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The Los Angeles, California Tornado of March 1, 1983

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For:

Committee on Natural Disasters
Commission on Engineering and Technical Systems
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1

INTRODUCTION

At 7:40 a.m. on March 1, 1983, the downtown metropolitan area of Los Angeles was struck by a tornado severe enough to cause significant structural damage to not only old buildings but also modern, engineered structures. The path of the tornado (see Figure 1) was such that it moved in approximately a south to north direction and passed within a quarter mile of major high-rise buildings.

Due to the lack of historical tornadoes in the area and the absence of the typical meteorological events preceding a midwestern tornado, the National Weather Service did not issue a tornado watch. However, the tornado did occur. This report summarizes the meteorological situation before and after the tornado, discusses the observed structural damage to buildings and lifelines, and examines the emergency planning and preparedness for such an event in the City of Los Angeles. The report's purpose is twofold. First, it provides a conveniently available account of the event and records the available data for historical purposes. Second, it identifies and recommends cases in which further in-depth study would contribute to the improvement of planning and engineering practice and to the mitigation of damage from tornadoes and other windstorms.

The next chapter presents a summary of the report's major findings and gives recommendations drawn from those findings. Chapters 3 through 6 provide the data supporting those conclusions.

FIGURE 1 The path of the March 1, 1983, Los Angeles tornado from approximately 7:40 to 8:05 a.m. drawn by Arthur Lessard, Meteorologist-in-Charge, Los Angeles Office, National Weather Service. Highway 10 runs horizontally through the map, and Highway 110 runs vertically. The tornado affected an area about 3-3/4 miles long and 1/3 mile wide. Circles indicate locations of severe damage, and the small arrows indicate the varying wind direction as judged by damage and debris.

2

SUMMARY AND RECOMMENDATIONS

One of the two main objectives of this study is to document the event of March 1, 1983, in Los Angeles for historical purposes. Chapters 3 through 6 address this task, and a summary of their major points follows.

1. The event of March 1, 1983, was a tornado that caused damage of intensity F2 on the Fujita scale. Its lifetime was about 20 to 25 minutes, from 7:40 to 8:05 a.m. local time.
2. Although the tornado of March 1, 1983, occurred under weather conditions not usually associated with vortices of this intensity, tornadoes of this severity and larger have occurred in southern California in the past, and there is no reason to assume that such an event will not recur in association with a future cyclonic storm.
3. Most of the damage to lifelines caused by the tornado occurred to overhead pole-suspended electric power lines and telephone cables.
4. Roofs and roofing were especially vulnerable to the tornado.
5. Older wood buildings suffered the most major structural damage.
6. Unreinforced masonry buildings built before 1934 suffered more damage than did newer reinforced masonry buildings designed to resist earthquake forces.
7. Structures and lifeline facilities in the City of Los Angeles have not been specifically designed for loading from tornadoes.
8. The emergency preparations undertaken in the City of Los Angeles to mitigate and respond to expected disaster events such as earthquakes, floods, and landslides significantly enhanced the city's preparedness for the problems caused by the tornado.

The observations given above and in the chapters that follow lead to three recommendations for further study that would contribute to planning and engineering practice as well as to mitigation of damage from tornadoes and other windstorms.

1. Tornadoes in Los Angeles differ greatly in structure from typical midwestern tornadoes. Specifically, the Los Angeles tornado occurred without the usual strong air-mass contrasts, vigorous frontal systems, and cumulonimbi towering to 20 km. The meteorological sequence of events preceding these types of tornadoes should be studied in more detail to help in their prediction.

2. Guidelines and/or standards to support the damage assessment process should be developed. Especially important are guidelines for determining the difference between damage caused by a particular, recent natural disaster and damage that occurred before a disaster or was caused by deferred maintenance.

3. Current building codes do not specifically require that tornado loading be considered. However, as this event demonstrates, a set of guidelines for tornado-resistant design should be developed. Both the effect of tornadoes on structures and their effect on lifeline systems should be considered.

3

METEOROLOGICAL CONSIDERATIONS

LARGER-SCALE METEOROLOGICAL CONDITIONS

On March 1, 1983, at 4:00 a.m. Los Angeles (12:00 Greenwich mean time or 12Z), a storm center at the 500-mb level was centered about 350 km west of the northern California coastline. This produced southwest or west-southwest winds of 56 to 67 mph (25 to 30 m/s) over southern California, as illustrated in Figure 2. The surface chart at 7:00 a.m. showed a low center almost vertically below the one at 500 mb. A frontal system dissociated from this low extended north-south over the southern California coastline, intersecting it somewhere between Oxnard and Los Angeles (see Figure 3). The surface front was not particularly well defined in terms of either pressure, temperature, or wind. Altogether, the weather system was a fairly typical, mature, well-developed winter cyclone of the sort that brings southern California its seasonal precipitation.

Figure 4 is the visible-radiation satellite cloud imagery at 8:45 a.m. local time. It shows an unusually heavy cloud mass associated with the frontal system covering the Los Angeles Basin. Unfortunately, enhanced infrared imagery was not available, owing to the failure of the GOES West some months earlier. Consequently, there is no way to determine the height of the cloudtops from the imagery.

A sounding made at the University of California, Los Angeles, at 6:00 a.m. shows a conditionally unstable layer between 1000 and 760 mb (see Figure 5). This sounding was taken for the California Air Resources Board and was not expected to be followed higher than 700 mb. Humidity was moderate to high throughout, indicating the potential for heavy rain showers. The unstable layer from 860 to 850 mb was probably an instrumental error.

MESOSCALE CONDITIONS

The most interesting quantitative data for the Los Angeles Basin as a whole are the radar-return plots from the National Weather Service at 1100 Wilshire Boulevard in western Los Angeles. These plots are shown in Figures 6 and 7. They exhibit severe ground clutter in returns from the direction of the center of Los Angeles, which is about 30 km to the east. However, for present purposes, they also show that at approxi-

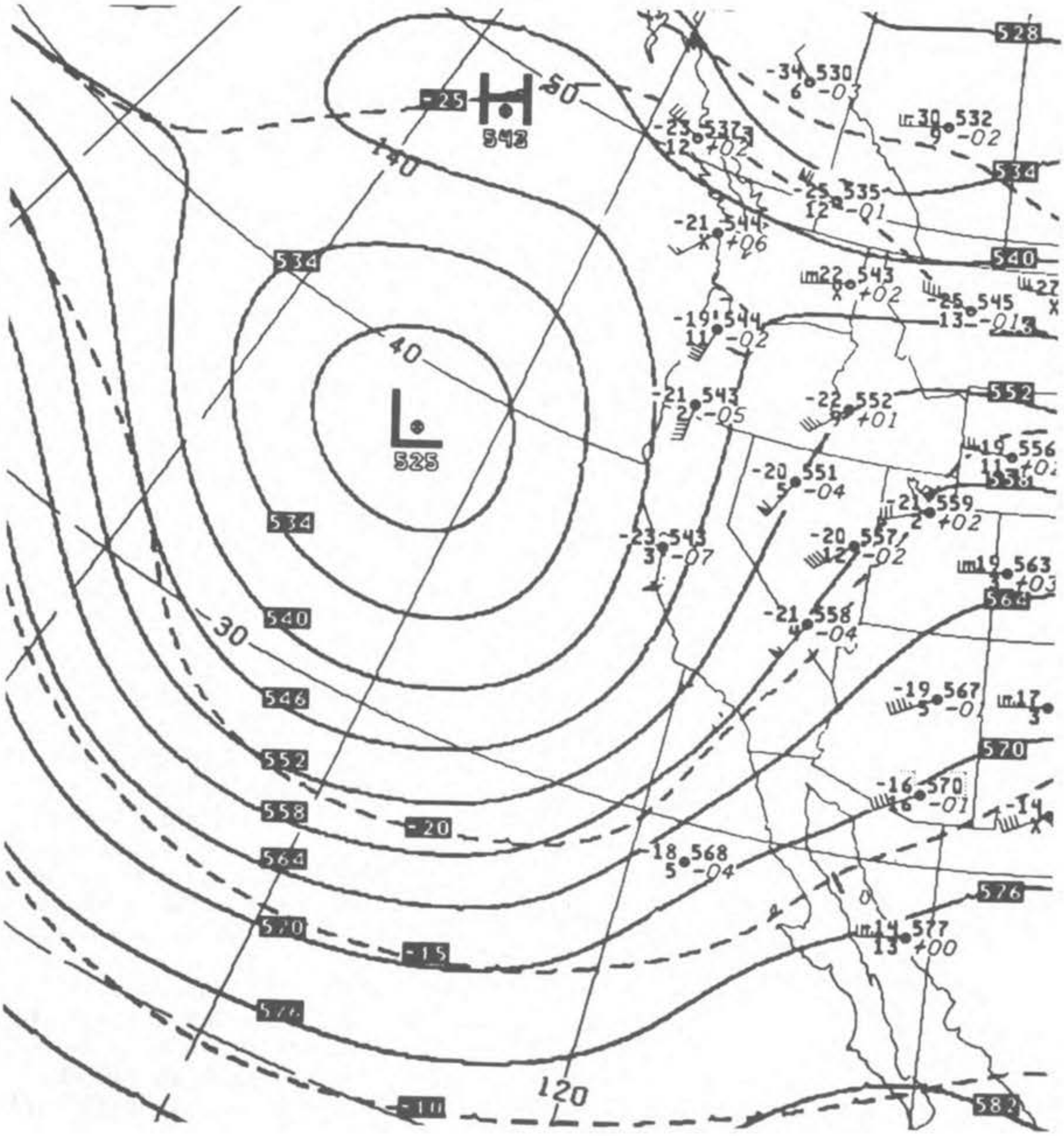

FIGURE 2 The National Weather Service 500-mb chart for 4:00 a.m. local time on March 1, 1983.

mately 8:01 a.m., when the tornado was causing significant damage to the Los Angeles Convention Center, the highest cloudtops in the Los Angeles Basin were at 5,500 m (18,000 ft; Figure 6) and not in the area of the tornado. In addition, none of the characteristic radar signatures of a tornado were observed.

These observations deserve careful consideration by meteorologists, particularly operational forecasters. In light of experience with the violent tornadoes of the Great Plains, it might be thought highly

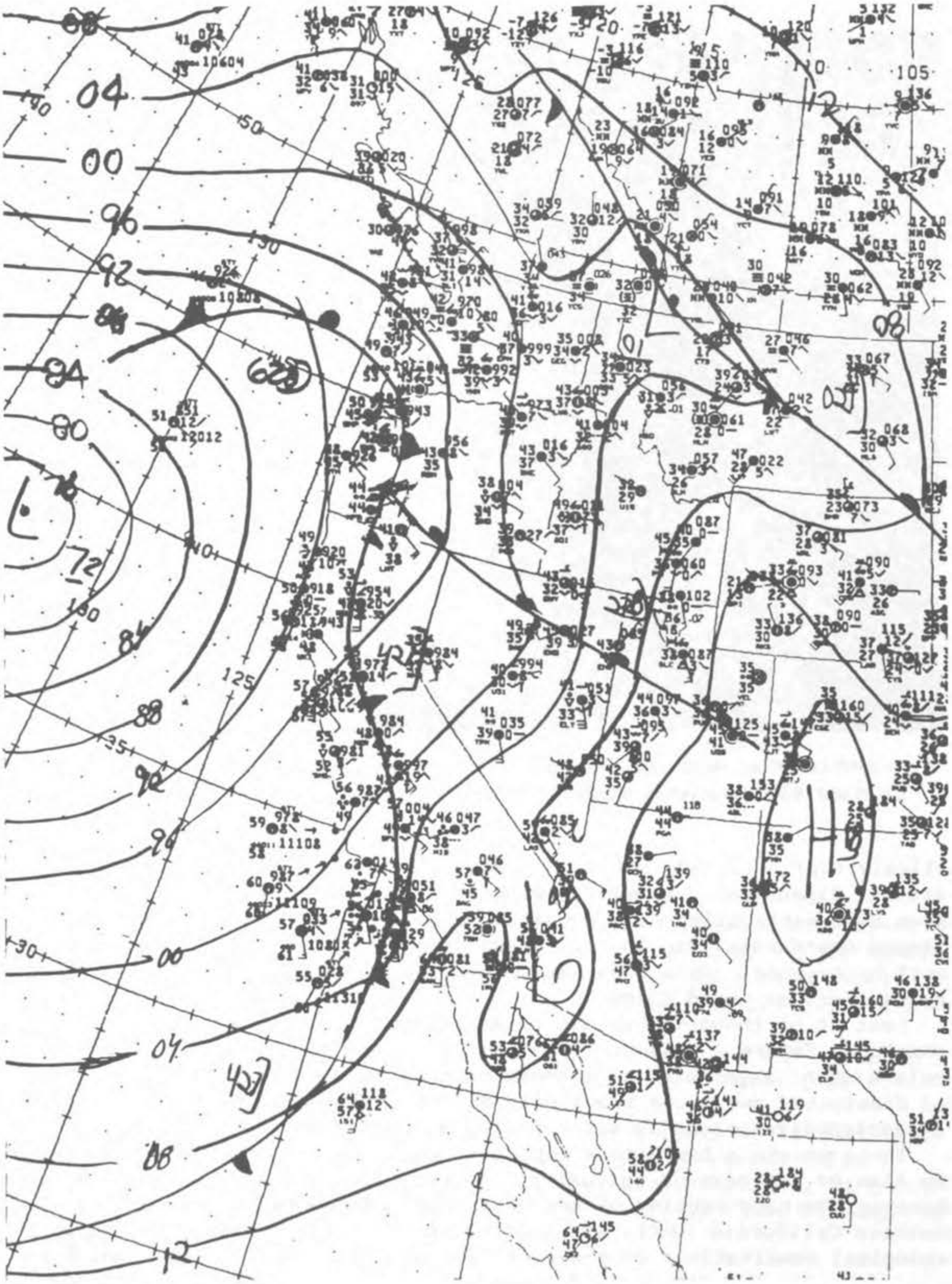

FIGURE 3 The National Weather Service surface chart for 7:00 a.m. on March 1, 1983.

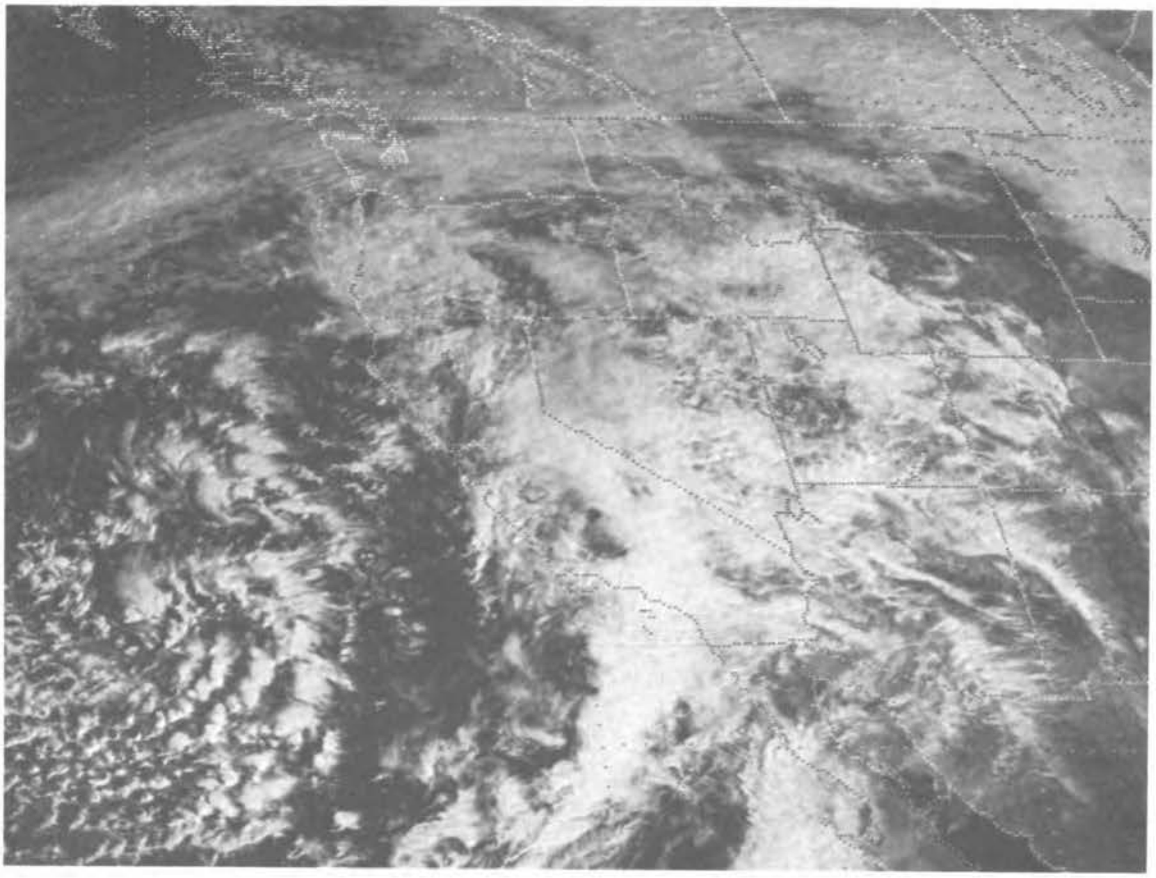

FIGURE 4 The National Oceanographic and Atmospheric Administration satellite cloud imagery for 8:45 on March 1, 1983.

unlikely that a tornado could be produced from a cloud of such modest vertical dimensions. However, mesoscale field research has recently shown that destructive severe weather phenomena, such as tornadoes and intense downbursts, can in fact arise from clouds of relatively "innocent" appearance. This does not, obviously, render the forecast problem any simpler, as noted below.

Lest it be thought that the radar-return contours for 8:01 a.m. were anomalous, Figure 7 presents a similar diagram for 10:45 a.m. It reveals a much larger area of intense backscatter, even though the tornado had dissipated two hours previously and no small-scale rotating storm of any destructive intensity was reported at this time.

There exists a fortuitous report of conditions near the tornado at the time of its maximum intensity. Between 7:30 and 8:00 a.m. a skilled observer, Bernard Ferrier of the Department of Geography, University of Southern California (USC), was instructing a class in elementary meteorological observations on the roof of eight-story Vivian Hall, which is located on the USC campus (see Figure 8). This building was about one kilometer from the tornado track (heavy line).

Among Ferrier's observations are the following:

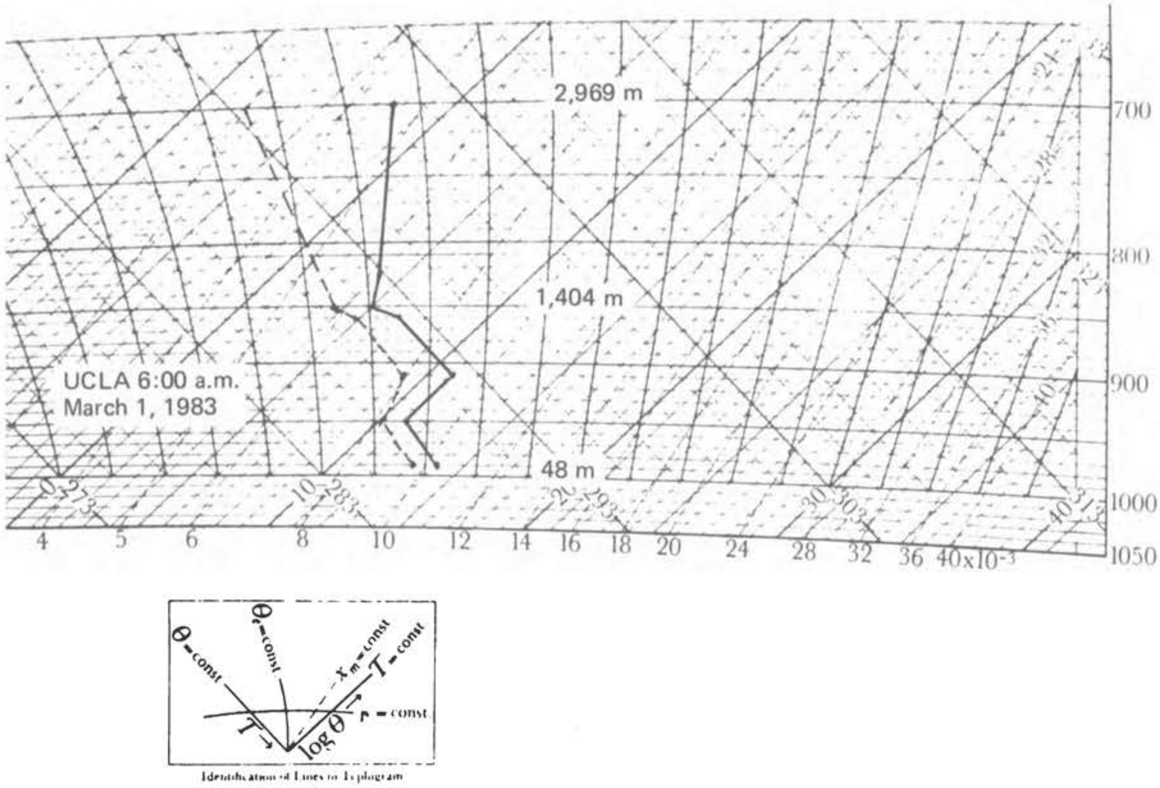

FIGURE 5 Temperature (solid line) and dewpoint (dashed line) taken from the University of California, Los Angeles, at 6:00 a.m. on March 1, 1983. The heights of standard pressures are indicated on the vertical scale; the isotherms are labeled in degrees Celsius; and the abiabats are labeled in degrees Kelvin.

1. Ferrier's hand-held anemometer indicated a maximum wind speed of more than 120 km/h (75 mph), the highest mark on the scale. (It should be noted that this is a maximum gust speed, not a mean wind speed.)
2. When the wind smashed the instrument shelter against the wall of a penthouse, the barometer registered 29.7 in.
3. The newly whitewashed instrument shelter was scoured by wind, rain, hail, and dust until little trace of its recent coat of paint remained.
4. Ferrier heard a roaring sound, the noise of 1,000 freight trains characteristic of tornadoes, and felt a vibration of Vivian Hall.
5. Hail fell briefly with diameters estimated by Ferrier at 1 cm.
6. No funnel cloud was visible to Ferrier at any time, although he looked for one.

Ferrier decided, upon observing these events, that the safety of his students took precedence over further meteorological documentation. However, as shown later, his observations are of great interest.

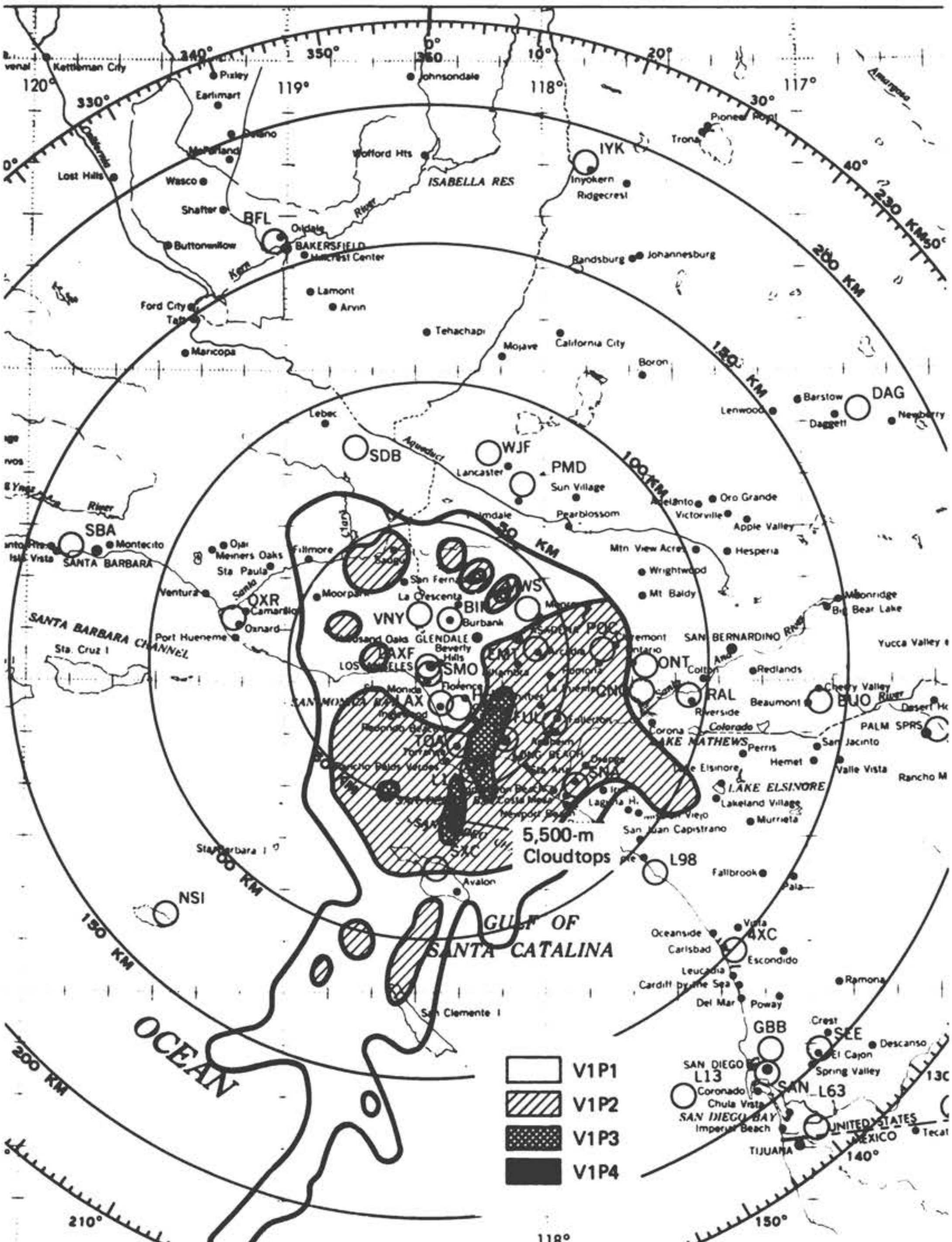

FIGURE 6 The Los Angeles National Weather Service radar-return contours for 8:01 a.m. on March 1, 1983. There are four intensities of return shown, labeled VIP (video integrator processor) 1-4. The maximum cloud-top height of 5,500 m (18,000 ft), corresponding to the return of greatest intensity, is taken from the radar's range height indicator.

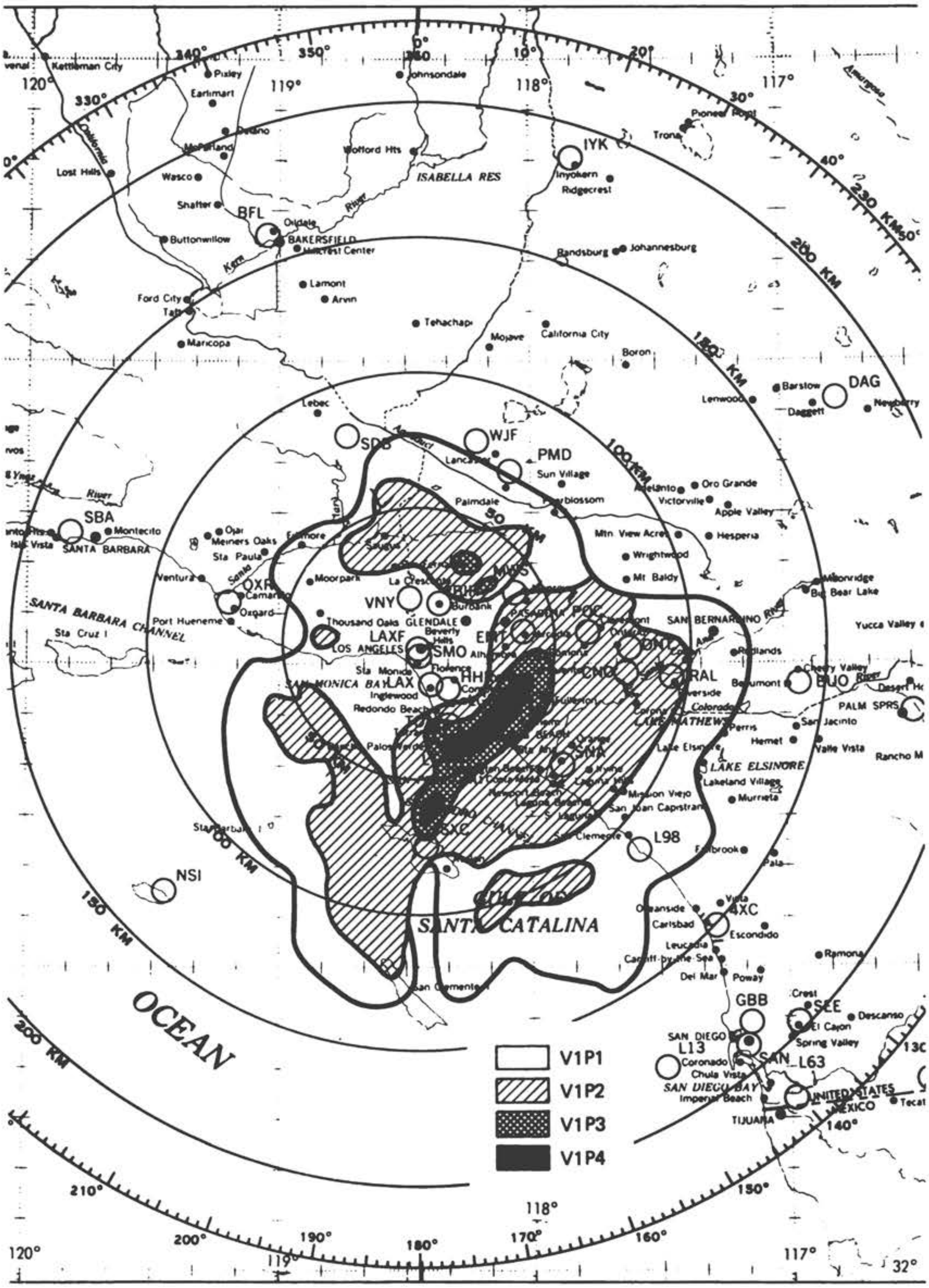

FIGURE 7 The Los Angeles National Weather Service radar-return contours at 10:45 a.m. on March 1, 1983, showing intense backscatter.

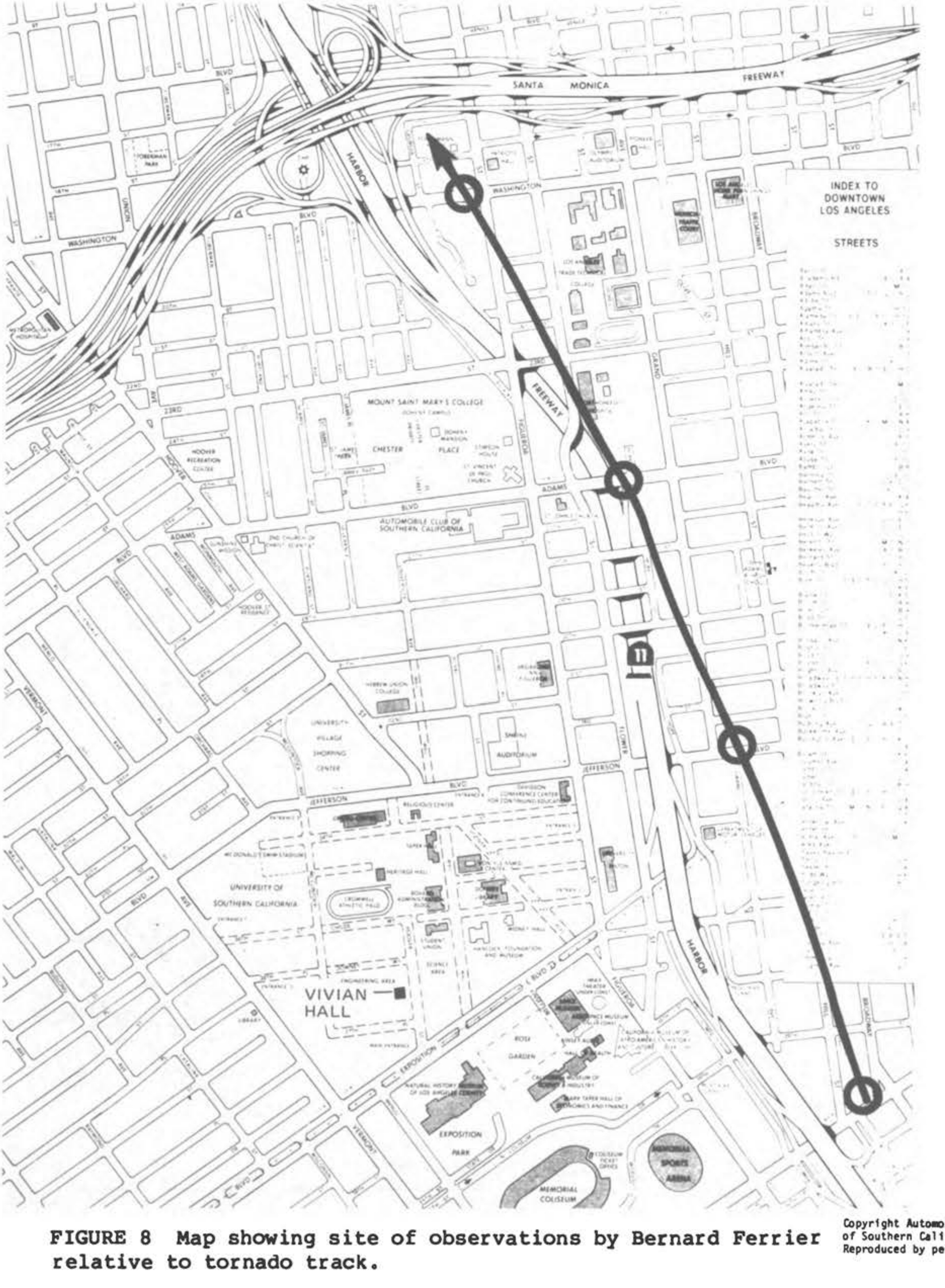

FIGURE 8 Map showing site of observations by Bernard Ferrier relative to tornado track.

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Arthur Lessard, Meteorologist-in-Charge at the National Weather Service, Los Angeles, prepared the tornado storm track shown in Figure 1. The arrows along the track indicate wind direction, as judged from damage and debris. It is clear from the pattern that the damage was caused by a small-scale rotating vortex and that the rotation was cyclonic or counterclockwise. The average translation speed of the tornado was about 10 mph.

METEOROLOGICAL FORECAST

The meteorological information available to the National Weather Service was characteristic of a weather situation producing heavy showery rainfall. This is what was forecast and this is what occurred.

By and large, perceptions of tornadoes in the United States derive from those of the Southeast, Midwest, and Great Plains. Meteorologists associate tornadoes with strong air mass contrasts, vigorous frontal systems, and cumulonimbi towering to 20 km. These features were not present on March 1 in the Los Angeles Basin. As mentioned above, field research is now revealing that tornado generation is entirely possible under conditions such as those that did obtain on March 1 in Los Angeles; but these field projects have the benefit of state-of-the-art instrumentation and data handling such as doppler radar and instrumented aircraft. On the morning of March 1, even the essential data of wind profiles aloft were unavailable at Vandenberg Air Force Base, San Diego, and UCLA. When the results of current research have been incorporated into operational techniques, and when the National Weather Service has remote sensing equipment that provide three-dimensional data coverage of adequate resolution, the spot forecasting of tornadoes may become routine. Current plans place this happy situation within the next decade.

TORNADO INTENSITY

Considerable criticism was directed toward the National Weather Service for its having resisted using the word "tornado" in describing certain weather events of the past, even though the popular press has used that term for many years. This situation has been partially due to non-uniformity of usage.

Over tropical oceans there is a gradation of storm severity--from tropical depression to tropical cyclone to hurricane or typhoon. These classifications are defined in terms of increasing wind speed. Similarly, there are various kinds of small-scale rotating wind vortices. The dust devil is a familiar example. The "Taquitz twister," a vortex originating in the canyons of the Palm Springs-Palm Desert area, is said to be capable of overturning automobiles. Other vortices can originate from within larger-scale storms and cause more extensive damage.

It would be natural to classify these vortices also in terms of wind speed, but their small scale and erratic motion render wind measurements difficult, except by advanced techniques such as doppler radar. Thus a gradation scale for <u>damage</u>--called the Fujita scale--is now used to define and classify tornadoes (see Figure 9). A tornado is thus defined

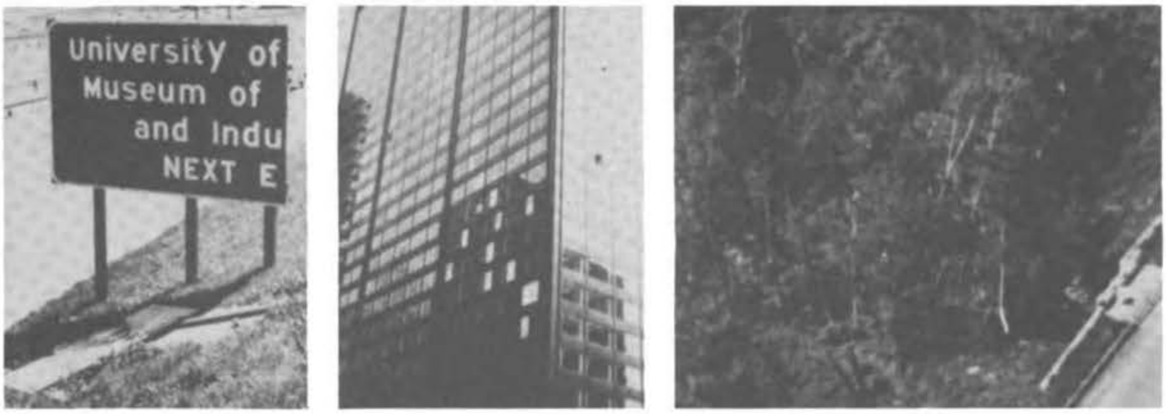

FIGURE 9A Light damage (F0) on the Fujita scale (winds 40 to 72 mph). Some damage to chimneys and television antennas; signboards damaged; some windows broken; twigs and branches broken off trees; shallow-rooted trees pushed over. Hurricane wind speeds begin at 73 mph.

FIGURE 9B Moderate damage (F1) on the Fujita scale (winds 73 to 112 mph). Surfaces of roofs peeled off; windows broken; mobile homes pushed off foundations or overturned; outbuildings demolished; some trees uprooted or snapped; moving automobiles pushed off roads.

as a small-scale wind vortex, originating from a cumulonimbus, that causes damage of scale F0 or higher.

According to this definition, it is quite clear that the event of March 1, 1983, was a tornado and that the appropriate Fujita scale was F2: roofs were torn off, large trees and utility poles were snapped, and debris became missiles. The pattern of damage shows an affected area approximately 500 to 600 m in track-width, with little or no damage

FIGURE 9C Considerable damage (F2) on the Fujita scale (winds 113 to 157 mph). Roofs torn off frame houses, leaving strong upright walls; weak buildings in rural areas demolished; mobile homes destroyed; frame houses with weak foundations lifted and moved; large trees snapped or uprooted; railroad boxcars pushed over; light-object missiles created; cars blown off highways.

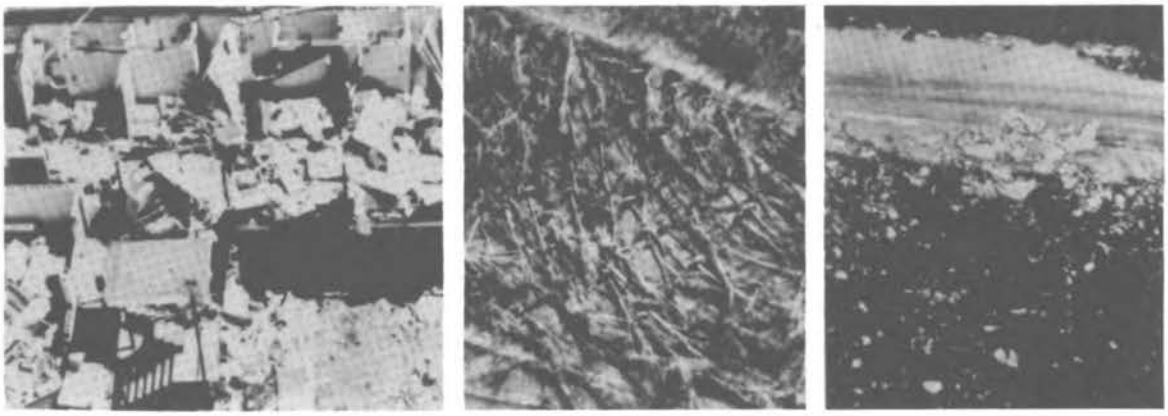

FIGURE 9D Severe damage (F3) on the Fujita scale (winds of 158 to 206 mph). Roofs and some walls torn off well-constructed frame houses; some rural buildings completely demolished; steel-framed hangar- or warehouse-type structures blown down; trains overturned; heavy cars lifted off ground and thrown; most trees in a forest uprooted, snapped, or leveled; weak pavement blown off roads.

outside. Thus the scale as well as the intensity is typical of a tornadic episode.

The observations reported from Vivian Hall on the USC Campus are of interest in this connection. The gust wind speed in excess of 75 mph is

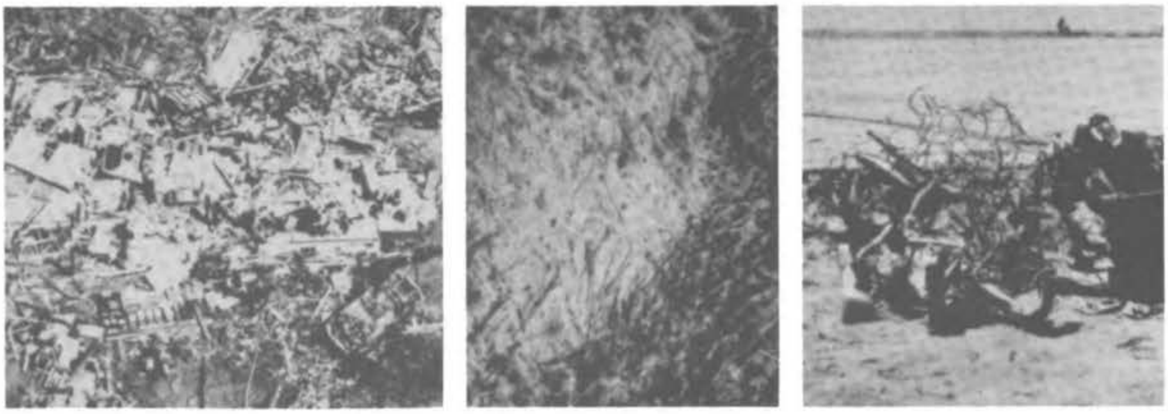

FIGURE 9E Devastating damage (F4) on the Fujita scale (winds of 207 to 260 mph). Well-constructed frame houses leveled, leaving piles of debris; steel structures badly damaged; structures with weak foundations blown some distance; cars and trains thrown or rolled some distances; trees debarked by small flying debris, uprooted, and carried some distances; large missiles generated.

FIGURE 9F Incredible damage (F5) on the Fujita scale (winds of 261 to 318 mph). Strong frame houses lifted off foundations and carried considerable distances to disintegrate; steel-reinforced concrete structures badly damaged; automobile-sized missiles carried through air in excess of 300 ft; trees debarked; incredible phenomena can occur.

Winds from 319 mph to sonic speeds would cause inconceivable damage (F6 to F12) on the Fujita scale. The extent and types of damage cannot be completely conceived. A number of missiles such as refrigerators, water heaters, storage tanks, and automobiles would cause serious secondary damage to structures.

consistent with the pattern of intense convergence necessary to produce the 113-mph wind speed one kilometer distant associated with the F2 damage scale. The reported pressure, however, is consistent with the large-scale pressure pattern of the weather chart. The pressure fall known to exist within tornadoes would have occurred on the small scale of the vortex itself.

CONCLUSIONS

The meteorological event of March 1, 1983, was a tornado with a vortex rotating cyclonically (counterclockwise) with vortex wind speeds probably in excess of 113 mph. Its lifetime was about 20 to 25 minutes, from about 7:40 to 8:05 a.m. The associated damage is assessed at F2 on the Fujita scale.

Given the weather data available at the time, particularly the radar reports of cloudtops at only 5,500 m, a tornado forecast or warning would have been difficult to justify on the basis of our current understanding of tornadoes. This event is worth careful study.

4

LIFELINES

Almost all of the damage to lifelines from the tornado that occurred in downtown Los Angeles between 7:40 and 8:05 a.m. on March 1, 1983, was to overhead pole-suspended electric power lines and telephone cables. Some damage also occurred to wooden power poles and to electric power and telephone equipment. The area affected was just east of the Harbor Freeway and about 3-3/4 miles long by 1/3 mile wide. It extended from Fifty-first Street on the south to Olympic Boulevard on the north.

ELECTRIC POWER SYSTEM

Most of the damage to the electric power system was caused by the rupture of overhead power lines by high-velocity winds (Figure 10). Almost all of the power lines in the affected area were damaged. These power lines included 34,500-V and 5,000-V subtransmission lines, 480-V and 240-V three-phase distribution lines to light industrial and commercial consumers, and 240-V and 120-V distribution lines to light commercial and residential customers.

Wooden power poles were also considerably damaged. About 15 poles were displaced from their vertical alignment due to the failure of the soils in which they were embedded because of high-velocity winds (Figure 11). Other poles failed as a result of flexural or shear overstresses. Among these were 25 poles that failed at ground level and others that failed at their mid-heights or higher (Figure 12). It seemed that poles sheltered by buildings from the wind failed at or above the roof level of the buildings.

Loss of power equipment was not extensive. Transformers, circuit breakers, and other control equipment were only damaged when they fell with or from damaged poles.

Because of the prevailing inclement weather on the day of the tornado, many repair crews were in the field. Some of the damage from the tornado was observed as it occurred and immediately reported to the chief dispatcher or other electric power controllers. A survey was taken as soon as the tornado subsided to assess the damage and to determine the equipment and material needed to reconstruct the damaged parts of the system.

FIGURE 10 Damage to electric power distribution lines.

Repair work was begun within hours (Figure 13). The Police and Fire departments were requested to evacuate those areas where electric power lines were down to protect the general public and people engaged in legitimate disaster response work. A general superintendent was also appointed to manage the entire reconstruction effort in the field. It was found that distributing and customer substations had not been damaged; all the damage was to the overhead subtransmission and distribution system. Therefore such materials as standard hardware, wooden

FIGURE 11 Wooden pole failure at ground level due to shear and flexural overstresses.

poles, conductor, and wire were ordered from existing stock, and the reconstruction effort started almost immediately.

The primary goal was to restore electric power to all customers who needed it, with priority given to essential facilities, such as the one hospital in the area. Most customers who could use power were reconnected by the day after the tornado. By the fifth day almost all customers were being furnished with electricity.

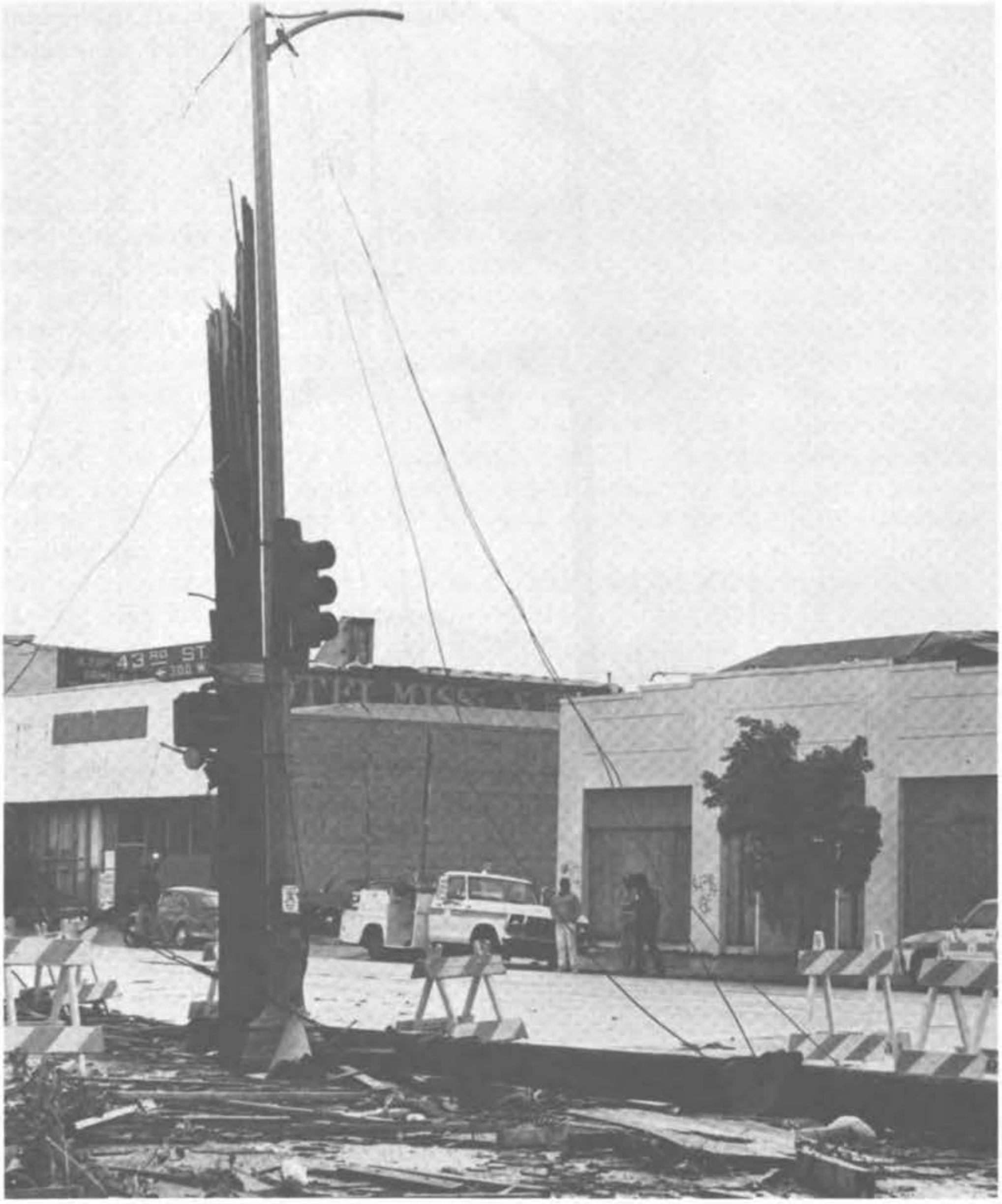

FIGURE 12 Wooden pole failure at midheight due to overstress.

TELEPHONE SYSTEM

The situation with the telephone system was similar to that with the overhead electric system, since most overhead telephone cables are suspended from the same poles as the power conductors. Most of the damage to telephone cables was from the rupturing or felling of cables due to the high-velocity winds. Power lines falling onto telephone cables also caused short circuits, resulting in the burning and melting

FIGURE 13 Restoration of electric power distribution lines by Los Angeles Department of Water and Power personnel.

of cable coverings such as lead, epoxy, and tar. These electrical short circuits also caused explosions in the telephone terminals from which customers are connected. Approximately 300 service drops, or service connections, were destroyed. Preliminary estimates of the damage to the telephone system exceeded $400,000.

Restoration of the damaged telephone facilities was started immediately. Within five days of the tornado, 90 percent of customers desiring service were reconnected. In addition, during the restoration of the damaged telephone system, much of a previously planned upgrading of the system in the affected area was performed.

TRANSPORTATION

No transportation facilities were damaged by the tornado. The only impact on transportation was caused by the closure of streets due to obstruction by building debris, fallen electric power and telephone poles, and conductors and equipment. Streets were also closed to mitigate hazards from fallen power lines that might have still been energized. The Police Department closed off traffic on a number of streets and restricted access to and from the Harbor Freeway. Public buses were permitted through the affected area only in the east-west direction, the narrow part of the area. In the north-south direction they were rerouted to nearby parallel streets. An undetermined number of private and commercial vehicles were damaged by falling or wind-driven debris.

The main arteries or streets were cleared of debris and open to traffic by the fourth day after the tornado. All streets were open to traffic by the eighth day.

NATURAL GAS

Approximately 165 outages occurred at residential and commercial natural gas connections. Most of these were caused by broken-off connections due to damaged structures; others were due to damaged appliances.

The Police Department authorized gas company servicemen to assess the damage to gas pipelines, connections, and structures and to take whatever action was necessary to ensure safety. Even where severe structural damage had occurred to buildings, meters were left on if it was considered safe and if the customer needed the gas.

CONCLUSIONS

The loss of lifelines in the affected area did not have a significant impact on the entire lifeline system. Within the damaged area, lifeline services were rapidly restored to customers who needed them, and their temporary loss did not greatly exacerbate the disaster.

Improvements to lifeline systems to better meet this particular kind of emergency, such as stronger power line poles and conductors, would be very expensive and not cost effective.

5

STRUCTURAL DAMAGE

To discuss the type of damage from the March 1, 1983, tornado, this chapter is divided into categories representing the typical kinds of damage observed.

DAMAGE TO SIGNS AND TRANSPORT OF AUTOMOBILES

Figures 14A and 14B show the condition of a large industrial advertising sign before and after the tornado. As is clear from the condition of the sign, its failure took the form of a twisting or torsional response. Very approximate engineering estimates relating the sign's surface area and its probable moment capacity indicate that it probably experienced a wind speed greater than 150 mph.

The tornado also picked up and transported several cars, as shown in Figures 15 and 16.

DAMAGE TO MASONRY BUILDINGS

Most masonry buildings in the path of the tornado experienced extensive glass damage to their storefront windows, as shown in Figures 17 and 18. Figure 17 also shows the roof and parapet damage typical of that suffered by many unreinforced masonry buildings. The unreinforced masonry buildings that had their walls anchored to their roofs as a result of a mandatory Los Angeles City parapet stabilization program, which required parapet walls to be strengthened for earthquakes, suffered less damage than did unanchored buildings. Figures 19 and 20 give two views of an unreinforced masonry building that collapsed. This collapse was attributed in part to the lack of adequate wall anchors.

Unreinforced masonry buildings built before 1934 suffered more damage than did the newer reinforced masonry buildings that were designed to resist earthquake forces. In addition to having reinforced walls, the newer buildings were better tied together and their roofs were securely anchored to the exterior walls. Roof and glass damage, however, was still evident in these newer buildings.

FIGURE 14A Industrial sign collapsed by tornado.

FIGURE 14B Repaired sign.

FIGURE 15 Auto overturned by tornado at 3200 South Grand Avenue.

FIGURE 16 Auto overturned by tornado at 3200 South Grand Avenue.

FIGURE 17 Collapsed masonry parapet.

FIGURE 18 Failed storefront windows.

FIGURE 19 Failed masonry bearing wall.

FIGURE 20 Failed masonry bearing wall.

OLD WOOD BUILDINGS

Old wood buildings experienced the type of damage shown in Figures 21, 22, and 23. This type of damage was primarily confined to the roof and upper part of the structure and in many cases was quite severe. The damage to such wood frame buildings was more extensive than the damage observed to the concrete and masonry buildings in the immediate vicinity. Figure 24 is an aerial view that graphically depicts the severity of damage received by the various types of buildings.

LOS ANGELES CONVENTION CENTER

The Los Angeles Convention Center experienced significant structural damage to the roof and upper-level panels during the tornado, as shown in Figures 25 and 26. As indicated by these figures, the path of the tornado from south to north produced wind force pressures sufficiently strong to tear the roof and cause members to fail, particularly in the southeast corner of the building. The City of Los Angeles has subsequently repaired the damage at a total cost of $3 million.

The Los Angeles Convention Center, constructed in 1971, represents state-of-the-art design for such buildings. No special wind study was performed on this building, and no special design considerations other than the wind pressures of the Uniform Building Code were used. In general, the structure behaved quite well from the perspective of its structural strength capacity. There was no evidence of any imminent collapse of primary structural systems that might have threatened human safety.

FIGURE 21 Damaged roof system at 268-70 West Forty-first Street.

FIGURE 22 Damaged wood building in the 200 block of West Fortieth Place.

FIGURE 23 Collapsed roof at 260 West Fortieth Place.

FIGURE 24 Aerial view of damaged area.

FIGURE 25 The Los Angeles Convention Center.

FIGURE 26 The Los Angeles Convention Center.

6

EMERGENCY PLANNING AND RESPONSE

In May 1980 the City of Los Angeles adopted ordinance No. 153,772, which amended Chapter 3 of Division 8 of the Administrative Code. The major purpose of the ordinance was to "centralize the direction and control of local emergency preparations, the duties, responsibilities and activities of all persons, organizations, departments of City government, and officers and employees of the City performing services in rendering aid in the event of a local emergency. . . ."

The ordinance created and assigned powers to an Emergency Operations Organization governed by a board. The board membership consists of the Chief of Police, who is designated the permanent chairman, the Chief Engineer and General Manager of the Fire Department, the City Administrative Officer, the Chief of the Public Works Division, the General Manager and Chief Engineer of the Department of Water and Power, the General Manager of the Personnel Department, the Superintendent of Building and General Manager of the Department of Building and Safety, the General Manager of the Department of General Services, and the General Manager of the Department of Transportation. The chairman of the board is also the deputy director of the organization, responsible to the mayor, who is the director of the organization. The City Administrative Officer is designated the overall coordinator of the organization. The chief of each division is responsible for formulating and maintaining operational plans to respond to any situation designated by the Mayor as a local emergency.

The board appointed an Emergency Operations Committee chaired by a representative of the City Administrative Office. This committee was given the responsibility of developing the city's policy and procedures for responding to any designated local emergency. The city then developed an Emergency Operations Center, which was to be activated in response to storm warnings, the occurrence of a disaster, or other designated local emergencies.

THE CITY BEFORE THE TORNADO IMPACT

A little more than a month before the tornado of March 1, 1983, on January 28, the Mayor declared a local emergency in the City of Los Angeles upon the recommendation of the Emergency Operations Board. High tides had caused a significant amount of damage to the coastline of Los Angeles County, particularly in the Playa del Rey area of the city, and the Emergency Operations Center was activated for 72 hours. The most significant damage to city facilities from this storm occurred to the power distribution facilities of the Department of Water and Power. This damage was estimated at $1.5 million.

On February 9, 1983, the President of the United States declared Los Angeles County a disaster area. This made the City of Los Angeles eligible for up to 75 percent reimbursement from the Federal Emergency Management Agency (FEMA) for repair and rehabilitation of all eligible storm-related damages, including tornado damage.

On February 28, 1983, a weather forecast was received predicting from 4 to 6 in. of rainfall within the ensuing 24-hour period. Anticipating that heavy runoff from wet mountainsides could cause severe mudslides during this second series of storms, the Emergency Operations Committee convened to determine whether the city's resources could be most effectively managed by activating the Emergency Operations Center. Upon the mayor's declaration of a local emergency, the center was activated on February 28, 1983, at 5:00 p.m., and officials from each department assembled there.

Although there was no prospect of a tornado, the city was prepared to respond when the emergency caused by the tornado of March 1, 1983, occurred. Because the Emergency Operations Center had been activated for other anticipated storm-related problems, it was estimated that the total response time for the tornado was about 1-1/2 hours better than it would have been had the center not been in operation.

Although Los Angeles has a weather forecast hookup with the Federal Aviation Administration, the Coast Guard, and the National Weather Service, the latter, in the past, had refused to acknowledge the possibility of tornadoes in the Los Angeles area. Thus citizens and city personnel had little general understanding of any potential tornado problem. It was believed by most people that tornados only occur in the Midwest. Thus the event of March 1 was a complete surprise.

EMERGENCY RESPONSE

During the 24-hour period from 6:00 a.m. on March 1 to 6:00 a.m. on March 2, 1983, the full effects of a major winter storm were felt in Los Angeles. Many low-lying areas of the city experienced flooding, hillside communities suffered from mudslides, and coastal areas were being continually pounded. As of 6:00 p.m. on March 1, over 3 in. of rain had fallen at the Los Angeles Civic Center.

The most severe storm-related damage was caused by the tornado that touched down south of the Civic Center shortly before 8:00 a.m. on March 1. The first indication of the tornado was given by a city Fire Department paramedic rescue ambulance, which was responding to an incident. The personnel radioed their sighting of a funnel-type cloud near the intersection of Forty-seventh Street and Broadway at about 7:59 a.m. Shortly thereafter the Fire Department began receiving calls reporting heavy wind damage from approximately the same area. Finally, an alarm at Fire Station 15 advising that a woman was trapped in a vehicle near the intersection of Hill Street and Jefferson Boulevard brought the first response of equipment. At the intersection, Engine Company 15 found cars blown about, power poles down, and a large amount of debris throughout the area. Engine Company 15 reported its findings and requested additional assistance to check the area for victims and additional problems.

The Los Angeles Fire Department immediately activated its disaster plan, sending additional engine companies into the area and dispatching helicopters to assess the problem. The first report of major damage concerned the Los Angeles Convention Center, where the helicopter pilot reported moderate damage to the roof area. He also reported severe damage to several other buildings in the area. Continued reporting indicated widespread damage to the area, including reports that entire second floors and roofs were missing on some structures.

The Emergency Operations Center immediately began assigning manpower and equipment to the area. City power crews were sent in to shut off live wires, and work crews moved in to clear debris for emergency equipment. The Police Department dispatched over 100 officers to the area, while the Fire Department ultimately dispatched 29 fire-fighting companies, three rescue ambulances, two helicopters, and one heavy utility to the emergency area.

Initially, the Fire Department set up a command post at Fortieth Place and Broadway, where the most damage was located. The Police Department set up their command post at Fifty-second Street and Broadway, on the edge of the damaged area. The Police Department coordinated with the California Highway Patrol and closed off all freeway ramps into the area. The Department of Building and Safety was requested to send inspectors to help assess damage. At 11:30 a.m. the Fire Department relocated their command post to the Police Department's command post at Fifty-second and Broadway. All of the utility companies and the Department of Building and Safety assigned representatives to the command post to enable direct communication.

The Fire Department assisted citizens by providing plastic sheeting and by working with them to cover damaged roofs so that the heavy rains would not further damage the contents of buildings. They remained in the damaged area and continued to provide support services as needed.

By 10:00 a.m. all critical notifications of personnel had been accomplished. The American Red Cross was notified at 9:45 a.m., and the media were fully informed as to the type of disaster by 9:30 a.m.

The response of the American Red Cross to the disaster began the same day as the tornado. Assistance was initiated to provide shelter to the victims of the tornado. The primary shelter for the tornado victims was at Manual Arts High School, a half mile west of the impact area. The shelter was opened on March 1 and remained open until March 6, 1983. The service center at Manual Arts remained open until March 7 and provided assistance to those victims who did not need emergency shelter.

The area declared the prime disaster area was between Seventh Street on the north, Slauson Avenue on the south, the Harbor Freeway on the west, and Central Avenue on the east. It was estimated by city personnel that 50 homes and 7 businesses were destroyed, that 58 homes and 82 businesses were damaged, that more than 100 people were made homeless, and that 32 people suffered minor injuries. Estimated losses were $4 million to the public sector, including the estimated $3 million damage to the Convention Center, and $11 million to private homes and businesses.

During the time the Red Cross shelter was in operation, 60 families consisting of 188 victims were provided with mass care. Casework service was provided to 101 families, 74 of which were given assistance. A total of $17,024 was spent to provide food, clothing, furniture, and lodging. The shelter was closed after all of its residents had been relocated either to new rentals or to family and friends.

The Police Department exercised its standard operating procedure to protect against unauthorized entry, immediately closing off the affected area and allowing access only to emergency personnel, residents, and business owners. Although the broadcast media continued to report that the closure was due to looting, the Police Department stated that there was no looting and that the purpose of the closure was to aid in emergency response, to ensure safety, and to protect private property. Some elements of the media, although advised to the contrary, continued to report such looting into the next day.

The immediate needs were to repair downed live electric wires and gas leaks and to restore telephone service. It was important to get key utility people into the area and to provide the opportunity for the Fire Department to assess damage building by building. As of 6:00 a.m. on March 2, 1983, the area bounded by Thirtieth Street, the Harbor Freeway, Vernon Avenue, and Main Street remained closed due to heavy damage.

In addition to the immediate response by units trained for emergencies, the Department of Building and Safety immediately assigned personnel to staff the Emergency Operations Center. The department also dispatched inspectors and engineers to the area to survey structural damage, to post warnings on hazardous buildings, and to consult with and advise people in the area. During the following three weeks, inspectors made further damage surveys, passed out general information sheets, and helped staff two disaster assistance centers established to coordinate relief activities for the city.

It is evident that the existence of a multiorganizational network that was designed to respond to emergencies greatly improved the effectiveness and efficiency of the disaster response. An editorial in the March 6, 1983, issue of the Los Angeles Times entitled "Post-Storm Evaluation" supported this conclusion by stating:

> Los Angeles is to be commended for the prompt and efficient manner in which its rescue and anti-looting forces responded to the freak tornado that terrified residents of the city's south-central area. And equally impressive were the efforts by public and private agencies in providing shelter and care for the homeless victims of the storms in various areas.

DISASTER AID

The tornado of March 1, 1983, was only one of a number of continuing disaster events that occurred in Los Angeles over a two-month period. The significant aspect of this event was that its major impact was on a segment of the community that had a relatively low economic ability to recover from the losses.

The Mayor immediately declared all of the areas of Los Angeles affected by the storm disaster areas. This set up a framework under which storm victims would be eligible for special personal and financial aid. The Mayor's declaration was immediately followed by a Presidential declaration authorizing the federal government to provide aid under the Disaster Relief Act and Small Business Administration programs.

The Los Angeles Convention Center, which had experienced an estimated $3 million in damages, was insured. The insurance policy covered all damage in excess of a $10,000 property loss deductible and a $10,000 liability deductible.

The Presidential disaster declaration made repair of damage to other city property eligible for 75 percent grant support by FEMA under the provisions of the Disaster Relief Act. As of April 27, 1983, there had been no damage survey by state or federal government survey teams to determine the eligibility of damage. The city's position was therefore that descriptive papers should contain all items that were storm related, even if the item could be considered ineligible. The city held that it would be more advantageous to file for all damages and then let the state and federal government claim what was not eligible.

Due to the large amount of tornado-related damage to residences, the city created two special emergency relief programs to be administered by the Community Redevelopment Agency (CRA) and the Community Development Department (CDD). Specifically, they were to provide low-interest loans for repair and reconstruction and free labor and building materials.

The CRA allocated $1 million to help residents repair their property. The area affected by the tornado was within a larger area that the CRA had already targeted for housing rehabilitation assistance. The agency had begun a site identification study in November 1982 to determine those areas most in need of financial assistance to upgrade homes. The special disaster aid program facilitated putting this program into operation. The funding came from the Bunker Hill Low and Moderate Income Replacement Housing Trust Fund, which was developed to replace housing removed from the downtown Bunker Hill area.

The CRA program provided low-interest loans to property owners for repair or reconstruction of housing units occupied by low- and moderate-income families, whether single- or multiple-family dwellings. An offer was also made to provide grants up to $20,000 for those who did not qualify for assistance elsewhere. In order to qualify, the housing unit had to be uninhabitable. There were no qualified applicants for the individual CRA grants.

The CDD Emergency Home Repair Program provided free labor through the existing Handyworker Program and $1,500 of free building materials.

Repairs to be made included roof repairs, removal of hazardous structures, replacements of windows and doors, and emergency electrical and plumbing repairs for single-family structures and apartments. Major work, such as the replacement of entire roofs or collapsed structures, was not eligible under the CDD program. Two community-based organizations, Pacific Asian Consortium in Employment and Community Care and Development Services, provided the work crews to perform the repairs.

The disaster assistance centers did not maintain records by disaster type or event. Thus it was not possible to separate tornado-related data from other data. The following data came from the Park Avenue Center, which was set up near the area affected by the tornado. Although people from other disaster areas filed their claims at the Park Avenue Center, most of those reporting to this center would have claimed tornado-related damage.

By the time the center closed, 1,291 people had filed applications for assistance under the federal programs. A verification process rejected 855 of these by determining that the damage was not related to the storm or that the parties were already insured against loss. Finally, 202 applications were accepted as eligible for disaster assistance. FEMA, the State of California Office of Emergency Services (OES), and the City of Los Angeles performed checks to ensure that benefits were not duplicated.

OBSERVATIONS

Compared with other major disasters, the March 1, 1983, tornado in Los Angeles placed only a moderate demand on the resources of the City of Los Angeles. It is clear that the prior planning for emergency response and the activation of the Emergency Operations Center contributed to the efficiency and effectiveness of the city's response.

Several observations can be made concerning the March 1 tornado.

1. Tornadoes are now an accepted reality in Los Angeles. Although the occurrence of the tornado was not believed immediately, it made no difference to the first responders.
2. The emergency response demonstrates that the procedures for responding to a tornado are the same as in other natural disasters. The Fire Department provided a security perimeter and helped assess damage, the utility companies secured live electric and gas lines, and the Department of Building and Safety helped assess damage and investigate structures.
3. By establishing an Emergency Operations Center as a standard procedure in a disaster, the multiorganizational network's communication is improved, which heightens the effectiveness of its search and rescue operations and its provision of aid to disaster victims. It was through the operation of the Emergency Operations Center that the Fire Department relocated its field command post to the Police Department's post outside the security perimeter.
4. The city's current building code does not specify design criteria for tornadoes. Implementation of the current earthquake

rehabilitation ordinance should reduce the risk of loss should a future tornado occur.

5. Because the Mayor and the City Council acted quickly to provide disaster assistance through the CRA and CDD programs, the interiors of buildings were protected from excessive water damage and overall losses were reduced. This effort also appeared to demonstrate to the community that the city was prepared to help those in serious need.

Although the city has an emergency response plan, an ordinance to support the activity, and a designated center staffed by members of all critical departments, there appear to be several problems in the city's disaster response.

1. Difficulty in achieving effective internal coordination and integration between members of the city's response network presented some problems. Except for the Police and Fire departments and the Department of Water and Power, personnel from most city departments are not generally available during a disaster.
2. The functional roles and responsibilities of participating members of the Emergency Operations Committee need to be clearly defined.
3. Some elements of the press did not correct their stories about looting at the disaster site even after statements by the Police Department to the contrary.
4. The community affected by the tornado experienced a net loss of both housing units and businesses even though the CRA and CDD moved quickly. Some small businesses will not be replaced. However, the event did offer the opportunity to redevelop part of the city and to require upgrading of some buildings to current fire codes.
5. The tornado struck a section of the city where many of the buildings suffered from a lack of general maintenance and repair. This resulted in a problem in determining which damage was caused by the tornado, and thereby qualified for governmental assistance, and which damage occurred before the disaster or arose from deferred maintenance, and was therefore not qualified for governmental assistance. As with any urban center, many buildings in Los Angeles are poorly maintained or have been damaged by numerous causes other than this particular natural event. The tornado that struck Los Angeles was relatively small and affected few buildings. A major natural disaster affecting many buildings will increase this problem significantly. Efforts should be devoted to the establishment of guidelines and/or standards to support the damage assessment process, thus providing efficient and rapid response to those who qualify for assistance.

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