## VIII. FINDINGS AND CONCLUSIONS

### a. The Immediate Response:

The typical immediate response of those in the buildings at the time of the earthquake was protective behavior - either self-protective or directed at a patient. It is not clear from the data on hand the extent to which self-protective behavior could be engaged in by the entire occupant population, nor how occupant capabilities varied among different sub-groups. However, the majority of those interviewed reported that they were able to engage in some form of protective behavior.

The typical activities engaged in by hospital staff immediately after the earthquake included checking on the condition of patients, and sometimes staff, on each floor of the nursing units, in some cases reassuring and calming patients. In one case patients were taken out of their rooms, taken out of bed and placed in corridors. At the collapsed buildings in the San Fernando hospital the immediate activity was search and rescue. Search and rescue activities include removing injured persons from collapsed structures, in which case great care must be exercised to prevent further collapse; rescuing people from beneath structural elements, nonstructural elements and building contents, and also locating, reassuring and removing uninjured or slightly injured people trapped by doors that have jammed.

One finding that affected the capability of the staff to respond successfully was the fact that, even though emergency equipment such as walkie-talkies, battery lanterns, and flashlights had been placed around facilities, this equipment in most cases was either damaged during the earthquake or staff members were unable readily to find the equipment in the darkness.

This experience underscores the importance of providing redundancy in the types of equipment supplied, as well as planning for these contingencies - such as darkness - and incorporating this planning in staff training. Another example of contingency planning is to train for the use of runners to communicate as part of disaster drills.

An important area that should be attended to as part of earthquake preparedness planning is the determination of the respective authority of individual physicians and hospital administration in determining patient disposition after the event.

b. Casualties:

One of the most striking findings is the small number of injuries sustained by staff and patients at all of the hospitals, except for the Veterans Administration Hospital, where 47 patients and staff perished, all in the collapse of two single buildings. This experience confirms the often expressed conclusion that the prime cause of death and severe injury is building collapse. Although four of the five hospitals in this study suffered severe structural damage, requiring evacuation and eventual demolition, only in the building that suffered collapse was there a large number of casualties.

In addition, however, there is a large element of chance. Another significant building collapse was that of the psychiatric day-care unit at Olive View Hospital which suffered a first floor collapse. However, due to the time of the earthquake in the early morning, all patients and staff were on the second floor. In all the hospitals at that time almost the entire hospital populations were located in the upper stories, while the ancillary areas on the lower floors and basements, sustained the greatest amount of nonstructural and, in some cases, structural damage. It is conceivable that if the earthquake had struck several hours later the pattern of casualties would have been different and the numbers much higher.

c. Evacuation:

The decision whether or not to evacuate the facility is the single most important decision that administration must make after the event. If the decision is made to evacuate, the subsequent economic and social history of the institution is changed, probably for years, the lives of staff are disrupted, and patterns of patient care are altered.

Fortunately, at San Fernando the earthquake damage was not accompanied by secondary disasters such as fire or the discharge of hazardous chemicals at any of the hospitals. This allowed hospital administrators a relatively generous amount of time to make the decision of whether or not to evacuate and in actually implementing that decision. However at the V.A. in San Fernando and Olive View Hospital, the two most damaged facilities, it seems that the decision to evacuate was made spontaneously by staff members on the scene and not by hospital administration, since these facilities were evacuated immediately and were in the process of being evacuated when the administration arrived. One would expect this situation in a severely damaged facility.

The most critical and difficult decision-making on the question of evacuation occurs with the marginally damaged facility, in which it may be difficult for the administration to determine the immediate safety (against aftershocks) and functional capability of the hospital. The fact that the Kaiser Hospital in Panorama City was pronounced safe within a few hours of the earthquake by a responsible structural engineer saved the building from evacuation and consequent economic and functional upheaval, even though there was over $3 million worth of repairs necessary. At Holy Cross a patient, who was a builder, pronounced the structure unsafe and advised evacuation.

One characteristic of this earthquake is that it occurred when the night shift was on duty and personnel were away from the facilities. It is not clear the extent to which the night shift had either prior training or authority in this sort of decision-making. Given that communication in most cases was intermittent at best, it was impossible for key hospital officials to make decisions until they arrived on the scene during the morning. If the earthquake had occurred earlier in the morning the difficulties of decision-making and general confusion would have been intensified.

In all cases the hospital elevators were knocked out by the earthquake, and patients initially had to be evacuated down stairwells. Since many fire stairs were damaged, and in the case of Olive View knocked out of commission by the earthquake, it is important when planning evacuation to designate alternative evacuation routes.

In the absence of corollary disasters such as fire, the length of time that it took to evacuate hospital patients did not seem to be too important, for those not in critical condition. For example, it took approximately five hours to evacuate the 540 patients who were in the main building at Olive View, a rate of about 2 patients per minute. It took about 1-3/4 hours to evacuate the 109 patients from Pacoima Memorial Hospital, also about 2 patients per minute. It took about 5-1/2 hours to evacuate the 186 patients at Holy Cross Hospital, or about 2 patients every three and a half minutes.

At Pacoima Memorial Hospital the decision to evacuate was not made until approximately 2 hours and 45 minutes after the earthquake, while at Holy Cross Hospital the decision was made about one hour and a half after the event.

In each case of evacuation the ambulatory patients were evacuated first, followed by non-ambulatory. Non-ambulatory patients were either evacuated in wheelchairs, with one staff member in the front and one staff member in the back; they were carried down on stretchers supplied by the fire department; carried by staff members using a two man carry technique; or carried down stairwells on mattresses. The latter was reported to be the least efficient technique.

Reports from several of the hospitals regarding the significance of prior training and other kinds of drills underscores the importance of this activity, and also the importance of including actual experience with the various carrying techniques as part of disaster drills.

d. Patient Disposition:

After evacuation, patients were assembled either in parking lots, on the grass outside of the building, or in the building lobby. The implications of outside assembly had it been raining or cold are easy to imagine. On the other hand, if patients are assembled in the interior of an unsafe building, the possible consequences of an aftershock can also be imagined so that this decision is of the greatest importance.

Usually patients were sorted into two basic groups: those who could be discharged, and those who needed to be transferred to either other facilities in the complex or other hospitals. In the two hospitals that were receiving injured from the outside community, and at the V.A. hospital, a triage was also set up. One important aspect of planning for an earthquake is to control access to and to segregate the final area.

Another finding relating to the evacuation decision, is the need to quickly develop a reliable damage assessment of the facility. This is necessary for evaluating safe exit routes, determining if the structure should be evacuated and sending people to alternate facilities in the complex. When this did occur, patients sometimes had to be moved several times as facilities thought safe were found to be suspect. Two techniques for developing such a capability are either to train the plant engineering staff in specific inspection methods or to establish a prior contract with a responsible structural engineer to give first priority to visiting the hospital and making a determination.

Hospitals that were part of larger systems simply sent their patients to other hospitals in the system. Private hospitals and a more difficult task in discharging patients who were evacuated.

One of the problems that occurred with re-routing was the identification of patients, since some of them had lost their wrist bands, and keeping track of their medical condition, since records often did not accompany patients to their new destinations. This resulted in the need to re-xray patients and the duplication of administrative processes. In many cases, nursing had to re-enter the evacuated buildings to retrieve patient records. One recommendation is that procedures be established for evacuating patient records with patients, and a system be designed to keep the record with the patient during the entire process.

e. Staff Disposition:

In general, hospitals that were part of a larger system were better able to accommodate their displaced staff by re-assigning them to other hospitals

in the same system. Some of the problems encountered in the process were low morale, job uncertainty, and transportation difficulties. This led to some resignations and probably retirement. The smaller hospitals had no alternative but to make temporary and permanent layoffs in maintaining their reduced levels of operation.

f. Alternate Use of Facilities:

In general, the hospitals which remained in operation seemed able successfully to adapt their existing facilities to changing health service needs. It should be noted that the recovery process for these hospitals took place in the context of several important changes in health care delivery, including the lessening of emphasis on in-patient care and the increased emphasis on out-patient care. For example, the new Olive View Hospital will have less than 400 beds, compared with the 888 beds that were in the original building. The recovery period was also marked by drastic escalations in construction cost, and by the introduction of complex new technologies and equipment. In fact it would be interesting to speculate that much of the equipment destroyed in the earthquake would in any event have been found obsolete and replaced during the course of the five years following the earthquake.

g. Recovery Process:

Since new lessons are learned from each earthquake, hospital administrators involved in hospital preparedness must be prepared for the unexpected. This includes dealing with public bodies through the introduction of more stringent reconstruction standards, planning for construction delays, and changes in disaster assistance and reimbursement policies.

It is probable that all the hospitals would have kept much better records than they did if they were familiar with the procedure of successfully applying for federal disaster assistance. As it turned out, the hospitals that were members of a larger system and were more bureaucratically oriented seemed to do a better job than the smaller hospitals in gaining reimbursement for their losses.

In addition, the system hospitals were better able to shift resources, including personnel and equipment, within the system.

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# APPENDIX I

## HOSPITALS AT THE THRESHOLD OF DAMAGE
## IMPERIAL VALLEY, CALIFORNIA: OCTOBER 15, 1979

# HOSPITALS AT THE THRESHOLD OF DAMAGE:
# IMPERIAL VALLEY, CALIFORNIA: OCTOBER 15, 1979

## INTRODUCTION

On October 15, 1979 a destructive earthquake shook the Imperial Valley of California. The quake, which occurred at 4:16:55pm (PDT), had a Richter $M_1$ magnitude of 6.6 and many aftershocks, the largest of which was 5.2. Its epicenter was on the Imperial Fault 16 km east of Calexico. There was no loss of life, but there was some property damage to the towns and surrounding areas of El Centro, Imperial, Brawley, and Calexico (all in the Imperial Valley, which is for the most part a flourishing, extensively irrigated, agricultural area).

Most of the commercial buildings in the principal towns in the affected area - El Centro, Calexico and Brawley - are one and two story structures of varying age. Many are relatively old and built of unreinforced masonry, but there is also a representative group of recent structures of relatively modern architecture and structural design.

In general, there was only minor structural damage to the typical commercial construction although a few buildings were subsequently condemned. There was some parapet damage, some veneer loss, some architectural damage, and occasional cracking; but, for the most part, the greatest effect apparently was the loss of library racks, store merchandise and other shelved items.

The six story reinforced concrete Imperial County Services Building, however, was severely damaged, and proved the exception to the rule.

## COMMUNITY HOSPITAL, EL CENTRO

The hospital was built in 1957, with a major addition in 1973 that was separated by seismic joints. It is a one story building of steel frame and bar joist construction with some concrete or block shear walls. The hospital has ninety-two beds plus ten bassinets.

The hospital received 37 patients because of the quake. They came in their own cars, police cars, or ambulances. Injuries were mainly cuts and bruises: there were no injuries from structural damage.

There was no panic and no injuries at the hospital (even one maintenance employee on a ladder at the time was not hurt). The lack of panic was helped by the fact that there was almost no damage in the building. One small crack occurred in a masonry wall, and some relative up-lift took place in floor slabs (about .25 inch) at some seismic joints.

Storage systems behaved well although some racks unbraced in the long direction were distorted. Pharmacy supplies were stored according to recommendations of American Pharmaceutical Association and were not upset. One sterilizer fell, but its oxygen valve prevented escape of oxygen. One refrigerator was upset, and a water softener tank surged out when its plywood cover fell off and hit the floor.

It was noted there appears to be no such thing as a one way valve on sewer and water lines, so they can surge back through drains and traps with ground motion. Power cut out, but the hospital emergency power cut in immediately and could take care of all requirements. (There is no elevator in this building).

The city telephone service cut out immediately, isolating the hospital from the outside. Doctors and staff could not be called, but most responded anyway and made their way back to the hospital (while we were there the administrator was reading a letter from a doctor complaining because he was not called with emergency instructions). The telephone was out on and off for 24 hours.

The local McDonald's, which is located a few blocks away, offered food supplies to the hospital. However, the hospital keeps a food supply because of experience in the severe flooding two years previously.

In general, emergency planning worked well, building and contents behavior were excellent, and staff response excellent. The lack of outside

communication was a major weakness, resulting in isolation of the administrator at a critical time for coordination purposes.

PIONEER MEMORIAL COMMUNITY GENERAL ACUTE HOSPITAL, BRAWLEY

Pioneer Hospital is a two story reinforced concrete structure, built in 1950 with accommodation for 78 beds. The hospital suffered minor nonstructural damage: several areas of hung ceiling ripped out and there was some plaster cracking. The building also suffered one broken water line in the Administration Building which affected the air-conditioning system.

Equipment loss was minor: it included one typewriter and a file cabinet that fell on a table, breaking it. The emergency room treated 23 injuries, mostly cuts and bruises, and one fractured pelvis. Most of the physicians lived close by and reported quickly. There were no injuries to staff or hospital patients. Ten patients were hooked up to hemodialysis machines when the quake struck; fortunately the machines continued to function although later the water purifier for the machines broke down and back-up apparatus had to be trucked 150 miles from an Orange County hospital.*

The disaster response of the hospital was very good and the disaster plan worked well. At 11:59pm (after the afternoon shock) an aftershock of M5.6 occurred whose effects were most prominent in the Brawley area. There are conflicting accounts of reaction at the hospital: according to the administrator some patients were moved into the lobby because they felt safer there. According to the County Health Director some nurses on the second floor panicked and moved their patients out of the building onto the lawn. The psychological strain caused by aftershocks, particularly when they approach or even exceed the main shock in perceived effects, is worthy of investigation. (One aftershock was felt by the authors when in the lobby of Pioneer Hospital in the afternoon of October 17).

* This incident was reported in the San Francisco Examiner, October 16, 1979.

CALEXICO HOSPITAL

Calexico Hospital is a one story reinforced concrete structure with 34 beds. The hospital suffered no structural damage and very minor nonstructural damage as a result of the main shock and aftershocks. The extent of disruption was limited to loss of several bottles falling off shelves. The hospital has a disaster plan, but the effect of the earthquake was so minimal that the disaster plan was not put into effect.

There were no injuries in the hospital itself: six earthquake victims were treated in the hospital's emergency room, and two of these six were admitted and kept overnight.

COMMENTARY

This earthquake - and its aftershocks - is useful in providing a threshold at which damage is just beginning to start, enabling initial points of weakness to be clearly identified. The most significant failure is that of communications: and in a more serious event this could have been most critical. Present reports indicate that the telephone service failed not for reasons of damage but because of overload. Calls blocked the system seconds after the quake, a lot of them made by telephone company personnel. The El Centro area normally makes 20,000 calls per hour: in the 24 hours following the earthquake approximately 90,000 calls an hour were processed. The County Health Service learned within 5 minutes of the first shock that some pay phones were still operating so that it was possible to communicate with the three hospitals and to learn the extent of damage.

The Sheriff's office dispatch radio went down immediately after the earthquake: each hospital had a radio transmitter, but it is not clear to what extent these radios operated after the earthquake.

For an hour after the earthquake there were no local radio stations on the air, including KILO, the designated "emergency" station. The station owner was reported as saying that if he had been there the station would have gone

on the air immediately. He was on a week's vacation, the first in three years.

When the earthquake hit, the owner said, it ruptured the line to the 5,000 gallon butane tank that powers the emergency generator and the gas leaked out. The owner said he could have switched to another tank. However, his crew members had been ordered not to turn on the emergency power unless the Imperial Irrigation District said that the power would be off for a considerable time. His staff did not attempt to start the generators and were too busy with the mess inside the station and in the emergency fall-out shelters. The station resumed broadcasting when normal power was restored. The owner of the other station in town reported that it would cost $3,000 to install auxillary power at his station, a cost that would be hard to justify economically because it is so seldom needed.*

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* Information on the radio stations is based on a report in the Brawley News, October 17, 1979.

# APPENDIX II

# PACOIMA MEMORIAL LUTHERAN HOSPITAL

# DAMAGE TO BUILDING SERVICES, EQUIPMENT, CONTENTS, AND NONSTRUCTURAL (ARCHITECTURAL) COMPONENTS

PACOIMA MEMORIAL LUTHERAN HOSPITAL

DAMAGE TO BUILDING SERVICES, EQUIPMENT, CONTENTS, AND NONSTRUCTURAL (ARCHITECTURAL) COMPONENTS

This listing of damage is derived from reports by hospital medical, administrative, and maintenance staff. It is not a complete list, but it exemplified damage which either was noticed by building occupants or affected their duties. The building suffered extensive structural damage but did not collapse: the building was evacuated and subsequently a large portion was demolished.

A. DAMAGE TO BUILDING SERVICES

1. Power generators knocked off platform: power out for half-hour then emergency came on: adequate but intermittent.
2. No emergency lighting in central supply.
3. Engineering staff shut-off mains and steam systems. It took 3-5 hours to check-out systems and bring boilers back in line.
4. Many electrical conduits damaged.
5. Water softeners and boilers damaged.
6. Water supply knocked out: water squirts up from breaks in mains, and no water in the delivery (obstetric) area, so no way to clean up after delivery.
7. No oxygen supply: lines severed, but leaks rapidly repaired.
8. Drinking water supply suspect: friend with well in Bishop brought in water in truck.
9. Telephone switchboard fallen off mounting and sitting in middle of lobby. However, telephone service remained for about half an hour after earthquake then went off: later became intermittent.
10. Nearby gas line exploded: gas lines were severed, but leaks rapidly shut-off by plant engineering staff.

B. DAMAGE TO BUILDING EQUIPMENT AND CONTENTS

1. All three elevators were disabled. One elevator was fixed during the first day, and used to remove heavier items of equipment.

2. By 10:00am engineering department decided one elevator was safe, and it was used to evacuate critical patients. However, elevators depended on emergency power, so intermittent operation only.
3. Nursing Areas: Two portable x-rays on a nursing floor rolled and were damaged. Beds thrown up against wall. Mounted T.V.s in patient rooms catapulted off mounts, some forwards, some sideways, but no patients injured.
4. Nursing Office: All files and books thrown on floor, desks jammed together. Inactive files in basement destroyed.
5. Third Floor, Nursing Station: Ceiling height doors of cupboard opened and I.V. solution spilled out and broken.
6. Fourth Floor, Nursing Station: Broken glass and bottles everywhere on floor.
7. Pediatric Nursing Station: All drawers emptied onto floor, baby food fallen off shelves and was strewn everywhere.
8. Dietary Area: "a mess;" all glass broken, juice all over floor, ovens moved off foundations, deep freeze and milk box inoperative through power loss.
9. Medical Records: Everything on pile in middle of floor. Metal shelves not bolted to wall had tipped forward, spilling records. All typewriters, desks and adding machines tipped over or fallen on floor and damaged beyond repair.
10. Central Supply: Devastated; broken glass everywhere.
11. Pharmacy: All bottles thrown from shelves, many broken.
12. I.C.U.: Most I.V. solutions in I.C.U. fell on floor and broken. Most supplies destroyed, all supply rooms damaged. I.C.U. beds lighter than typical beds and moved easier.
13. OR & Delivery: Sliding door cabinets, supplies intact. Medications housed in patient cubicles also salvageable.
14. Obstetrics: Incubators rolled around. Doorless medical cabinet destroyed. Nitrous oxide tank in labor area tipped over, but usable. I.V. bottles, and other glass materials in labor area broken.

15. Radiology: All file cabinets tipped over.
All radiology equipment damaged.
Developer and fixer in darkroom splashed over.
Most supplies fell from open shelves.
Debris and glass all over floor.
One x-ray machine made operable later in morning by repairmen, used in emergency room.
Developer made operable: had become contaminated when hospital water supply shut-off.

C. NONSTRUCTURAL (ARCHITECTURAL) DAMAGE

1. Debris in stairwells, but not major obstruction. But front stairwell completely disabled.
2. Windows blown out: all windows on one half of north side broken. Top hinged windows at rear of third level nursing station flung open. Windows in medicine room, second level, broken and pushed in and could not get in room.
3. Front door cracked and jammed.
4. Broken glass on third floor corridor from interior viewing windows.
5. Partitions fell over in pediatrics on fourth floor.
6. Entrance to Radiology blocked by damage.
7. Plaster all over, and cracks in walls.
8. I.C.U. - "lots of glass on floor."
9. Some sinks pulled out of walls by aftershocks.
10. Third Floor: ceiling tiles, dust, broken glass and other debris on floors, but do not prevent movement.
11. Ceiling in corridor outside emergency room "out of kilter."