Simulation in Earthquake Planning and Emergency Response Management, chapter in Terminal Disasters: The Use of Computers in Emergency Management, Marston, S., ed., Monographs in Environment and Behavior Series, No. 39, Institute of Behavioral Sciences, University of Colorado, Boulder, 1986.

- (1986b) Simulation Modeling of Fire Following Earthquake, Proc. Third U.S. National Conference on Earthquake Engineering, Charleston, S.C., 1986.

- (1986c) Lifeline Aspects of Fire Following Earthquake, Workshop on Abatement of Seismic Hazards to Lifelines, Building Seismic Safety Commission, Washington, 1986.

- (1986d) Fire-related incidents, section in Report on the North Palm Springs, California, Earthquake-July 8, 1986, EERI Special Earthquake Report, Earthquake Engineering Research Institute Newsletter, A.G. Brady, ed.

Steinbrugge, K.V. et al (1971) *San Fernando Earthquake, February 9, 1971,* Pacific Fire Rating Bureau, San Francisco CA.

Stewart, J.P., J.D. Bray, R.B. Seed, and N. Sitar (1994) Preliminary report on the principal geotechnical aspects of the January 17, 1994 Northridge earthquake. Earthquake Engineering Research Center Report No. UCB/EERC 94/08, University of California, Berkeley, June.

Tierney, K. et al (1995) Societal Impacts and Emergency Response, section in *Northridge Earthquake of January 17, 1994 Reconnaissance Report, Vol. 1, Tech.* Editor J. F. Hall, Earthquake Spectra, Supplement C to Vol. 11, April.

Wiggins, J.H. (1988) Fires Following the Whittier Narrows Earthquake, Report to the National Science Foundation, Crisis Management, Inc., Redondo Beach, CA.

NIST-114
(REV. 6-93)
ADMAN 4.09

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

MANUSCRIPT REVIEW AND APPROVAL

(ERB USE ONLY)	
ERB CONTROL NUMBER	DIVISION
PUBLICATION REPORT NUMBER NIST-GCR-98-743	CATEGORY CODE
PUBLICATION DATE March 1998	NUMBER PRINTED PAGES

INSTRUCTIONS: ATTACH ORIGINAL OF THIS FORM TO ONE (1) COPY OF MANUSCRIPT AND SEND TO THE SECRETARY, APPROPRIATE EDITORIAL REVIEW BOARD

TITLE AND SUBTITLE (CITE IN FULL)

Fire-Realted Aspects of the Northridge Earthquake

CONTRACT OR GRANT NUMBER
60NANB5D0147

TYPE OF REPORT AND/OR PERIOD COVERED
October 1996

AUTHOR(S) (LAST NAME, FIRST INITIAL, SECOND INITIAL)

Scawthorn, C., Cowell, A.D. and Borden, F.
EQE International, Inc.
San Francisco, CA 94104

PERFORMING ORGANIZATION (CHECK (X) ONE BOX)
- [ ] NIST/GAITHERSBURG
- [ ] NIST/BOULDER
- [ ] JILA/BOULDER

LABORATORY AND DIVISION NAMES (FIRST NIST AUTHOR ONLY)

SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (STREET, CITY, STATE, ZIP)

U.S. Department of Commerce
National Institute of Standards and Technology
Gaithersburg, MD 20899

PROPOSED FOR NIST PUBLICATION
- [ ] JOURNAL OF RESEARCH (NIST JRES)
- [ ] J. PHYS. & CHEM. REF. DATA (JPCRD)
- [ ] HANDBOOK (NIST HB)
- [ ] SPECIAL PUBLICATION (NIST SP)
- [ ] TECHNICAL NOTE (NIST TN)
- [ ] MONOGRAPH (NIST MN)
- [ ] NATL. STD. REF. DATA SERIES (NIST NSRDS)
- [ ] FEDERAL INF. PROCESS. STDS. (NIST FIPS)
- [ ] LIST OF PUBLICATIONS (NIST LP)
- [ ] NIST INTERAGENCY/INTERNAL REPORT (NISTIR)
- [ ] LETTER CIRCULAR
- [ ] BUILDING SCIENCE SERIES
- [ ] PRODUCT STANDARDS
- [ ] OTHER NIST-GCR

PROPOSED FOR NON-NIST PUBLICATION (CITE FULLY) [ ] U.S. [ ] FOREIGN

PUBLISHING MEDIUM
- [ ] PAPER
- [ ] DISKETTE (SPECIFY)
- [ ] OTHER (SPECIFY)
- [ ] CD-ROM

SUPPLEMENTARY NOTES

ABSTRACT (A 2000-CHARACTER OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, CITE IT HERE. SPELL OUT ACRONYMS ON FIRST REFERENCE.) (CONTINUE ON SEPARATE PAGE, IF NECESSARY.)

Data collection and analyses relevant to fires following the Mw 6.7 Northridge Earthquake on January 17, 1994 were performed with the support of the National Institute of Standards and Technology. In the period 4:31AM (i.e., time of main shock) to midnight, there were approximately 110 earthquake related fires. Incident data is compiled in a database termed **FFNRE** Fires Following the **N**orth**R**idge **E**arthquake), which is provided in hardcopy form and magnetic media (diskette), as well as being available on the Internet (at **www.eqe.com**). Fire department operations are detailed at five selected fire incidents. Analyses, and comparison with the 1971 San Fernando and 1995 Hanshin (Kobe) earthquakes, identified a number of ignition factors and provides important observations, lessons and avenues for future research (regarding ignition sources, fire service operations, and utility performance) towards mitigation of this problem.

KEY WORDS (MAXIMUM OF 9; 28 CHARACTERS AND SPACES EACH; SEPARATE WITH SEMICOLONS; ALPHABETIC ORDER; CAPITALIZE ONLY PROPER NAMES)

earthquakes; fires, fire data; fire department operations; fire investigations; ignition sources; water supply

AVAILABILITY
- [X] UNLIMITED
- [ ] FOR OFFICIAL DISTRIBUTION - DO NOT RELEASE TO NTIS
- [ ] ORDER FROM SUPERINTENDENT OF DOCUMENTS, U.S. GPO, WASHINGTON, DC 20402
- [X] ORDER FROM NTIS, SPRINGFIELD, VA 22161

NOTE TO AUTHOR(S): IF YOU DO NOT WISH THIS MANUSCRIPT ANNOUNCED BEFORE PUBLICATION, PLEASE CHECK HERE. [ ]

WORDPERFECT