GREATER ANCHORAGE AREA EARTHQUAKE RESPONSE STUDY

1980

Prepared By
Alaska Division of
Emergency Services
Contract DU210-2

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PREFACE

The purpose of this report is to provide the Federal Emergency Management Agency, the State of Alaska, and local Municipalities with a rational basis for planning earthquake and tsunami relief and recovery operations in southcentral Alaska. The maps, tables, and other data in this report have been prepared for this purpose <u>only</u>. Application of the material in this report to other types of analysis should be undertaken with care, and due attention should be given to the limitations and restrictions placed on the data and conclusions stated.

INTRODUCTION

The purpose of this report is to provide essential data needed by disaster response agencies for their pre-disaster planning for a major damaging earthquake/tsunami for southcentral Alaska primarily in the populous Anchorage Municipality. The Federal Emergency Management Agency recognizing the need for pre-disaster planning entered into an agreement with the State of Alaska, Department of Military Affairs, Division of Emergency Services to undertake this study in area described above with special emphasis on estimating the damages to the Anchorage Municipality since it contains the majority of the States' population. Anchorage in its urban environment, is much more dependent upon the infrastructure than is rural Alaska. Primary attention has been placed on the damage to winter survival lifelines of the infrastructure such as electric power and natural gas. Facilities critical to disaster relief and recovery have also been given a great deal of emphasis.

The objectives, scope, and format of this report are similar to the NOAA reports, "A Study of Earthquake Losses in the San Francisco Bay Area," 1972, "A Study of Earthquake Losses in the Los Angeles, California Area," 1973, and USGS's report, "A Study of Earthquake Losses in the Puget Sound, Washington Area," 1975.

The methodologies used in the aforementioned reports have also been used in this southcentral Alaska report, except that some of them have been revised to fit the Alaskan situation. The supporting details for some of the methodologies described in the preceeding studies have not been repeated in this report.

ACKNOWLEDGEMENTS

This study was prepared by members of the Alaska Division of Emergency Services (ADES), for the Federal Emergency Management Agency (FEMA), Region X, under HUD Contract DU210-2.

Much of the material for the contents of this study was researched, compiled and edited by Duane Bessette, Wendy Rader and Christy Miller of the ADES staff. The engineering firms of DOWL Engineers and ABKJ Inc. researched and compiled the remainder of the material. Mr. David Cole, Vicky Sterling, Roberta Goldman, Alma Hartman, Arthur Anderson and Arthur Jacobs were the principal contributors from the engineering firms.

Other staff members from ADES assisted in the work leading to the final product. These included Mr. Clyde Bloker who contributed communications information and Ms. Audry Motznik who edited the grammar and spelling. Most of all, we appreciate Mrs. Suzi O'Docharty who patiently typed and retyped the manuscript.

Other contributors from the private and public sector include: Perry Johnson, David Sinclair, "Bud" Schultz, Larry Markley, Hank Nikkels, Tom Starr, Al Pistorius, Benjamin Wattum, Jack Harris, George Shaginaw, Rodger Funk, Jack Brown, Annette Burst, Jan Dixon, Lynne Johnson, Mark Johnson, Robert Hall, Stephen La Fevers, Barbara Miller, Ray Dickey, John Muth, Richard Pauley, David Reisinger, Ronald Seavetto, Jerome Smith, John Franklin, Bruce Staser, Jack Steele, Gerald Travis, Jack Ziemke, Howard Slack, Dick McCart, and William DuVall.

Invaluable assistance was rendered by FEMA, Region X staff members and special recognition is given to Mr. Richard Buck and David Peyton. Mr. Karl Steinbrugge's technical expertise and general guidance was of paramont importance in the completion of the study.

STATEMENT OF THE PROBLEM

The purpose of this study was to estimate the amount of damage to critical facilities (hospitals/clinics) within the Municipality of Anchorage, which might be expected to occur during potential earthquakes along the local fault systems. The seismicity of the Anchorage region, and the fault systems which can most seriously affect the area will be described later herein.

The study was divided into three areas of data collection and analysis:

- Seismic parameters related to potential ground shaking within the Municipality
- Structural and occupant data of the critical facilities (hospitals/clinics)
- Assessment of building damage, and deaths and injuries associated with potential seismic activity and the structural integrity and occupant load of the critical facilities.

DATA COLLECTION AND LIMITATIONS

The seismic assessment of the area was performed by combining the results of several seismic investigations performed for various sites within the Municipality, and coupling this information with the published literature specific to Southcentral Alaska.

Building and occupancy data was collected from various sources, some of which included: original drawings and specifications of the major facilities, hospital and clinic staff and patient records, walk-through inspections of the facilities, and on-site interviews with personnel of the facilities. Where information regarding support staff and patient/visitor load was not available, estimates were made based on "typical" data obtained at similar facilities.

The assessments of potential building damage, and deaths and injuries related to hospitals and clinics were based on the judgement of the experienced structural engineers who performed the plan review and walk-through inspection of the major facilities, and on statistical summaries of these parameters recorded for major earthquakes which have occurred in the past within populated areas of the United States.

Detailed and rigorous investigations required for site-specific seismic design studies were not within the scope or the intent of this study. Therefore, the seismic parameters presented herein (isoseismal intensities, recurrence intervals, etc.) are very general in nature, and should be used for emergency response planning purposes only, <u>not</u> for design. Moreover, the <u>estimates</u> of building damage and personal injuries presented in this study reflect the <u>general</u> behavior of each type of building (reinforced concrete, steel, wood frame, etc.) and structural system (shear wall, moment resisting frame, etc.), but do not and could not address the <u>specific</u> behavior of each uniquely detailed structure. Again, it should be noted that the results presented herein are general in nature, albeit produced using rational methods and sound engineering judgment and experience, and should be used for response planning purposes only.

REGIONAL GEOLOGIC SETTING

The Municipality of Anchorage lies in the physiographic province known as the Cook Inlet Lowlands. The Cook Inlet Lowlands occupies a structural trough (coastal trough), which is bordered to the west and north by the Alaska and Aleutian Ranges (Alaska/Aleutian Province), and to the south and east by the Talkeetna, Chugach and Kenai Mountains (Pacific Border Ranges). The Pacific Border Ranges is the southern province of the larger major physiographic division known as the Pacific Mountain System. This system is one of the four major Alaskan physiographic divisions identified as the northwesterly extension of major physiographic divisions of Canada and the western conterminous United States. The Pacific Mountain System includes two dramatic mountain provinces (Alaska/Aleutian and Pacific Border Ranges) separated by an extensive coastal trough (Cook Inlet/Susitna Lowlands) (Figure 1).

The Alaska/Aleutian Province is a region of extreme seismic and volcanic activity, which has been identified with the subduction zone formed as the Pacific Ocean plate dips below the North American continental plate. The collision of these two tectonic plates and the resulting subduction zone has formed the Aleutian Island chain and the contiguous Aleutian Range on the Alaskan Peninsula. This volcanic island arc and

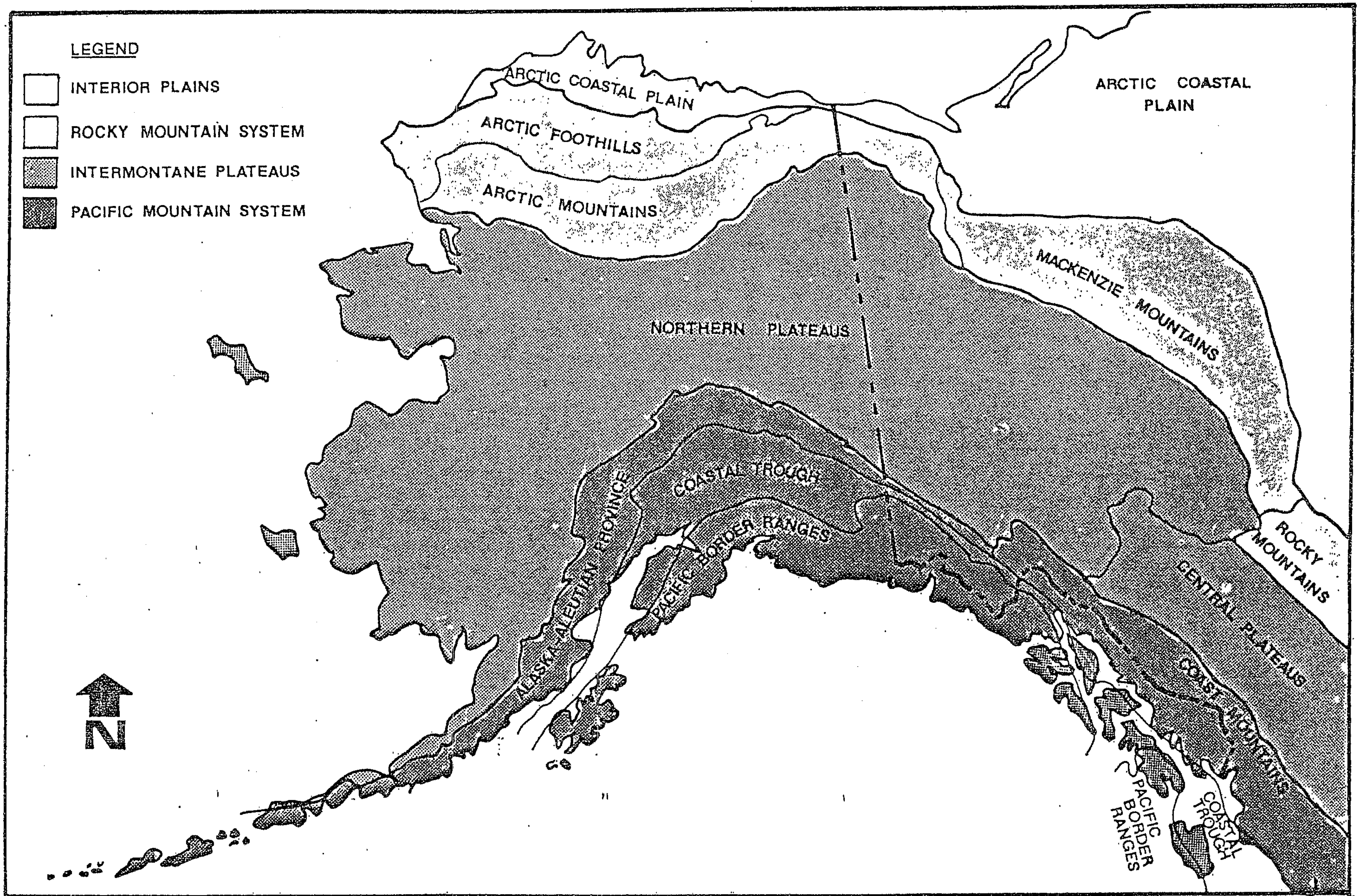


FIGURE 1 PHYSIOGRAPHIC DIVISIONS OF ALASKA

associated deep ocean trench (Aleutian Trench) are typical expressions of arcuate volcanic island/trench groups found throughout the Pacific. The somewhat regular distribution of the volcanism around the continental margins of the Pacific have led to the coining of the popular name "The Ring of Fire" for this region.

Most of the seismic activity of the world takes place along the areas of collision between the continental and oceanic plates. It is, in fact, the mapping of the earth's seismic activity that led to the recent theory of global plate tectonics. The Aleutian Island Arc and its continued continental expression -- the Alaskan Peninsula -- form the concave northward expression of orogenisis (mountain building) related to the collision of the North American Continental Plate and the Pacific Ocean Plate. The Alaska Range is the concave southward expression of this same phenomenon. Together these two mountain ranges merge to form an area 3,200 miles long and 100 to 300 miles wide in which approximately six percent of the world's earthquakes occur. The majority of these shallow-focus earthquakes (focal depths less than 70 kilometers) occur between the Aleutian Trench to the south, and the volcano chain to the north.

AREA SEISMICITY

The seismicity related to Anchorage is produced by three major faults affecting the area (Figure 2) -- the Aleutian Megathrust (about 25 miles directly below), the Castle Mountain Fault System (about 25 miles west),

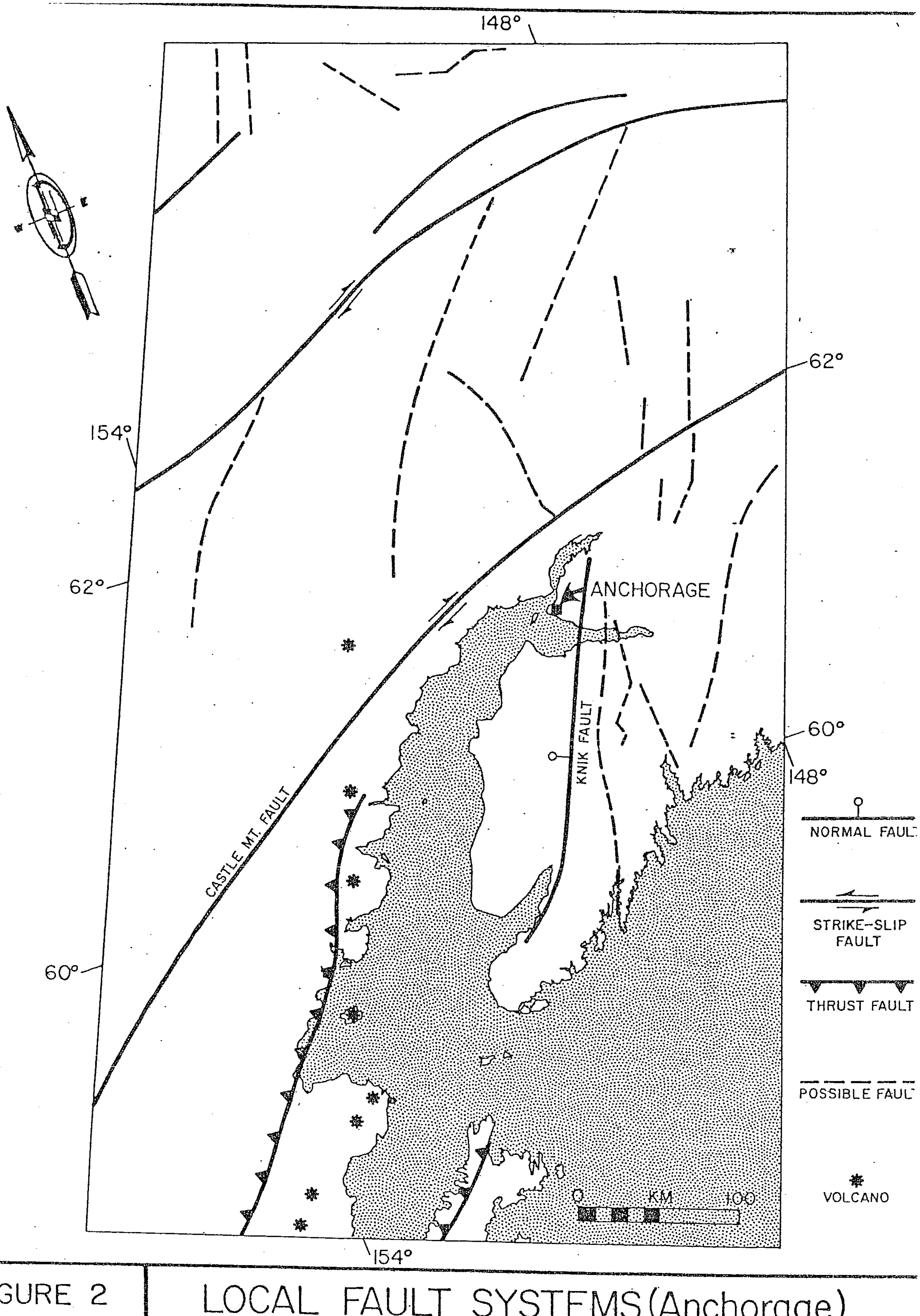
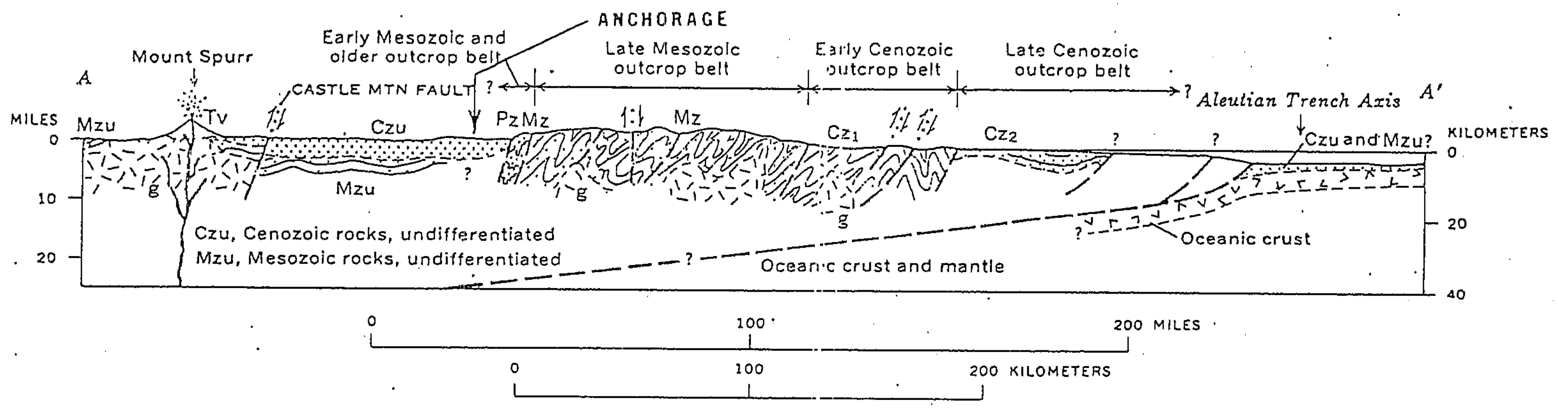


FIGURE 2 LOCAL FAULT SYSTEMS (Anchorage)

and the Knik Fault, also known as the Chugach Mountain Front Lineament (about six miles east). Past and potential future seismic events related to these faults were examined in this study.

Aleutian Megathrust

The subduction zone between the North American and Pacific Ocean tectonic plates is topographically expressed in the North Pacific by the arcuate Aleutian Island chain, the mountains which form the Alaskan Peninsula, and the deep Aleutian oceanic trench. The subduction zone in this area of the Pacific is thought to be a shallow north dipping (reverse fault) thrust zone termed a "megathrust" (Figure 3). The unusually shallow angle of thrust is inferred from hypocentral locations and fault plane solutions of the earthquakes that continually express the tectonic realignment along the northern limits of the Pacific Ocean Plate. Although a simplistic interpretation of earthquake epicenters and topographic expression implies the Aleutian megathrust is a smooth circular arc with a radius of approximately 1280 kilometers (800 miles), it is now believed that the arc is composed of relatively short straight line segments joined together at slight angles. It is further thought that these segments are tectonically independent, and may be separated by transverse tectonic features somewhat like the transform faults associated with areas of sea floor spreading. There has been a tendency for the hypocenters of large earthquakes to occur near one end of these blocks, and the accompanying aftershocks to spread over the remaining portion, so that during large events strain is released over an entire segment of



Tv

Andesitic extrusive rocks of active or dormant volcanoes

Cz2

Late Cenozoic bedded rocks
Lighter pattern where projected offshore

Cz1

Early Cenozoic bedded rocks
Lighter pattern where projected offshore

Mz

Late Mesozoic bedded rocks
Lighter pattern where projected offshore

PzMz

Paleozoic and early Mesozoic bedded rocks
Lighter pattern where projected offshore

g

Granitic plutonic rocks

Undifferentiated rocks

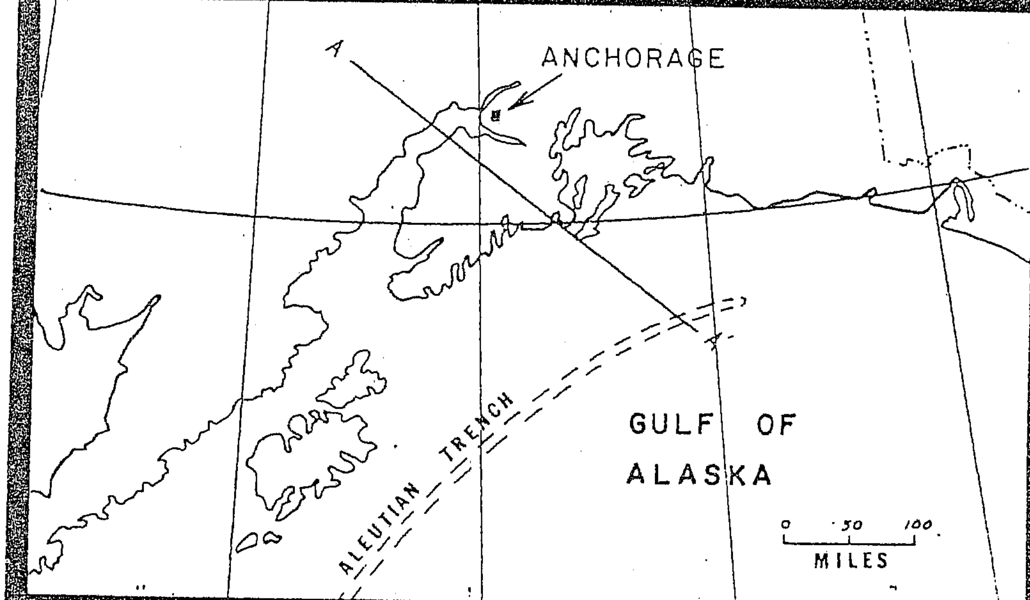


FIGURE 3

Idealized Geologic Cross Section

the megathrust zone, but stops abruptly at the discontinuity between individual segments (Sykes, 1971).

Nearly the entire Aleutian Arc between 145°W and 170°E has ruptured in a series of great earthquakes (M_L greater than 7.8) since the late 1930s (Keller, 1970). The last great event was the 1964 Prince William Sound Earthquake, which was the largest ever recorded on the North American continent (8.4 to 8.6). It is believed that this activity is typical rather than atypical for this area, and that future earthquakes of magnitude 7.9 or larger can be expected along the megathrust.

Castle Mountain Fault System

The Castle Mountain Fault, which lies approximately 25 miles west of Anchorage, has been classified as a right-lateral (dextral) strike-slip fault by Grantz (1966) although it is thought by some to be a reverse fault steeply dipping to the northwest. The fault strikes southwest from Lake Louise east of the Talkeetna Mountains through the Susitna Lowlands where it is thought to join the Lake Clark Fault in the Aleutian Mountains. The continuity of these two faults has not been satisfactorily demonstrated; therefore, for this study the limits of the Castle Mountain Fault are restricted to the Susitna Lowlands segment and the Talkeetna Mountains segment. The combined length of these two segments is approximately 350 kilometers (215 miles).

Several kilometers of right-lateral slip have been mapped in Cretaceous and Tertiary lithologic units along the eastern half of the fault. These displacements are believed to have taken place during Eocene to Oligocene time. Large vertical displacements associated with reverse dip-slip faulting have taken place since Miocene time. The vertical offsets are steeply dipping to the north or near vertical. At least three meters (10 feet) of Recent dip-slip displacement have been observed along the central portion of the fault; however, no historic fault breaks are known to have occurred. Even the 1964 Prince William Sound earthquake caused no known slippage along the fault, although the Castle Mountain Fault System is within the area of gross tectonic warpage caused by this event.

Seismic activity along this fault generally is associated with low magnitude (3.0 to 4.5) shallow events. Only six earthquakes with magnitudes of 6.0 or greater are associated with this fault. Of these six only two were greater than 7.0. The maximum historical earthquake is believed to be a magnitude 7.3 event which occurred in 1943; however, the lack of standard seismograph stations in Alaska, as well as incomplete travel time data prior to 1964, resulted in somewhat imprecise location of earthquake epicenters and hypocenters prior to this time. Although the 1943 event has an epicentral location north of the fault trace, it is believed that this earthquake should be associated with the Castle Mountain Fault.

Knik Fault

The Knik Fault, also known as the Chugach Mountain Front Lineament, is the source of some controversy among geologists and seismologists. The stratigraphic and lithographic evidence presented by Clark and others has shown the fault to parallel the base of the Chugach Mountains that border the Cook Inlet-Susitna Lowland. The fault is believed to be about 135 miles long, and to extend from its inferred intersection with the Castle Mountain Fault in the Matanuska Valley to the southern tip of the Kenai Peninsula, where its surface expression dips below the sea. Stratigraphic evidence indicates that this fault is a normal fault steeply dipping to the west.

There is much dispute about the seismic activity along the Knik Fault. Some investigators believe the lack of physiographic expression within the Recent alluvial deposits which flank the western limits of the Chugach and Kenai Mountains suggests the fault is inactive. However, seismicity studies performed by Gedney for previous projects in the Anchorage area indicate the fault indeed is active. He stated that during the period between April 1968 and November 1973, about 150 seismic events have taken place along the fault. Further data obtained for this area have supported the results of his earlier seismicity study.

Complete information concerning the general seismicity of the Knik Fault is lacking because of incomplete historical records, and the masking effect of seismic activity along the underlying Aleutian Megathrust.

The installation of a more complete network of seismic instrumentation throughout Alaska has produced, and will continue to produce, more accurate and complete information on epicentral location and depths of seismic events along this and other faults in Alaska.

Even though the seismicity of the Knik Fault is disputed, it is felt that the proximity of this fault to Anchorage and its potential, if not actual, activity warrants the inclusion of this fault into the general seismic schema of the area. It is believed that a magnitude 6.7 earthquake in the Kenai Lowlands, which occurred in 1954, can be attributed to this fault. This event will be considered the historical maximum along the Knik Fault for this study.

Other Southcentral Alaska Faults

The aforementioned faults will be considered as those most critical to the Anchorage area because of their proximity and potential activity. Other faults in Southcentral Alaska are relatively distant, and their effects on Anchorage should be minor compared to the potential activity of the faults in the immediate area (Figure 4).

Approximately 250 kilometers (150 miles) north of Anchorage lies the Denali Fault System. The Denali Fault System arcs 1400 kilometers (854 miles) across central Alaska from the Yukon Territory, Canada, to Bristol Bay in the Bering Sea. The fault is divided into three major segments -- the eastern or Shakwak Valley segment, the western or Farewell

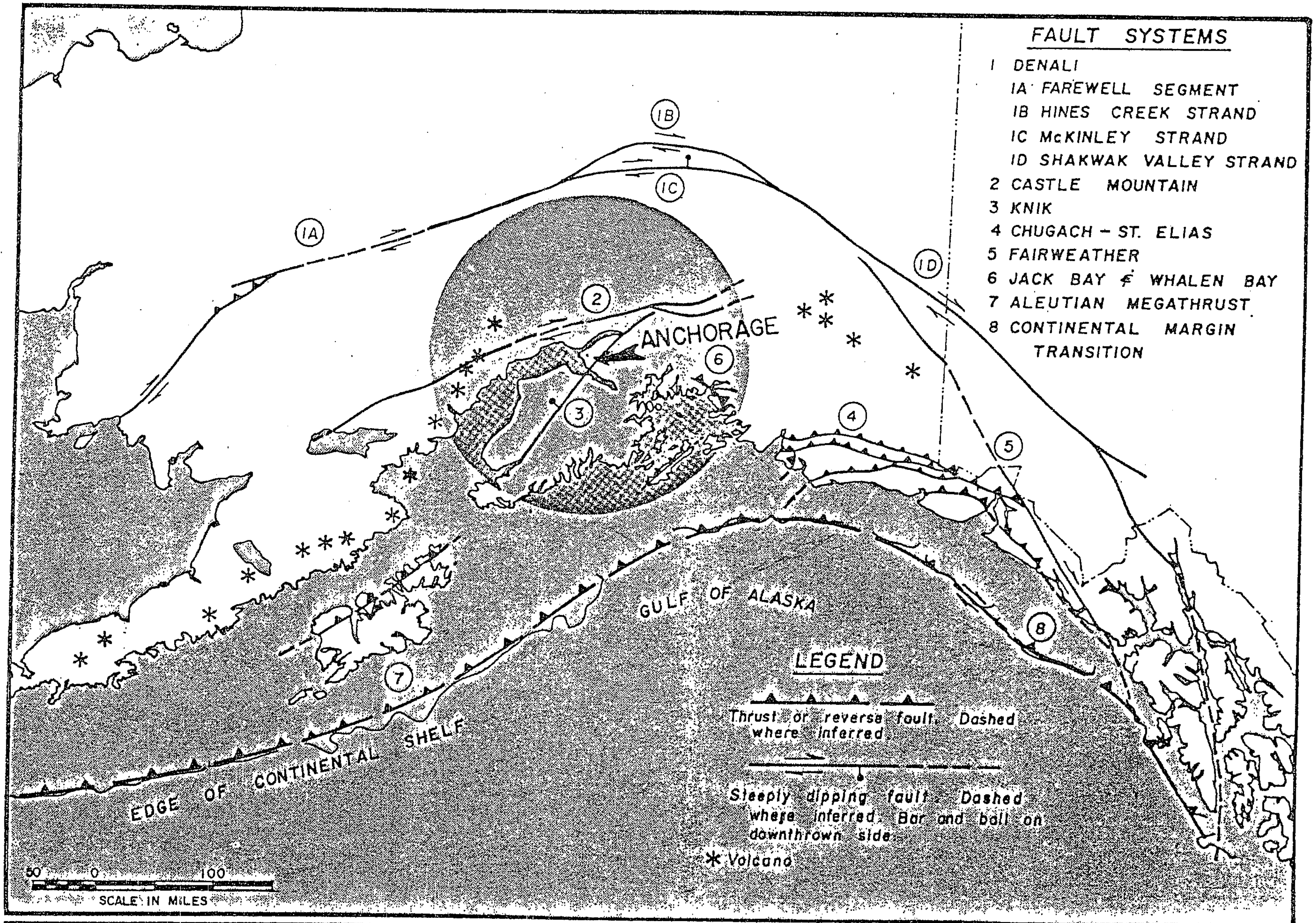


FIGURE 4 MAJOR FAULTS IN SOUTHCENTRAL ALASKA

segment, and the two strands of the central segment identified as the Hines Creek Strand and the McKinley Strand. Grantz (1966) suggested that the younger southern strand (McKinley) has "short-circuited" the older, and longer, northern strand (Hines Creek) thus becoming the active section of this portion of the fault system.

In spite of the geologic evidence of major prehistoric displacements along the Denali Fault System, the currently measured slip rates along the fault (less than three millimeters per year) (Page and Lahr, 1971), and the historic record of past earthquake activity indicate that this fault system has historically had a low level of seismicity. Only two historic events with magnitudes larger than 7.0 are believed to be associated with this fault system. A magnitude 7.4 earthquake which occurred along the McKinley Strand in 1912, and a magnitude 8.3 event in 1904 is associated with the Farewell segment of the fault system. Eleven earthquakes of magnitude 6 or greater have occurred throughout the central and eastern segments of the system since 1900.

The Bruin Bay Fault lies to the west of Cook Inlet, and is thought to be connected to the Castle Mountain Fault by the Moquawkie Contact. The Moquawkie Contact is about 80 kilometers (50 miles) from Anchorage at its closest approach.

The Kenai Lineament, Hanning Bay, and Patton Bay Faults lie to the southeast from Anchorage. The Kenai Lineament is the nearest to Anchorage -- approximately 115 kilometers (70 miles).

FUTURE EARTHQUAKE ACTIVITY

An empirical statistical method normally is used to estimate recurrence intervals between potentially destructive earthquakes within a study area (Richter, 1958). Previous seismicity studies of the Anchorage area were reevaluated and updated with more recent local earthquake data. An analysis of the three faults believed to most adversely influence the area is presented below.

Aleutian Megathrust

The lack of complete historical data, and the complexity of the tectonics of the Aleutian Megathrust, make definitive statistical analysis of future seismic activity along this fault quite difficult. Gross tectonic strains (about two inches per year) leading up to the great 1964 earthquake in Prince William Sound have led to estimates of recurrence intervals of 120 to 170 years. However, historical records suggest return intervals as short as 30 years. It is estimated that terrace uplifts on Montague Island associated with megathrust activity are separated by approximately 850 years, yet some fault rupturing on the island is thought to be as recent as 150 to 300 years. Thus, the uncertainty and variability of earthquake recurrence along this fault is clearly demonstrated.

Kelleher, Sykes and others have studied the spatial and temporal distribution of great earthquakes (M greater than 7.7) along the Aleutian Megathrust Zone and the major fault systems of southcentral and south-eastern Alaska. Although the historic records are somewhat meager for this region, apparent trends suggest the space-time distribution of great earthquakes approaches linearity, and progresses from east to west. Moreover, the aftershock zones of great earthquakes (rupture surfaces) tend to abut one another with very little overlap. Great and large earthquakes do not appear to rerupture the same area within a span of several tens of years. The exception of this "rule" is the sequence of great events which occurred at the turn of the century along the Chugach-St. Elias Fault System near Yakutat Bay.

Areas of seismic quiescence ("seismic gaps") between rupture zones have been observed along the Alaska-Aleutian tectonic boundary as well as other tectonic margins in the Pacific (Figure 5). Observation of the historic space-time sequence of earthquake occurrence has shown that gaps between two rupture zones tend to "fill in" with large or great earthquakes within a few tens of years in the Alaska region.

A gap of 200 to 300 kilometers (120 to 180 miles) is evident between the aftershock zones of the 1958 Lituya Bay earthquake (M=7.9) and the 1964 Prince William Sound earthquake (M=8.5). The Chugach-St. Elias Fault System lies within this gap.

In 1970 Kelleher postulated this region to be the likely location of a major earthquake within the following 20 years. His hypothesis was born out on February 28, 1979 when a magnitude 7.7 occurred north of Icy Bay (60.62^{O}N141.51^{O}W). Preliminary evaluation of this event, and attendant

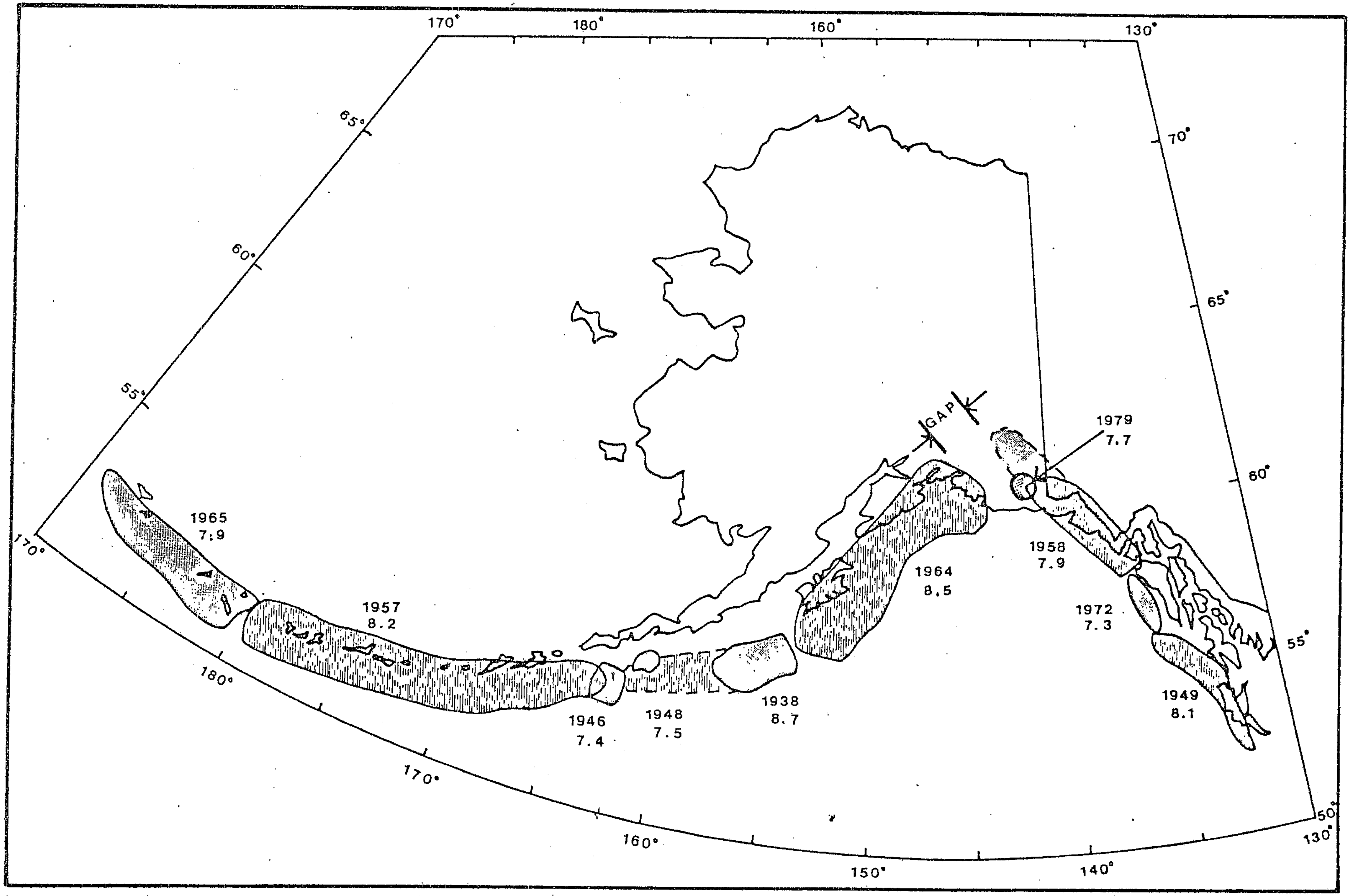


Figure 5 Seismic Gaps in Alaska

aftershocks, inferred that the accumulated strain in the eastern portion of the gap had been released (Lahr, 1979). Estimates of the seismic moment and accompanying fault slip (approximately 4.5 meters) associated with the main shock can account for the strain accumulated in the area since the 1899-1900 series of events near Yakutat Bay, if an average relative motion of five to six centimeters (about two inches) per year between the Pacific and North American plates is assumed. However, the entire gap was not filled in this tectonically complex "corner" of Alaska during the rupture sequence (Lahr, et al, 1979); therefore, the probability of a major earthquake occurring within the gap in the near future should still be considered high.

There is evidence to show that the megathrust extends below Anchorage at a depth of 25 to 30 miles. Some believe release of strain energy near Prince William Sound during the 1964 earthquake has resulted in an increase in strain energy along other portions of the megathrust, and more importantly in that portion underlying Anchorage. For this reason a "maximum credible" earthquake of magnitude 8.5 occurring 25 miles directly below Anchorage was assumed in our analysis. The "maximum credible" earthquake is defined as the largest earthquake that could affect the site regardless of probability. However, because of the lack of complete historical data, the "maximum probable" earthquake assumed for this fault was a magnitude 7.5. The "maximum probable" earthquake is one that is likely to occur during the life of the structures (assumed to be 50 years for the purpose of this study).

Castle Mountain Fault

Surface features in the Susitna Lowland reveal the Recent activity of the Castle Mountain Fault. Although the two largest earthquakes on record for this fault were magnitudes 7.0 in 1933, and 7.3 in 1943, it is believed a magnitude 8.0 earthquake is possible based on the apparent length of the fault. An earthquake of this magnitude would have to rupture along most of the fault and would, therefore, have its closest approach to Anchorage at about 25 miles. An earthquake of this magnitude would be the "maximum credible" earthquake associated with the fault. A magnitude 7.5 earthquake was assumed as "maximum probable" earthquake associated with this fault.

Knik Fault

The presence of the Aleutian Megathrust and its associated seismic activity directly below the Knik Fault has made gathering of accurate information concerning the seismicity of the Knik Fault quite difficult, if not impossible. The installation of a network of modern seismographic stations in Alaska subsequent to 1968 has greatly enhanced the data available concerning this fault. Although the time frame of the data base is rather limited, reasonable results of recurrence intervals have been produced. Data used in previous studies for this fault have been updated to include the later events. Incorporation of the later data into these studies has not changed the original estimates. Although the maximum historic event associated with this fault is a magnitude 6.7

TABLE I

EARTHQUAKE SUMMARY

Fault System	Fault Length (miles)	Potential Magnitude M	Distance of Fault From Site (miles)	Bedrock Motion		Recurrence Interval (years)
				Predominant Period (sec)	Maximum Acceleration (% g)	
Aleutian Megathrust	--	8.6	25-30	0.45	0.34	400 - 150
		8.4		0.44	0.32	200 - 100
		8.0		0.40	0.28	100 - 50
Castle Mountain	350	8.0	25-30	0.40	0.28	200 - 100
		7.5		0.37	0.24	80 - 40
		7.3		0.35	0.22	60 - 30
Knik	135	7.5	6	0.37	0.54	180 - 100
		7.0		0.32	0.49	80 - 50
		6.0		0.25	0.37	20 - 15

earthquake, we feel a magnitude 7.0 event is possible along this fault during the life of the structures.

The recurrence intervals associated with the earthquakes used in this study appear in Table I.

SEISMIC RISK

The term "seismic risk" might be defined as the probability that a specific site will experience a given level of ground shaking during a specified design period. The design period is usually considered as the socioeconomic life of the structures or systems under consideration.

Although advances have been made in the field of earthquake prediction in recent years, the necessary precursory parameters are not yet well defined, nor is the requisite instrumentation deployed regionally to measure and record such data. Therefore, the seismic exposure or seismic risk associated with the Anchorage area was assessed by the more classic probabilistic approaches, and was tempered with the less rigorous intuitive observations of regional seismic history.

Regional seismic risk analyses commonly are based on the assumption that earthquakes occur randomly in space and time within a given area. A Poisson distribution model is used, which assumes that future events will occur randomly and independently of past events, but with the same mean frequency distribution of the historic events within the region.

This procedure has limitations because it is based solely on statistical interpretation of the historic seismic activity of the study region. Little account is given to regional geologic setting, or the geophysical processes that actually produce earthquakes. The recent theories of global plate tectonics, and the continuing expansion of the World Wide Seismological Network have begun to allow significant advancements to be made in the fields of regional geology and seismology. However, until more complete source models are developed and the actual earthquake data base is greatly expanded, long-range earthquake prediction techniques will continue to rely heavily on statistically based stochastic probability analyses.

Statistical Procedure

The historic distribution of earthquakes (seismicity), according to magnitude, location, and time of occurrence within the Cook Inlet/Prince William Sound Region was researched through our earthquake data files (Figure 6). These files were obtained from the National Oceanic and Atmospheric Administration (NOAA) Environmental Data Service. Our files are updated periodically to include the most recent worldwide events.

The historic seismicity of this region was analytically described according to the relationship proposed by Richter (1958).

$$\log n = a - b M$$

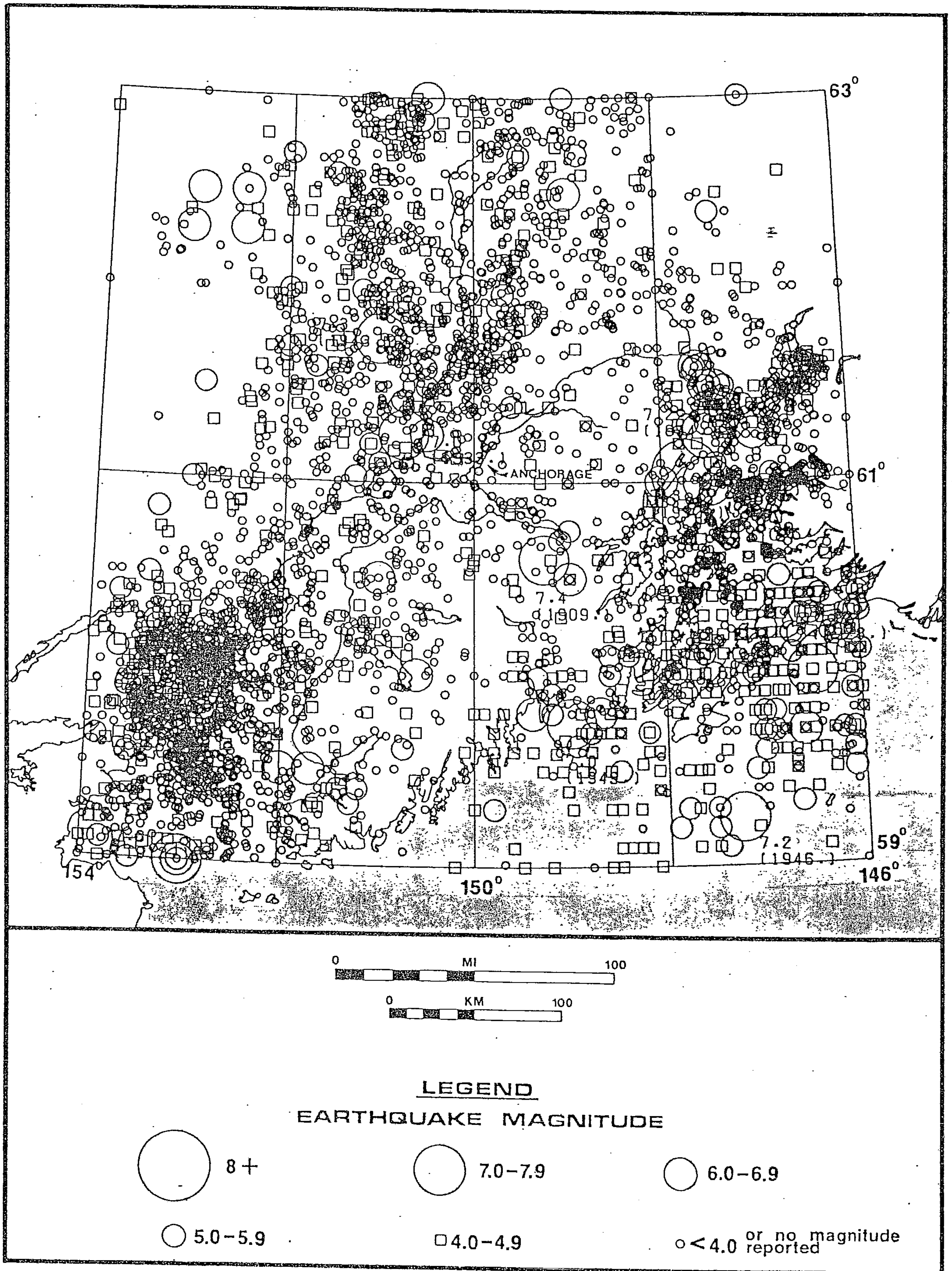


FIGURE 6 EARTHQUAKE EPICENTERS 1899-1977

Where: n = number of shocks of magnitude M or greater per unit time for the study region

a and b = constants

A graph of this relationship for the Anchorage area is shown in Figure 7. This plot shows the historic frequency distribution, or the mean annual distribution of earthquakes within the study region. The size of the region was determined by selecting a lower limit of ground motion that might affect the study area (in this case a ground acceleration of 0.05g), and, using one of several attenuation relationships, the maximum distance from the area that an upper bound magnitude earthquake (M=8.5) would produce this level of ground acceleration was determined. The resulting distance was used as the "search radius" for this study. All earthquakes known to have occurred within the area circumscribed by this radius were used as the data base.

ISOSEISMAL MAPS

An isoseismal map was constructed for the Anchorage area to form a general basis for the evaluation of critical facilities (Figure 8). This map is very general in content and is to be used for planning and evaluation purposes for this study only. It should not be used for site specific evaluation or design.

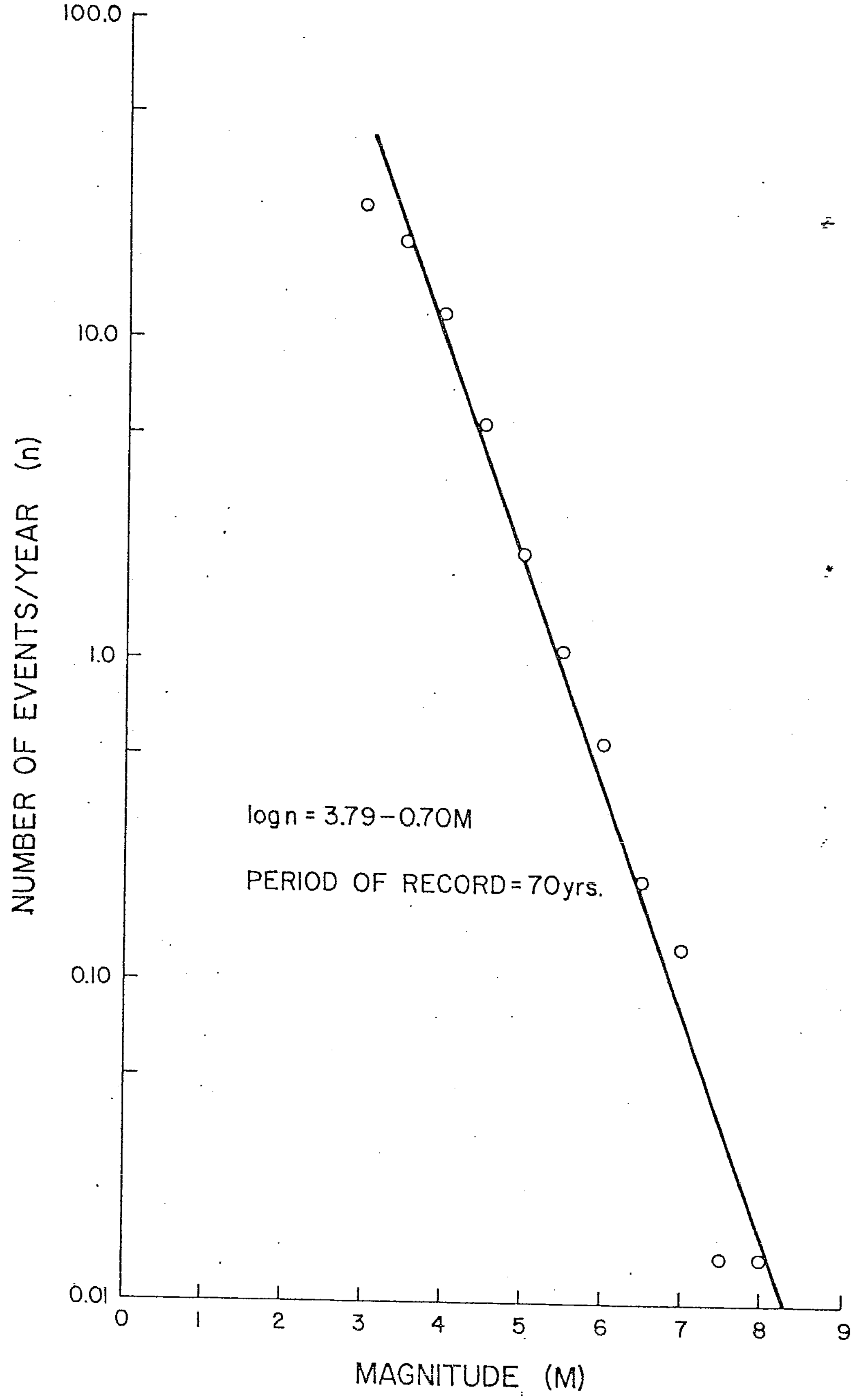
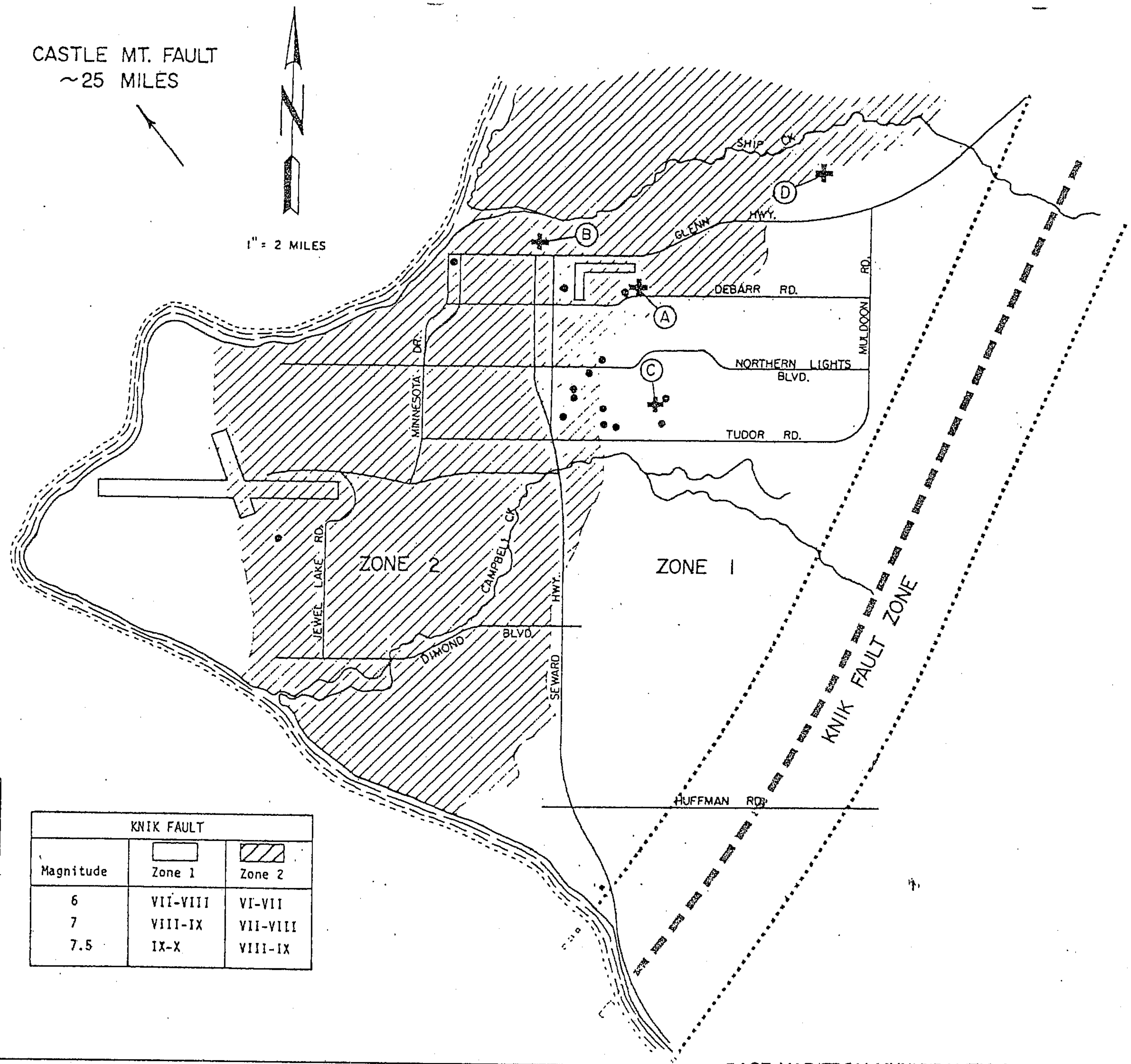


FIGURE 7 — CUMULATIVE MAGNITUDE FREQUENCY RELATIONSHIP (ANCHORAGE REGION)

(A)	Alaska Hos[illegible]l and Medical C[illegible]r
(B)	PHS Alaska Native Medical Center
(C)	Providence Hospital
(D)	USAF Hospital Elmendorf



CASTLE MT. FAULT AND ALEUTIAN MEGATHRUST		
Magnitude	Zone 1	Zone 2
6	VI-VII⁻	V-VI
7	VII-VIII	VI-VII
8	VIII-IX⁺	VII⁺-VIII⁺
*8.5	IX-X	VIII-IX

*Aleutian Megathrust Only

KNIK FAULT		
Magnitude	Zone 1	Zone 2
6	VII-VIII	VI-VII
7	VIII-IX	VII-VIII
7.5	IX-X	VIII-IX

FIGURE 8 EARTHQUAKE INTENSITY DISTRIBUTION - ANCHORAGE

BASE MAP FROM MUNICIPALITY OF ANCHORAGE GEOTECHNICAL HAZARD ASSESMENT STUDY. 1979.

The isoseismal map was constructed based on seismic attenuation relationships proposed by Schnabel and Seed (1972) and spacial distribution of shaking and length of fault rupture proposed by Housner (1969). Additionally, the results of several ground response analyses performed for sites within the Municipality were combined with the general subsurface geology of the Anchorage Bowl (Trainer, 1965) to estimate the probable intensity and character of ground shaking within the Municipality.

For the purposes of this study the Municipality was divided into two zones. The soil within Zone 1 can be generally described as a deep deposit of dense glacial tills overlain by outwash material of glacial origins. The Zone 2 soils can be described generally as a deep deposit of dense till overlain by 100 feet or more of Bootlegger Cove clay which is in turn overlain by a dense glacial outwash deposit.

The response of these two decidedly different deposits to the same earthquake should be quite different in intensity and character. Zone 1 should amplify higher frequency shaking and should transmit rather high amplitude motions. Zone 2, on the other hand, should tend to amplify low frequency (long period) shaking, and should "filter" or "absorb" high amplitude high frequency shaking. In fact, there appears to be an upper bound to the peak ground motions that can be transmitted through the deep Bootlegger deposits by events produced on the local fault systems.

It should be noted that the seismic intensities shown in Figure 8 are those described in the Modified Mercalli Intensity Scale (MMI). This scale describes the effects of earthquakes in somewhat subjective and general terms. Moreover, the scale describes the general response of the population within the felt area, as well as that of natural and man-made structures. The ranges of intensities shown on the isoseismal map were used in this study to describe the probable behavior of typical structures to various earthquakes, but not necessarily the geologic hazards or population response associated with those events. Additionally, a range of intensities was necessary to describe the varied behavior of the many types of structures encountered within the study area, and to account for the uncertainty of site and/or structure-specific response.

The version of the Modified Mercalli Intensity scale published by Richter (1958) is reproduced below. This version is a slight abridgement of the original, and includes Richter's description of construction included in this version.

MODIFIED MERCALLI INTENSITY SCALE

I. Not felt. Marginal and long-period effects of large earthquakes.

II. Felt by persons at rest, on upper floors, or favorably placed.

III. Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.

VI. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV wooden walls and frame creak.

V. Felt indoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.

VI. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken (visibly, or heard to rustle).

VII. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.

VIII. Steering of motor cars affected. Damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.

IX. General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations.) Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake fountains, sand craters.

X. Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.

XI. Rails bent greatly. Underground pipelines completely out of service.

XII. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

Definition of Masonry A, B, C, D:

Masonry A: Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.

Masonry B: Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.

Masonry C: Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.

Masonry D: Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

EFFECTS ON LOCAL MEDICAL RESOURCES

For the purpose of this study the medical facilities within the Municipality of Anchorage were divided into two catagories -- major hospitals and clinics. There are four major hospitals within the Municipality, and 16 clinics. For this study, medical facilities with 100 or more beds which offer the full range of health care and emergency services were considered to be major hospitals. "Clinics" were defined as medical facilities where two or more M.D.s have offices in the same structure, and where some form of minimal emergency services can be supplied; or a medical facility which could be used as a collection point and aid station for casualties after an areawide natural disaster has occurred. Offices which lacked a clinical laboratory, x-ray and pharmacy were not considered. Although it is recognized that the clinics would probably not be heavily relied upon for emergency support, if the four major hospitals remain in service after a major earthquake they do, nonetheless, house approximately 40 percent of the physicians and medical support personnel during normal working hours. Therefore, the potential for damage and loss of life within these facilities was included in this study.

Because of the marked difference in the number of people utilizing medical facilities during various times of a typical day, two estimates of deaths and injuries were computed for the facilities -- one during peak hours of operation (3:00 p.m.), and one during hours of minimal activity and minimal staff requirements (3:00 a.m.). The estimates of damage to the structure will of course be independent of the time of day.

Staff/Patient Inventory

The number of staff, patients and visitors were compiled for each medical facility. This information was gathered from hospital or clinic records where possible, or estimated from typical doctor:support staff:patient ratios where records were not available. It should be noted that the "clinics" described in this report have no capacity for overnight in-patient care, and therefore the occupancy load at 3:00 a.m. would be nil.

Building Inventory

All the medical facilities existing in Anchorage at the time of this study were constructed after 1950. Most of them, in fact, were constructed after 1960. Therefore, these facilities were designed with the seismic lateral force provisions set forth in the Uniform Building Code (UBC) which was in effect at the time of their design. The UBC was adopted by the building officials of Anchorage in 1950, and since that time they have routinely required the use of the highest seismic zone specified in the Code.

Tables 2 and 3 describe the medical facilities in general terms, and summarize the staff/patient loads for peak and slack hours (3:00 p.m. and 3:00 a.m.) of a typical day.

3LE 2

HOSPITAL SUMMARY

NAME	BUILDING DESCRIPTION: YEAR / CODE	TYPE	LATERAL FORCE RESISTING SYSTEM	NO. STORIES	BED CAPACITY	AVERAGE PATIENT LOAD	NO. DOCTORS	PERSONS ON SITE 3:00 P.M.: NO. STAFF	NO. OUT-PATIENTS	NO. VISITORS	NO. DOCTORS	3:00 A.M.: NO. STAFF	NO. OUT-PATIENTS	NO. VISITORS
Alaska Hospital & Medical Center*	1976 / *	RC & SS	SW & MRF	7	154	70% (108)	1	73	5	108	1	20	3	—
DeBarr Professional Office Building*				5	—	—	12	42	50	—	—	—	—	—
PHS Alaska Native Medical Center	1953 / '46 UBC	RC	SW	7	170	75% (128)	45	202	160	75	2	32	5	—
Providence Hospital South Tower	1961 / '58 UBC	SS	RCC	5	116	88% (102)	1	51	30	75	—	31	5	—
Providence Hospital North Tower	1973 / '70 UBC	SS	MRF	5	134	88% (118)	8	57	—	200	1	42	—	—
USAF Hospital Elmendorf	1954 '49 UBC	RC	RCC	7	200	55% (110)	28	330	75	150	1	39	4	4
TOTAL	—	—	—	—	774	566	95	755	320	608	5	164	17	4

* DeBarr P.O.B. and AH&MC structurally are one building. Construction is RC for first six stories, SS above. Built to 1973 Municipal Life and Safety codes. Dynamic structural analysis was performed.

Key to Abbreviations

Code - UBC - Uniform Building Code
Construction Type - RC - reinforced concrete
SS - structural steel

Lateral Force Resisting System - RCC - reinforced concrete core
MRF - moment resisting frame
SW - shear wall

TABLE 3

CLINIC SUMMARY

	BUILDING DESCRIPTION		PERSONS ON SITE - 3:00 P.M.			
NAME	YEAR°	TYPE	NO. STORIES	NO. DOCTORS	NO. STAFF	NO. PATIENTS
Anchorage Fracture and Orthopedic Clinic	1970	Wood	1	6	26	20
Anchorage Medical and Surgical Clinic	1960	SS	1	7	20	20
Anchorage Neighborhood Health Center*	1981	SS	1	5	5	15
College Village Clinic	**	CMU & Wood	1	4-7	12	5
Dale Street Professional Building***	1980	SS & CMU	2	6	--	--
The Doctors Building	1978°	CMU & Wood	2	8	27	12
Eagle River Medical Clinic	1967°	CMU & Wood	2	2	3	3
Fort Richardson Troop Clinic	1955	RC	1	2	30	15
Geneva Woods Medical Center	1976	Wood	2	11	35	19
Kulis ANG Clinic****	1975	RC	1	--	1	1
Lake Otis Medical Center	1973	Wood	2	20	56	55
LaTouche Professional Center	1976	SS & RC	3	9	56	35
Medical Park	1972	CMU & Wood	2	12	42	50
Providence Professional Building	1971	RC	3	30	90	50
University Professional Center	1977°	SS	2	7	31	27
TOTAL	---	---	---	132	434	327

FOOTNOTES

* A steel & glass passive solar design building is under construction adjacent to the 1-story concrete block building which is in use at this writing. The new building is scheduled for completion in April-May 1981, at which time the concrete block building is to be razed.

** Year of construction is unavailable. Structure appears to have been built in two stages, both within past 10-15 years.

*** Interior of this building is receiving finishing touches and is not yet fully occupied. Number of doctors and types of equipment are expected to increase.

**** The Kulis Air National Guard Clinic typically is staffed by one person who is either a Physician's Assistant or an Emergency Medical Technician. One weekend per month, a doctor is on site to conduct physicals.

Deaths and Injuries

Few, if any, of the quantitative parameters which predict the real behavior of structures during earthquakes can be evaluated deterministically; however, they can be rationally utilized in a probabilistic sense to gain insight into the probable behavior of structures of concern. No reputable engineer or builder knowingly designs or constructs a building or support system which would fail during earthquakes which are considered to be probable during the design life of a facility, yet there are periodic "surprises" during even moderate earthquakes which result in seemingly "unusual" numbers of deaths and injuries, and patterns of destruction. Therefore, one should augment statistical generalities with experienced judgment when projecting the consequences of past earthquakes to those of potential events. Both statistical and judgmental approaches were used during this study.

The numbers of deaths and injuries per 100,000 people for several past earthquakes which have occurred in or near populated areas of the United States were examined as functions of earthquake magnitude and as functions of earthquake intensity. The historical data base was limited to that of the United States because the differences in construction materials and techniques used in other parts of the world make inclusion of those data inappropriate. Moreover, the U.S. data was evaluated with regard to the date of occurrence to compare the change (decrease) in the deaths and injuries ratios to the general improvement of design philosophy and construction techniques that have taken place steadily since the turn of the century. This approach may seem somewhat simplistic; however, as time progresses the majority of the structures in communities within seismically active areas tend to be designed and constructed according to the latest advances in earthquake engineering, and, therefore, should be more earthquake resistive. Since Anchorage is basically a "modern" city, that is, the majority of its buildings were constructed after 1940, it can rationally be expected that most of the structures within the city will perform better than those of older cities elsewhere in the conterminous United States. This inference should be especially true for the medical facilities within the Muncipality.

All of the present medical facilities in Anchorage were constructed after 1950, and most of them were constructed after 1960. Hence these facilities were designed according to the seismic lateral force provisions set forth in the Uniform Building Code (UBC) in effect at the time of their design. No medical facilities evaluated in this study are currently housed in structures designed or constructed without regard to seismic requirements and lateral stability, such as is the case in older cities in other areas of the country where many medical facilities are currently housed in unreinforced or lightly reinforced masonry structures. Therefore, the exposure to seismically induced deaths and injuries of the occupants of medical facilities in Anchorage should be appreciably less than those occupying older unreinforced or marginally reinforced building in areas of similar regional seismic activity.

Graphs representing the number of deaths and injuries per 100,000 people for various magnitude earthquakes possible on the local fault systems were constructed for this response study based on the rationale described in the preceding discussion. These graphs are presented in Figures 9 and 10.

Normally in studies of this nature the <u>number</u> of deaths rather than the <u>ratio</u> of deaths per 100,000 is depicted graphically; however, because the ratio is relatively small in this instance and the size of the population is also small, the statistical projection of the number of people killed is less than one in the worst case. For example, from Figure 9 the number of deaths per 100,000 in medical facilities for a magnitude 8.5 earthquake generated on the Aleutian Megathrust is 20. Applying this number to the total population within medical facilities at peak hours of the day (approximately 3300 staff and patients) statistically results in less than one death.

$$(20/100,000) \times 3300 = 0.66$$

The ratio of deaths per 100,000 would have to be increased to approximately 30 to statistically project one death occurring in any one of the medical facilities in Anchorage. Moreover, to project the death of one doctor in any medical facility during peak hours of operation would require a death per 100,000 ratio of approximately 440 for all medical facilities in Anchorage. A statistical ratio this high is felt to be excessive given the general quality of design and construction of the medical facilities

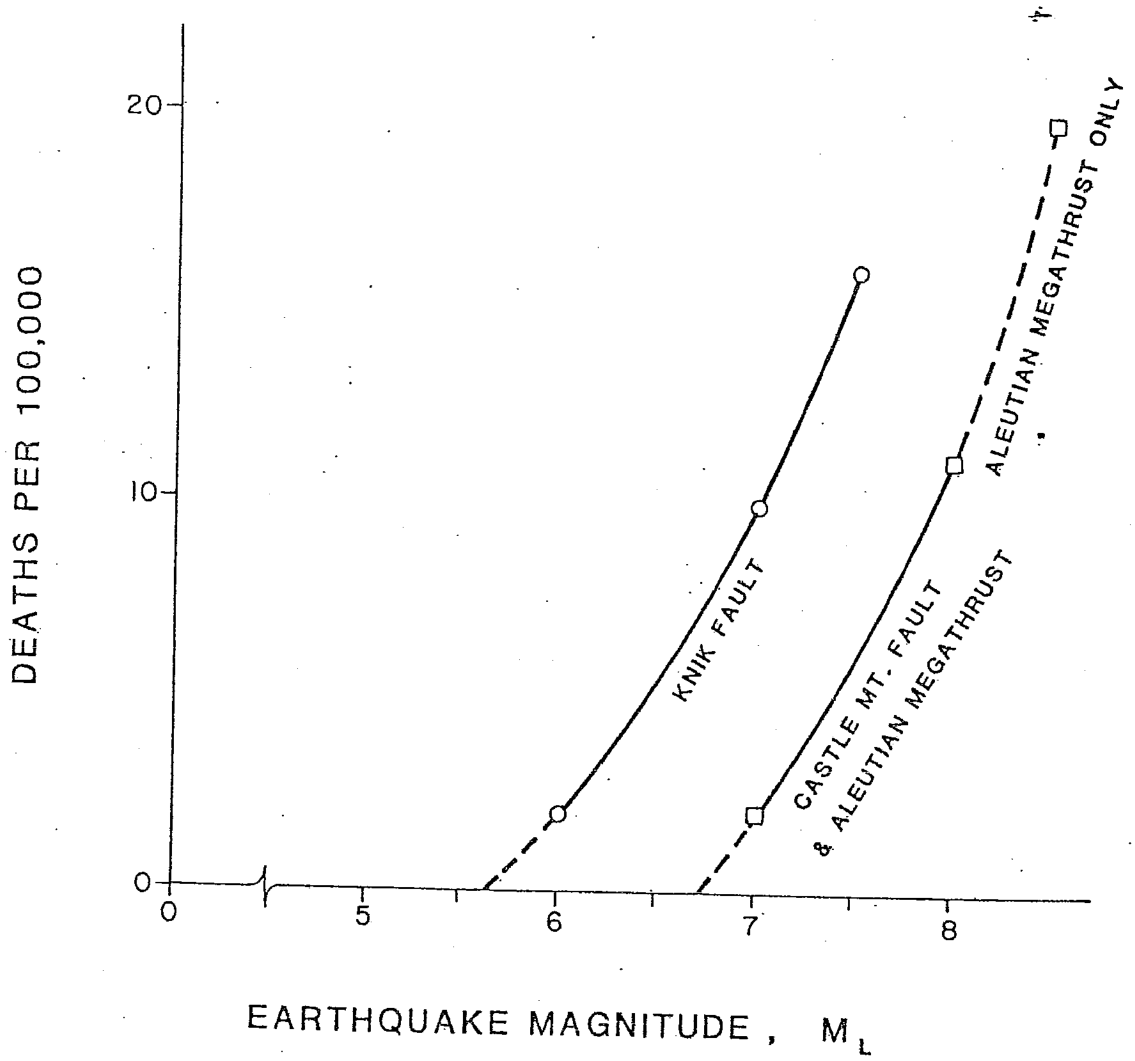


FIGURE 9	DEATHS PER 100,000 (HOSPITAL POPULATION)

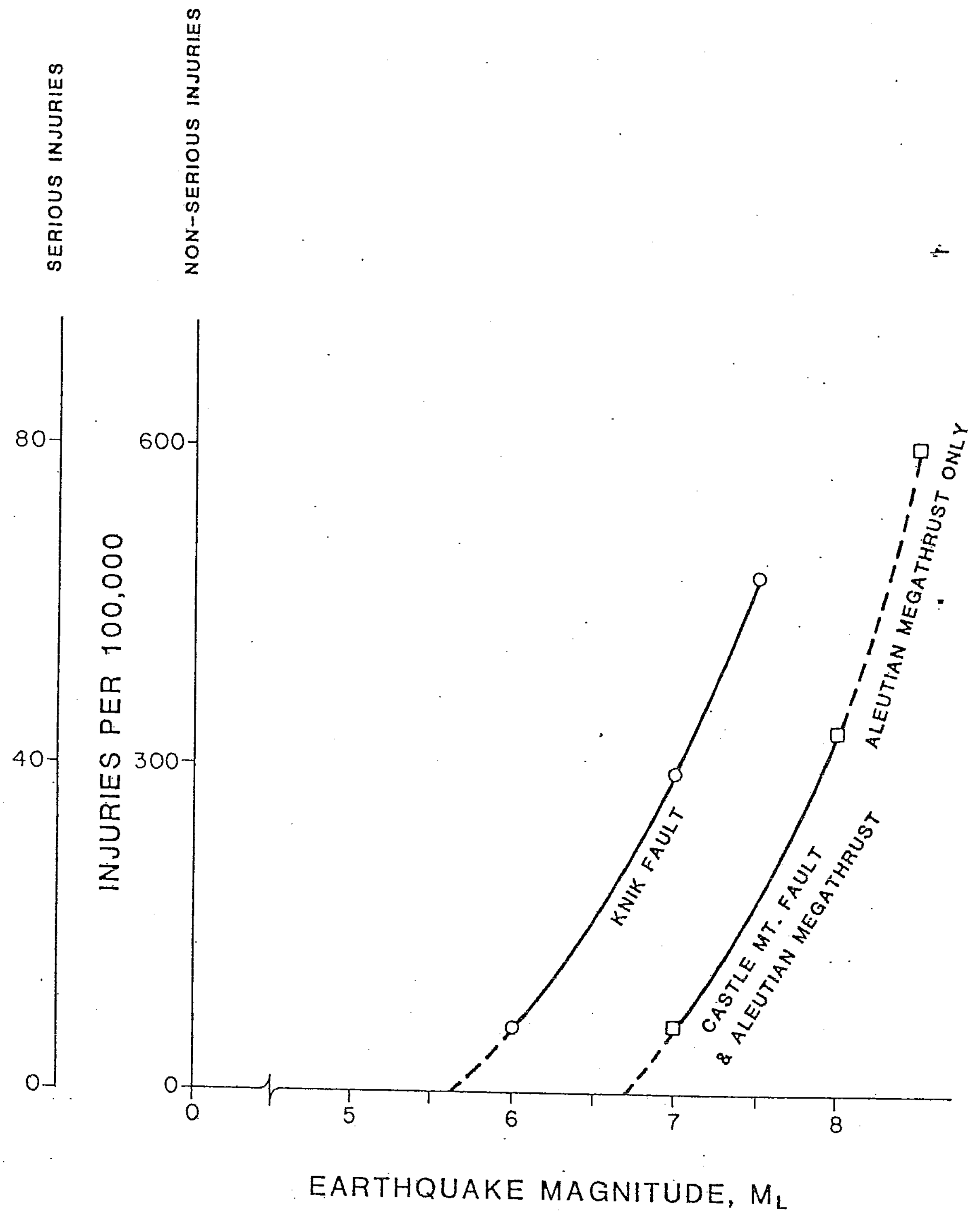


FIGURE 10 | INJURIES PER 100,000 (HOSPITAL POPULATION) in Anchorage. The low mortality ratio for occupants of these facilities seems to have been demonstrated during the 1964 event, even though that earthquake may not have been the probable maximum with regard to potential structural damage within Anchorage.

Similarly, using typical "serious injury" and "non-serious injury" per 100,000 ratios of 4 and 30 times the death per 100,000 ratio respectively, results in very low estimates of the <u>total</u> number of people injured within medical facilities. Moreover, estimates of the number of injuries for any given segment of the medical facility population (doctors, staff, patient/visitors) based on these statistical averages and the number of people in the population under consideration, generally result in estimates of less than one.

As mentioned previously herein, the statistical projections of a study of this nature should be tempered with experienced judgment to arrive at reasonable estimates of what <u>might</u> occur during major earthquakes. Therefore, estimates of deaths and injuries were also made based on field inspections of the facilities and review of their construction drawings.

For response planning purposes it is not unreasonable to assume that one or more of the older medical facilities which were damaged in the 1964 earthquake could be the source of casualties during a future major event. This possibility is based on the damage incurred to those structures in 1964, and the extent of rehabilitation performed subsequently. Additionally, the present understanding of the nature of earthquakes and the response of buildings to earthquake shaking has resulted in significant improvements in design philosophies and construction methods, which now point out some of the inadequacies of past design and construction practices. Accordingly, Table 4 is included to account for unforeseen circumstances, which might inflict unusual, yet possible, casualty tolls on medical staff and patients.

PHYSICAL DAMAGE TO MEDICAL FACILITIES

The estimated present value of medical facilities in Anchorage is approximately $180 million. This estimate is based on present (1980) replacement value for comparable facilities. The four major hospitals account for approximately 70 percent or $126 million of the total, leaving about 30 percent or $54 million associated with clinical facilities. The damage or dollar value of repair or replacement should the area be affected by a major seismic event is independent of time of day. Therefore, damage figures were not estimated for peak (3:00 p.m.) and slack (3:00 a.m.) hours of operation.

The totals for all medical facilities for various possible earthquakes are shown in Figure 11. Approximately 60 percent of the total damage figure can be associated with the medical clinics, and 40 percent with the major hospitals. The larger share of the estimated damage was attributed to the clinics because in general the clinics were not designed with as high an importance factor as the hospitals, nor were they constructed under as stringent construction surveillance procedures. Here again, these figures are based on "typical" behavior of the types of structures which comprise the medical facilities in Anchorage.

TABLE 4

DEATHS AND INJURIES
(POSSIBLE EXTREME EVENT)

		3:00 p.m.	
		Deaths	Injuries
Doctors	(73)	2	15
Staff	(532)	13	100
Patient/Visitors	(698)	20	150
TOTAL	(1303)	35	265

		3:00 a.m.	
		Deaths	Injuries
Doctors	(3)	--	--
Staff	(71)	2	15
Patient/Visitors	(251)	8	60
TOTAL	(325)	10	75

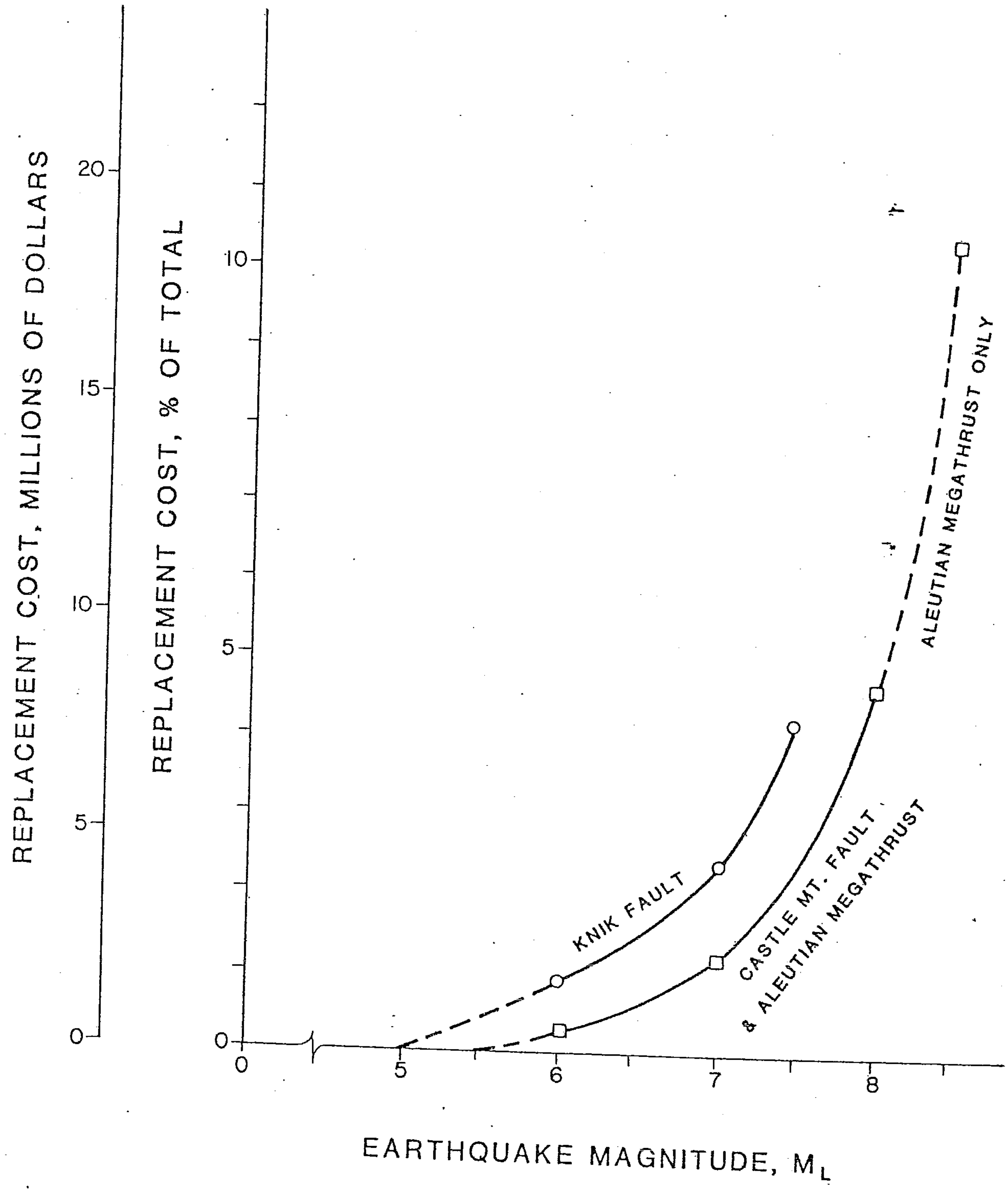


FIGURE 11	DAMAGE TO MEDICAL FACILITIES

For planning purposes it is not unreasonable to assume that one of the older major hospitals will be dysfunctional after a severe earthquake. Although complete collapse of one of these structures is not anticipated, structural and architectural damage may be such that the structure would not be considered safe for continued occupancy immediately following a major earthquake, or the facility would be dysfunctional due to damaged support systems and treatment facilities. If damage of this degree should occur to one of the major hospitals, the total damage figure could be as high as $30 million.

Loss of bed capacity subsequent to a major earthquake was addressed similarly. Figure 12 shows the probable loss of available hospital beds for the various postulated earthquakes. And, should one or two of the major hospitals become dysfunctional after a major event, 25 to 50 percent of the available hospital beds would be lost for the emergency response needs of the community.

A corollary to the loss of hospital beds and treatment facilities for those injured during a destructive earthquake would be the need to transport both the pre-quake patients and their medical records from damaged facilities to interim medical care centers. The logistics of evacuating non-ambulatory as well as ambulatory patients from a facility disrupted and put out of service by an earthquake could become the critical factor in minimizing the number of post-quake casualties. Moreover, plans to insure that the patients' medical records accompany them to the interim facility should be part of the hospitals' emergency evacuation plan.

For response planning purposes it is reasonable to assume that approximately 100 to 200 patients and their records along with any special life support equipment would have to be relocated subsequent to the occurrence of a nearby "maximum event".

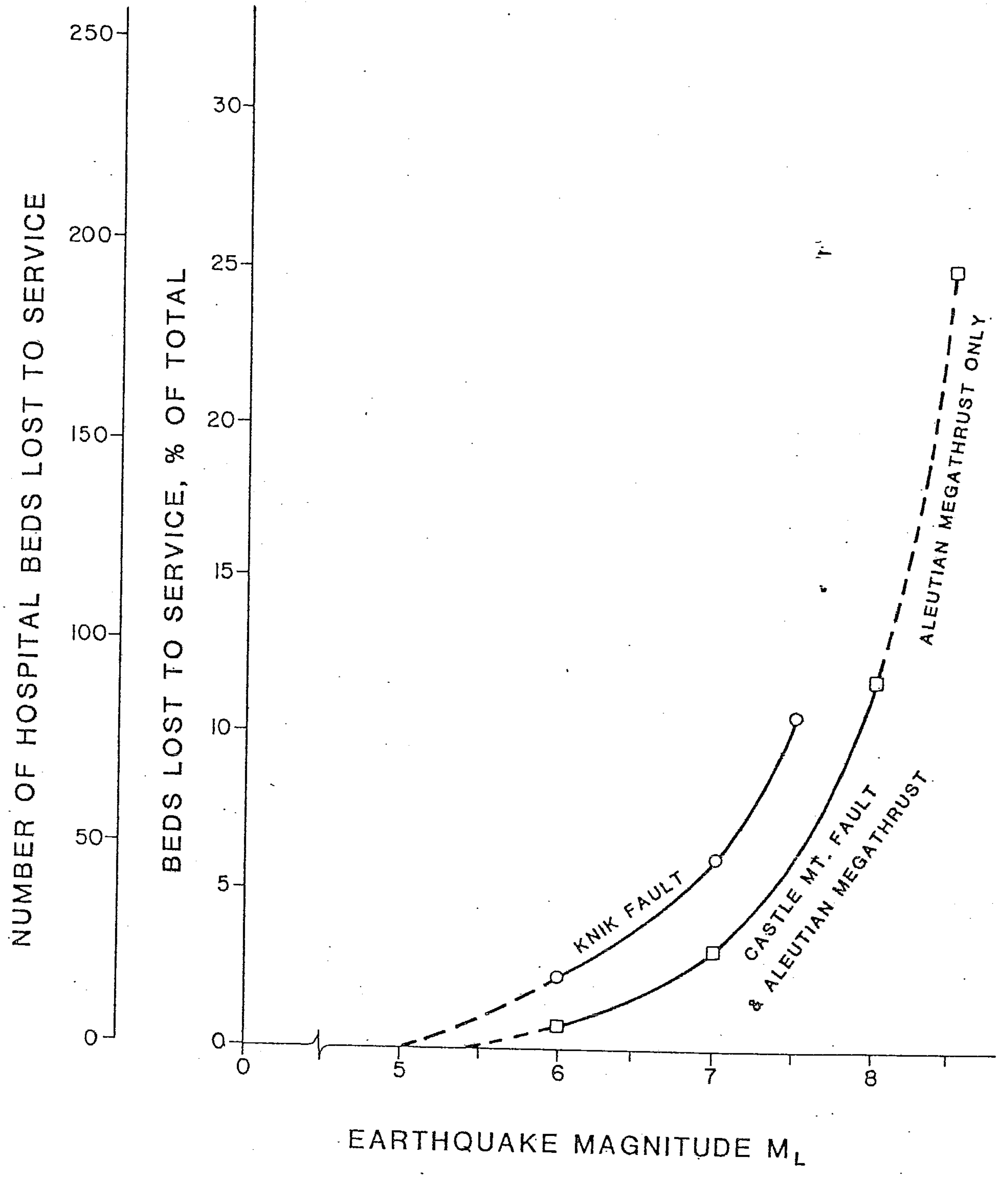


FIGURE 12	LOSS OF HOSPITAL BEDS

DEATHS AND INJURIES

Background

Useful earthquake vulnerability studies have been prepared in recent years for four major metropolitan areas in the United States: San Francisco, Los Angeles, Puget Sound, and Salt Lake City. A significant component in each of these studies was an estimation of potential casualities, both deaths and serious injuries. The methodologies developed in all four studies form the basis for the methodology used in this report.

No two areas are the same with respect to the kinds of and geographic distribution of construction types and their geologic settings, and to the types of earthquakes which may affect the area. Fortunately, existing methodologies can be used and simplified when applied to Anchorage in the event of a reoccurrence of the 1964 event. Most importantly from a life safety standpoint, Anchorage has no inventory of old non-reinforced brick or stone buildings having structurally weak sand-lime mortar. Secondly, housing is mostly single family wood frame dwellings or of similiar lightmass habitational constructions; deaths and injuries are minimal in these structures when landslide is not a factor. Lastly, essentially all multi-unit habitational structures, including high-rises, are earthquake resistive to one degree or another.

The 1964 earthquake had predominently long period ground waves which tended to adversely select and damge high-rise buildings. *[A discussion of this phenomena tends to be technical, and need not be repeated here; the interested reader may turn to "The Prince William Sound, Alaska, Earthquake of 1964 and Aftershocks," ESSA, U.S. Department of Commerce, Volume II, Part A, pp. 12/14 for an explanation.] Table 5 is a summary of damage to multistory buildings in Anchorage in 1964. It must be remembered that it is the damaged and collapsed buildings which are the usual cause of life loss and injuries -- excluding the highly localized hazards of landslide and tsunami.

What is the prognosis with respect to multistory pre-1964 buildings and those built subsequently? Earthquake proof construction does not exist in Anchorage or elsewhere. Earthquake resistive design methods and building codes are constantly improving, but they are not yet perfect. This was quite evident when examining the collapsed newly built Psychiatric Unit and the near-collapse of the Medical Treatment Building of Olive View Hospital in the 1971 San Fernando shock. For another example, the severely damaged modern County Services Building in 1979 El Centro, California will probably be a total loss. Neither the 1971 nor the 1979 California earthquakes were nearly as large as the 1964 Alaska shock. While overall performance of earthquake resistive multistory buildings has been good to excellent, for response planning purposes it's not unreasonable to expect major damage to one of these buildings in a future great Alaskan earthquake centered near Anchorage.

*A good del of this section was taken directly from three previous earthquake studies in this series by USGS (1975,1973,1972).

The Historical Record

Table 6 of this report is a listing of earthquakes in the United States having relevance to this study. Excluded was the 1872 Owens Valley earthquake in which 23 persons were killed in Lone Pine, California, out of a population of 250 to 300; this exclusion was based on non-relevant construction; i.e., adobe and stone houses, usually without any kind of mortar. Foreign earthquakes normally have minimal relevance due to construction or other differences, and were therefore also excluded from Table 6.

The published back-up information to Table 6 is not as strong with respect to deaths and injury information as those for buildings and other property damage. Deaths attributed to heart attacks may or may not be included, and the text leaves the matter unclear in most cases. Injuries leading to deaths may be included under injuries or under deaths. What constitutes the dividing line between "serious injury" and "injury" is rarely stated in reports, and the given data are often incomplete. Whether or not emotional cases were included is usually not stated, although some of these cases would have required medical attention. Particular attention should be paid to "Impact of the Earthquake on Health and Mortality" by M. Lantis, in "The Great Alaska Earthquake of 1964: Human Ecology," National Academy of Sciences.

Table 7 is a listing of deaths and injuries per 100,000 population for selected American earthquakes. Earthquakes with life losses less than 8 were excluded from the listing, and the 1872 Owens Valley earthquake was omitted for reasons already stated. Quite possible the cut-off figure should be much larger than 8 since the data for Tehachapi in the 1952 Kern County earthquake are so few as to be seriously questioned when used for extrapolation. Also, the effect of a single major collapse can strongly affect the losses per 100,000 population; see, for example, the variations in Table 7 upon inclusion of the deaths at the Veterans Administration Hospital from the 1971 San Fernando shock. Table 7 is a useful guideline when applied with judgement and in the context of the time of day, appropriate comparative construction, and appropriate Modified Mercalli intensities.

Building Inventory

For realistic usage, the death and injury ratios in Table 7 must be used in conjunction with the construction types found in the study area. In turn, this data may be viewed in terms of the daytime and nighttime populations in the area being examined.

Dwelling Data

Almost invariably within the Anchorage study area, single family dwellings are of wood frame construction or mobile homes; these construction types are inherently very safe. On the other hand, buildings (such as apartment structures) containing many housing units are often of fire-resistive construction or of mixed construction, having walls of either reinforced unit masonry or reinforced concrete. Normally these multiple unit structures are much more vulnerable to earthquake damage than are wood frame structures.

Source data regarding the geographic distribution of dwellings in the Anchorage area was the "1979 Housing Stock" which was provided by the Anchorage Planning Department. Their information was broken down into geographic grid units, with the number of single family dwellings, duplexes (by units), multi-family units, and mobile homes enumerated for each geographic grid unit.

Non-Wood Frame Building Data

Commercial, Warehousing, Public, Etc.

Non-wood frame buildings include many construction types, many kinds of materials of construction, and many types of occupancies. The findings in the previously cited ESSA report (pp. 14/28) regarding 1964 damage in Anchorage can be extrapoliated to represent current conditions, reducing the needs for building inventories.

Analysis

For wood frame dwellings, a death ratio of 12/100,000 has been used in previous vulnerability studies. This assumes a MMI of IX. However, a 25 percent reduction is approximate for Anchorage in view of the higher percentages of new homes than in the previously cited four study areas. Secondly, the type of ground motion would be favorable to reduced casualties in wood frame dwellings not located in the slide areas (similar to 1964). Assuming that all persons would be in wood frame dwellings at the time of the shock, the estimated number of deaths is:

(12/100,000) x (75%) x (203,000 population) = 18 deaths

Due to this low figure, it does not seem reasonable to make computational adjustments for persons away from homes during the day, or for the low percentage who would be in non-wood frame habitational units.

Deaths and injuries would also occur in the habitational, mercantile, industrial, school, and other occupancies which are not of wood frame construction. A death ratio of 64/100,000 may be used for these modern buildings. The estimate of daytime, summer business district population is based on surveys of proprietors and apartment managers conducted by ADES in 1979. Listed below is the computation for deaths during the summer in the business areas:

(64/100,000) x (41,400 population in these buildings) = 26 deaths

It is reasonable to anticipate one multistory building collapse out of the numerous buildings which are 5 stories or higher in Anchorage. The rational has been provided in previous paragraphs, but it is impossible to identify such a building. An occupant load of 100 is not an unreasonable average.

A serious injury, as used here, is defined as one which requires some period of hospitalization. All other injuries are considered nonserious. A nonserious injury may require treatment by a doctor on an outpatient basis.

This report uses the same method of estimating injuries as A Study of Earthquake Losses in the Puget Sound, Washington Area (USGS, 1975). Serious injuries are estimated by multiplying the number of deaths, assuming no multistory buildings collapse, by a factor of 4. It is thought that such a collapse would effect the number of deaths, but not greatly effect the number of injuries. Nonserious injuries are estimated by multiplying the number of deaths by a factor of 30.

Summary and Conclusion

Estimated number of deaths:	Summer		Winter	
	day	night	day	night
In wood frame structures	18	18	18	18
In offices, mercantile, public, etc. buildings of non-wood frame construction	26	16	25	15
In one multistory building collapse	100	100	100	100
TOTAL	144	134	143	133
Estimated number of serious injuries	176	136	172	132
Estimated number of nonserious injuries	1,320	1,020	1,290	990

TABLE 5

DAMAGE TO MULTISTORY BUILDINGS IN ANCHORAGE, ALASKA, 1964

...uilding Name ...nd Occupancy	Year Built	Stories	UBC Seismic Zone	Structural System: Frame	Structural System: Floors	Structural System: Exterior Walls	Structural System: Core	Principal Lateral Force Bracing System	% Damage (of replace- value)	Remarks
...irport Control ...ower	1952	6 and base- ment	?	R/C	5 and 6 in. R/C	Insulated metal	None	R/C frame	100	Also damaged in 1954 shock.
...nchorage- ...estward Hotel)	1960	14 and base- ment	3	Steel, with some R/C columns	5 1/2 to 6 1/2 in. R/C on MD on steel beams	Insulated metal and R/C	See re- marks	R/C shear walls	12	Landslide shifted building about 1 foot R/C around elevators not a major core.
...ordova ...Office)	1960	6 and base-	2(?)	Steel	2 1/2 in. R/C on MD on steel joist and beams	Insulated metal and 4 in. R/C	R/C	Steel moment connections; shear walls in R/C core	20	
...lmendorf ...ospital	1955	7 and base- ment	3	R/C	6 in. R/C	Nonstructural hollow concrete block	R/C	R/C shear walls	1 (See re- marks).	Lower height buildings not listed. Structural damage 1%; nonstructural greater
...ur Seasons ...partments)	1964	6	3	None	8 in. prestressed post-tensioned R/C; tendons not grouted	Plastered studs	R/C	Shear walls R/C central core	100	Lift slab using steel columns.
...ll (Office)	1962	8	3	Steel (see remarks)	5 in. R/C on steel beams	Insulated metal	R/C	Shear walls in R/C central core	20-25	Central core was R/C bearing
...ik Arms ...partments)	1950	6 and base- ment	2	Incomplete	5 1/2 in. R/C	R/C	R/C	R/C shear walls	Negligible	Building moved 10 to 11 feet, due to land- slide
... McKinley ...partments)	1951	14 and base- ment	2	R/C (see remarks)	5 1/2 in. R/C on R/C beams	R/C bearing	R/C	R/C shear walls	40	R/C interior beams and columns. Walls bearing. Almost identical to 1200 L Building
...0 L ...artments)	1951	14 and base- ment	2	R/C (see remarks)	5 1/2 in. R/C on R/C beams	R/C bearing	R/C	R/C shear walls	30	R/C interior beams and columns. Walls be...ig- Almost identi... to McKinley Building

TABLE 5

DAMAGE TO MULTISTORY BUILDINGS IN ANCHORAGE, ALASKA, 1964

uilding Name nd Occupancy	Year Built	Stories	UBC Seismic Zone	Structural System: Frame	Structural System: Floors	Structural System: Exterior Walls	Structural System: Core	Principal Lateral Force Bracing System	% Damage (of replace- value)	Remarks
enney (depart- ent store)	1962	5	3	None	10 in. R/C slabs on R/C columns	Precast R/C on 2 sides; R/C on	Essen- tially	R/C exterior walls	100	Some hollow concrete block exterior walls.
ovidence ospital	1961	5 and base- ment	3	Steel	5 1/4 in. R/C on MD on steel beams	Insulated metal	R/C	Shear walls in R/C central core	2 1/2	Stair and elevator tower and lower height buildings not listed.

BREVIATIONS: UBC - Uniform Building Code
R/C - Reinforced concrete. Poured-in-place unless otherwise specified.
MD - Metal deck. Usually having trade name "Corruform" or "Cofar".

SOURCE: Environmental Science Services Administration, "The Prince William Sound, Alaska, Earthquake of 1964 and Aftershocks," Vol. II, Part A, page 216, (1967).

TABLE 6

SELECTED U.S.
EARTHQUAKES, 1811-1972

Name of Earthquake	Date and (local) Time	[1]Epicenter Location	[2]Maximum Modified Mercalli Intensity	[1]Richter Magnitude	Approximate Length of Surface Faulting (miles)	[3]Lives Lost	[4]Dollar Loss	Remarks
ew Madrid, ssouri	Dec. 16, 1811 (about 2:15 AM) Jan. 23, 1812 (about 8:50 AM) Feb. 7, 1812 (about 10:10 AM)	36 N. 90 W.	XII (for each shock)	Over 8	See remarks	1 death	-------	Richter assigned a magnitude of greater than 8 based on observed effects. Surface faulting possibly occurred: see Fuller, p.58(Bibliography)
arleston, Carolina	Aug. 31, 1886 (9:51 PM)	32.9 N. 80.0 W.	X	----	None	27 killed outright, plus 83 or more from related causes.	$5,000,000 to $6,000,000	-----------
n Francisco lifornia	Apr. 18, 1906 (5:12 AM, PST)	38 N. 123 W.	XI	8.3	190 minimum 270 possible	700 to 800 deaths	$4,000,000 incl. fire; $80,000,000 earthquake only.	Portions of the San Andreas fault are under the Pacific Ocean.
nta Barbara, lifornia	June 19, 1925 (6:42 AM)	34.3 N. 119.8 W.	VIII-IX	6.3	None	12 to 14 deaths	$6,500,000	The dollar loss is for the City of Santa Barbara: losses elsewhere were slight.
ng Beach lifornia	Mar. 10, 1933 (5:54 PM, PST)	33.6 N. 118.0 W.	IX	6.3	----	Coroner's report: 86, 102 killed is more probable.	$40,000,000 to $50,000.000	Epicenter in ocean. Associated with Inglewood fault.
ena, Montana	Oct. 12, 1935 (0:51 AM, MST)	46.6 N. 112.0 W.	VII	---	None	---------	$50,000	First of three destructive shocks: Oct. 12, 18, and 31.
ena, Montana	Oct. 18, 1935 (9:48 PM, MST)	46.6 N. 112.0 W.	VIII	6.25	None	2 killed, "score" injuried	$3,000,000 to over $4,000,000	-------
ena, Montana	Oct. 31, 1935 (11:38 AM, MST)	46.6 N. 112.0 W.	VIII	6.0	None	2 killed, "score" injuried		-------

Imperial Valley, California	May 18, 1940 (8:37 PM, PST)	32.7 N. 115.5 W.	X	7.1	40 minimum	8 killed out-right, 1 died later of injuries	$5,000,000 to $6,000,000	M.M. IX for building damage and M.M. X for faulting.
Santa Barbara, California	June 30, 1941 (11:51 PM, PST)	34.4 N. 119.6 W.	VIII	5.9	-----	None killed, 1 hospitalized	$250,000	Epicenter in ocean.
Olympia, Washington	Apr. 13, 1949 (11.56 PM, PST)	47.1 N. 122.7 W.	VIII	7.1	None	8 deaths	$15,000,000 to $25,000,000	-----
Kern County, California	July 21, 1952 (4:52 AM, PDT)	35.0 N. 119.0 W.	XI	7.7	14	10 to 12 deaths in Tehachapi	$37,650,000 to buildings $48,650,000 total. (incl. Aug. 22 aftershocks).	M.M. XI assigned to tunnel damage from faulting: vibration intensity to structures generally VIII, rarely IX. Faulting probably longer, but covered by deep alluvium.
Bakersfield, California	Aug. 22, 1952 (3:41 PM, PDT)	35.3 N. 118.9 W.	VIII	5.8	None	2 killed and 35 injured in Bakersfield	See above.	Aftershock of July 21, 1952.
Fallon-Stillwater, Nevada	July 6, 1954 (4.13 AM, PDT)	39.4 N. 118.5 W.	IX	6.6	11	No deaths, several injuries	$500,000 to $700,000, incl. $300,000 to irrigation system.	M.M. IX assigned along fault trace: vibration intensity VIII. First of two shocks on same fault.
Fallon-Stillwater, Nevada	Aug. 23, 1954 (10:52 PM, PDT)	39.6 N. 118.5 W.	IX	6.8	19	No deaths		M.M. IX assigned along fault trace: vibration intensity VIII. Second of two shocks on same fault.
Fairview Peak, Nevada	Dec. 16, 1954 (3:07 AM, PST)	39.3 N. 118.1 W.	X	7.1	35	No deaths	-----	M.M. X assigned along fault trace: vibration intensity VII Two shocks considered as a single event from the engineering standpoint.
Dixie Valley, Nevada	Dec. 16, 1954 (3.11 AM, PST)	39.8 N. 118.1 W.	X	6.8	30	No deaths	-------	

ureka, California	Dec. 21, 1954 (11:56 AM, PST)	40.8 N. 124.1 W.	VII	6.6	None	1 killed	$1,000,000	------
Port Hueneme, California	Mar. 18, 1957 (10:56 AM, PST)	34.1 N. 119.2 W.	VI	4.7	None	No deaths	-------	Epicenter in ocean.
San Francisco, California	Mar. 22, 1957 (11:44 AM, PST)	37.7 N. 122.5 W.	VII	5.3	None	No deaths, about 40 minor injuries	$1,000,000	------
ebgen Lake, ontana	Aug. 17, 1959 (11:37 PM, MST)	44.8 N. 111.1 W.	X	7.1	15	19 presumed buried by landslide, plus probably 9 others killed, mostly by landslide.	$2,334,000(roads and bridges) $150,000 (Hebgen Dam) $1,715,000(land-slide correction)	M.M. X assigned along fault trace. Vibrational intensity was VIII maximum. Faulting complex, and regional warping occurred. Dollar loss to buildings relatively small.
rince William ound, Alaska	Mar. 27, 1964 (5:36 PM, AST)	66.1 N. 147.5 W.	----	8.4	400 to 500	110 killed by tsunami: 15 killed from all other causes.	$311,192,000 (incl. tsunami)	Also known as the "Good Friday Earthquake." Fault length derived from seismic data.
uget Sound, ashington	Apr. 29, 1965 (8:29 AM, PDT)	47.4 N. 122.3 W.	VIII	6.5	None	3 killed outright, 3 died from heart attacks.	$12,500,000	M.M. VII general, M.M. VIII rare.
arkfield, alifornia	June 27, 1966 (9:26 PM, PDT)	35.54 N. 122.3 W.	VII	5.5	23 1/2 and 5 1/2	No deaths	Less than $50,000	Damaging earthquakes in same area in 1901, 1922, and 1934. The 1966 shock had peak acceleration of 50% G.
anta Rosa, alifornia	Oct. 1, 1969 (9:57 PM, PDT)	38.47 N. 122.69 W.	VII-VIII	5.6	None	No deaths. 15 injuries. 1 heart attack.	$6,000,000 to buildings. $1,250,000 to contents.	Two shocks considered as a single event from the engineering standpoint.
anta Rosa, alifornia	Oct. 1, 1969 (11:20 PM, PDT)	38.45 N. 122.69 W.		5.7	None			

San Fernando, California	Feb. 9, 1971 (6:01 AM, PST)	34.40 N. 118.40 W.	VIII-IX	6.6	12		58 deaths, 5,000 reported injuries	$478,519,635	Many reported injuries were minor, but public or charitable services requested.

ABBREVIATIONS:

M.M. = Modified Mercalli Intensity

PST= Pacific Standard Time

PDT = Pacific Daylight Time (Subtract 1 hour for PST)

MST = Mountain Standard Time

AST = Alaska Standard Time

FOOTNOTES:

[1] Slight variations will be found in various publications.

[2] M.M. Intensities are those assigned by the U.S. Coast & Geodetic Survey (now NOAA) when available.

[3] Original sources do not always clearly indicate if deaths include those attributable to exposure, unattended injury, heart attack, and other non-immediate deaths.

[4] Value of dollar at time of earthquake. Use of these figures requires a critical examination of reference materials since the basis for the estimates vary.

TABLE 7

DEATH AND INJURY RATIOS
Selected United States Earthquakes

Earthquake	Date	Time of Occurrence	Deaths per 100,000 Population	Injuries per 100,000 Population
harleston, S. C.	Aug. 31, 1886	9:51 p.m.	45 outright; 113 total	-
an Francisco, Calif.	April 18, 1906	5:12 a.m.	-	-
San Francisco			124	104 serious
Santa Rosa			116	69 serious
San Jose			80	38 serious
anta Barbara, Calif.	June 29, 1925	6:42 a.m.	45	119
ong Beach, Calif.	March 10, 1933	5:54 p.m.	26	1,300
nperial Valley, Calif.	May 18, 1940	8:37 p.m.	18	40 serious
uget Sound, Wash.	April 13, 1949	11:56 p.m.	1	-
ern County, Calif. Tehachapi	July 21, 1952	4:52 a.m.	-	-
akersfield, Calif.	Aug. 22, 1952	3:41 p.m.	3	47
laska	March 27, 1964	5:36 p.m.	-	-
Anchorage			9	315 (17 serious)
an Fernando, Calif.	Feb. 9, 1971	6:01 a.m.	see below	180 serious
Excl. Vet. Adm. Hospital			12	-
Incl. Vet. Adm. Hospital			64	-

PUBLIC UTILITIES

The public utilities included in this section are natural gas and electric power. These two utilities have been singled out due to the tremendous impact both have on winter heating in Anchorage. A long term loss of either in winter months could cause wide spread suffering and many homeless families due to dwellings being uninhabitable.

The long term loss of water and sewer would also cause much inconvenience; however, temporary measures can be taken to alleviate the situation both by individuals and the public utility. For example, in the 1964 earthquake, "Firehose and portable pumps and chlorinators were used first, but these were soon replaced in the Turnagain and port areas, and to a lesser extent elsewhere, by aluminum irrigation pipe laid on the surface and connected to dwellings with garden hoses." (Eckel, 1967).

Sewer systems also sustained much damage during the 1964 earthquake, especially in slide areas, and temporary measures again were initiated by individuals and the utility. On the short term, such things as "honey bucket" collections can be organized while repairs are being made.

Data Collection

The individual utilities were most cooperative and very willingly furnished data on their own systems. Some field inspections of the utilities were made; however, most of the information collected was based upon historical records and the data furnished by the utilities.

NATURAL GAS

Natural gas is considered the single most important winter lifeline for survival since the majority of the residents in the Anchorage Municipality use it to heat their homes. Most homes use gas fired hot air or hot water furnances both of which also require electric power to run blowers and pumps. This heating arrangement makes the electric power's criticality secondary as pertains to the gas. It should be noted, however, if one has gas service but not electric service, it is possible to restore complete home heat by using a small portable electric generator. The reverse is not true. Without gas a small generator could furnish some heat (portable electric heater) but it is doubtful that the entire house could be heated in this manner to prevent freezeup of water/heat pipes.

Adding to the criticality of the gas supply is the fact that all of the electric power generating equipment located in the Anchorage Municipality is fueled by natural gas as its primary source. Thus, an interruption of the gas due to a pipeline break would also cause a loss of Municipal Power, some Chugach Electric power, and power for both of the military bases. All of the power plants in town have alternate fuel sources but this fuel will last only a couple of days (see Table 8). The remainder of the power for the Anchorage Municipality is generated outside of Anchorage by Chugach Electric Corp. in Beluga, which is located across Cook Inlet from Anchorage, and at the Eklutna Hydro Project which is near Palmer, Alaska, northeast of Anchorage. See Electrical Power in this section for more details. In order to properly assess future potential earthquake damage to the present natural gas system, it is first necessary to review how well the system survived the 1964 "Great Alaska Earthquake" and then, in turn, postulate from that baseline.

In 1964, gas was transported to Anchorage through a high pressure pipeline which originated at Kalifonsky Beach near Kenai on the Cook Inlet. The single 12 inch pipeline crossed the Kenai Peninsula and branched into two parallel pipes for the Turnagain Arm undersea crossing which emerged near Potters Flat Railroad Train Depot. From there to the main distribution station near Tudor Road a single line was again utilized. There was a total of 93 miles of pipeline from the Kenai Peninsula and it survived the earthquake virtually undamaged (Eckel, 1967). One small break was detected at milepost 55 and it was quickly and easily repaired once reached (Eckel, 1967).

The 120 miles of gas distribution system within Anchorage sustained nearly $1 million worth of damages (Eckel, 1967). Actually, the damage was light due to the fact that the system was newly constructed (less than three years old) and used modern code specifications. The major damage was in the landslide areas where near surface materials moved both laterally and vertically (Eckel, 1967).

There were two landslide induced breaks in high pressure lines within Anchorage. One was near the Alaska Native Hospital and the other near the power plant on Ship Creek. Gas service was restored to the power plant within 30 hours (Eckel, 1967). It is interesting to note that the entire City did not lose gas service and for those that lost service, "Gas became available in homes and businesses in Spenard and the southern part of Anchorage within 48 hours, and 90 percent of the entire system was restored within two (2) weeks after the earthquake" (Eckel, 1967).

In the spring and summer months following the earthquake, the Gas Company systematically relieved the strain on both the high pressure line and the City distribution system. Since the ground was frozen at the time of the earthquake the underground pipes were movement restricted and the resulting strain remained until the spring thaw. Uniquely, the Gas Company mapped all the areas where repairs were made and overlayed their work onto a map to identify strain suspect areas. The lines crossing fractures were identified and excavations were made. The pipes were cut and "Some pipes were under such tension that the cuts opened as much as 2 inches; elsewhere compressive forces shortened the pipes. Successive exposures and cuts in the lines were then made at 50-foot intervals away from the origins until points were reached where cuts resulted in no movement of the pipes" (Eckel, 1967).

Essentially, the same procedure was used to relieve the strain on the gas transmission line. Thus, the entire system was restored to a "like new" condition in the summer following the earthquake.

Subsequently, the distribution system has expanded to coincide with the tremendous population increase in Anchorage. Additionally, a trasmission line has been installed to service the Eagle River area. All modern technology has been used in the expansions and each service connection is supplied with an automatic safety cut-off valve. This valve will cut off the gas supply due to excess flow or underpressure and it is also somewhat sensitive to strong vibrations according to Gas Company officials. Once the safety switch is tripped for any reason, it must be manually reset by the Gas Company. They, of course, would only restore the gas supply to the user after the cause for the activated safety valve has been determined and corrected.

The gas transmission line has also been expanded to give additional redundancy to the system. From a single line on the Kenai Peninsula in 1964, there are now several loops of larger diameter pipe going to three different gas sources. There are now two parallel lines across the Kenai Peninsula as far as Potters Flat on the Anchorage side of Cook Inlet. From that point there are three lines into Anchorage, whereas, in 1964 there was only a single line.

In order to postulate a "worst case natural gas situation" the following scenario was generated and presented to the Alaska Gas Compnay for resolution:

> During mid-winter a major earthquake severed both natural gas pipelines crossing the Inlet, thereby, totally eliminating the natural gas supply to Anchorage. What can be done to restore service and how long would it take?

According to the Alaska Gas & Service Company, the Inlet crossing can be repaired regardless of the time of year. At low tide, the majority of the pipeline is exposed and can be repaired using special equipment. Spare pipe and pipe clamps are both available locally for the repairs and the Gas Company keeps in contact with contractors in the area who have the equipment necessary to work in the mud flats. There is a run of 500' or less near the opposite shore from Potters Flat that is under approximately 15' of water at low tide. If the break occurred in that streach of parallel pipe a new pipe could be pulled to breach the underwater break. The pipe and required weights are available in Gas Company stocks.

The time required to make the repair for the most difficult break should not exceed seven days. Inclement weather could delay the repair beyond the seven day estimate.

It is interesting to note that the undersea crossing was inspected by the Gas Company following the 1964 earthquake and they found it to be in excellent condition. The Gas Company felt it survived better than any other portion of the system.

In conclusion, the probability of a break in both of the natural gas pipelines crossing the Inlet is quite low with a repeat of the 1964 type earthquake. Further to have the break occur in the most difficult to repair portion is even more remote. And lastly, if both lines are severed in the most difficult location it is estimated it will still only take a matter of days (7 days maximum) to repair even in mid-winter.

Analysis

Considering an earthquake of the same intensity and magnitude of the 1964 "Great Alaskan Earthquake" one can feel relatively safe making certain assumptions regarding the natural gas system insofar as earthquake response planning is concerned. It should be noted that an in-depth engineering study has not been accomplished since the information usage is for disaster response planning only and finite accuracy is not required. As a matter of fact, there is a tendancy to lean towards the "worst case" since a measure of overkill in disaster response planning is desireable.

The gas transmission lines leading into Anchorage are expected to survive with little or minor damage, none of which would be severe enough to interrupt the supply of gas. This assumption is based upon the historical evidence of how the transmission line reacted favorably to the 1964 earthquake along with the improvements and redundancy now existing.

The distribution system within Anchorage is also expected to survive quite well except in suspected slide areas. Using the earthquake hazard zones 4 and 5 as depicted in the Harding Lawson Study, (Harding-Lawson, 1979) the Alaska Gas and Service Company determined there are 3,800 gas service connections in those areas, with 60 percent in Zone 4 and 40 percent in Zone 5. Considering a total loss of customers in both zones (which is unlikely), there would be an interruption of the gas source affecting approximately 12,000 people. This is computed using a family size of slightly over three.

It is estimated that 50 percent of the service would be restored within 48 hours and 80 percent within 96 hours. The remaining portions of the entire system should be nearly all restored within two weeks. This information is also reflected in the section regarding the homeless.

Fires, due to gas explosions, will be a rarity due to the safety valves located at each service connection. It is anticipated that many homes may have their gas shut off by the safety valve due to seismic shaking but will be quickly restored by the Gas Service Company resetting the valve.

In summary, although the natural gas supply is the most critical winter survival lifeline, it is very likely to survive a severe earthquake quite well except in landslide areas. Even in these areas destruction will not be complete and restoral action can be accomplished very rapidly. Most homes which are in a slide area that remain otherwise habitable should have their gas restored within 48 hours. All gas except for a very few stubborn cases should be restored within two weeks. Homeless figures have been computed by using the expected gas outages coupled with the expected electrical outages.

ELECTRIC POWER

Background

The Anchorage Municipality is furnished electrical power primarily from two sources, Municipal Light and Power (ML & P) and Chugach Electric Association (Chugach). Additionally, both Fort Richardson and Elmendorf AFB have their own generating capabilities and the Alaska Power Administration has a hydroelectric plant at Eklutna which furnishes power to Chugach and ML & P.

The Municipal Light and Power furnishes approximately one third of the Municipality's power covering an area roughly following the old city limit lines. Much of the Municipality's commercial power requirements are satisfied by ML & P. (See Table 8 for a complete listing of the area's generating capacities by location, type of fuel and standby fuel where applicable). As indicated in the table, all of ML & P's power is generated within the Municipality except for a small amount purchased from the Alaska Power Administration (APA); therefore, long transmission lines which are susceptible to shock and slide damage are not a severe problem to ML & P.

ML & P peak power requirements for midwinter with low ambient temperatures experienced are estimated to be approximately 137 Mw during the upcoming 1980-1981 season. Total available ML & P power substantually exceeds this peak requirement; however, total available power is not the limiting parameter when considering earthquake damage restoral. For example, the majority of ML & P's power is (or will be in the future) generated at the ML & P Oil Well Road facility. If this facility were destroyed, the First Avenue and Post Road generation plant could only furnish about 85 Mw or slightly over one-half the peak winter requirement. Given the reverse situation, whereupon, the Oil Well Road Plant survives but the Post Road Plant did not, all peak ML & P requirements could be satisfied by the one large Oil Well Road plant. The ML & P power generating system survived the 1964 "Good Friday Earthquake" moderately well. The gas turbines in the First Avenue and Post Road generating plant were automatically shut down by the vibration controls reacting to the first shocks (Eckel, 1967). There was little damage to the plant; however, the natural gas supply was lost due to a landslide breaking the gas transmission pipeline leading to the plant. "Six standby diesel generators were also inoperative because water main breaks stopped the supply of cooling water. Some intermittent power was restored to the city within two and one-half hours after the earthquake, when the turbine plant was started with bottled gas and then converted to oil for fuel" (Eckel, 1967). The plant's fuel storage tank was also destroyed by slide action which necessitated fuel delivery by truck from Elmendorf AFB to keep the turbine operating. Firm power was not restored to the city system until the gas line was repaired. "As a result, power was restored to nearly all of Anchorage by midnight Sunday, March 29" (Eckel, 1967). In overall summary, ML & P's power generating capability was partially restored two and one-half hours after the event and was fully capable within 55 hours.

ML & P's distribution system survived the 1964 earthquake amazingly well. "The municipal power-distribution system, both aerial and underground, was almost undamaged except in slide areas" (Eckel, 1967). Gigantic landslides took its toll by wrecking two substations which required relocation while the vibrations caused light to moderate damage to most of the other substations (Eckel, 1967).

Chugach furnishes approximately two thirds of the power required for the geographical area of the Anchorage Municipality. The exact split of power furnished by Chugach versus ML & P is not important as far as response planning is concerned, but a rough estimate of the split is helpful in case it becomes necessary to backfeed power from one system to another. See Figure 13 for the Chugach System.

Anchorage has experienced a tremendous growth in population since 1964 with the greater portion of the urban housing being built in the Chugach service area. Keeping pace with the increased demand for electrical power, Chugach has built a large generation facility located across Cook Inlet from Anchorage to the west and hence to the south. This impressive plant is located near the village of Tyonek and is commonly referred to as the "Beluga Station." It is situated next to several gas wells that furnish the fuel for this gigantic facility. This one facility alone is nearly capable of furnishing the entire Chugach peak winter load requirement, and as of this writing it is being expanded by another 60 Mw waste heat recovery generator to be on-line by late 1980.

The Beluga Station was constructed after the 1964 earthquake so there is no historical evidence to use as a basis of assessment. As a matter of comparison, the Village of Tyonek located near Beluga survived the 1964 earthquake with little property damage. "One waterline, buried eight feet deep, was broken by ground fissures where it crossed swamp deposits near the lake. Unattached articles in homes were shaken, but there was no structural damage, no chimneys fell, and a large water tank on the hill above the village was unaffected" (Plafker, Kachadoorian, Eckel, and Mayo, 1969). Thus, it is reasonable to expect the generating facilities at Beluga to react similarly in a repeat of a 1964 type earthquake.

In 1964, Chugach electric generating capabilities was comprised of the Knik Arm coal-fired steam plant near the mouth of Ship Creek in Anchorage, the Bernice Lake gas turbine plant in Kenai, and the Cooper Lake hydroelectric plant on the Kenai Peninsula. The Bernice Lake Plant furnished power principally for the Kenai Peninsula and was not a factor in the Anchorage scenario. The Cooper Lake facility did <u>not</u> sustain any serious damage in the 1964 Alaskan Earthquake. "The Knik Arm Plant, however, was severely shaken, and coal bunkers, ash handling system, and other elements were either weakened or destroyed. The most serious damage was not noticed until two weeks after the earthquake when high tides made apparent the fact that tectonic subsidence and local compaction had lowered the mouth of Ship Creek. Sea water flooded the cooling pond and the ash aisle in the basement of the plant" (Eckel, 1967). Nevertheless, the Knik Arm Plant was in full operation in less than a week after the earthquake.

The Chugach distribution system was also severely damaged. "About 50 poles broke and 25 transformers were dropped to the ground. Underground lines and several substations in downtown Anchorage were destroyed by landslides" (Chugach Electric Assoc., 1964). There was no power coming over the Chugach transmission lines from the Kenai Peninsula, and the Eklutna Plant was temporarily out of service. The Chugach transmission lines along the north side of Turnagain Arm sustained heavy damage, "...particularly between Girdwood and Portage...-13 tower structures were destroyed and 60 others required extensive repairs" (Eckel, 1967). "In the mountains, earthquake-triggered avalanches destroyed several towers on the line between Portage and Cooper Lake and between Cooper Lake and Seward" (Chugach Electric Assoc., 1964). Restoral of the Chugach generating capacities took less than a week; however, rebuilding the transimission lines extended into early May.

The Eklutna Hydroplant was operating at near its maximum of 32 Mw when the "Great Alaskan Earthquake" occurred in 1964. The initial shock eliminated all the power to the plant and it occurred when almost all the maintenance personnel were off site. As first estimated, the damage to the plant appeared to be light, and service was restored to the plant itself within 30 minutes by opening the line service switches (Logan, 1967). The 115-kv Palmer transmission line was out due to destruction of 7,500 feet of line by earthquake induced snow slides. After some temporary repairs were made to the switching equipment, the Anchorage line was energized on March 27, at 10:10 p.m., the Matanuska Electric Association Reed substation at 10:43 p.m. and the Palmer substation, the next day at 10:00 a.m. (Logan, 1967).

Both of Eklutna's hydro generating units went off the line on March 28 due to dropping pen stock pressure. The pressure restored itself and one unit was put back on line. This signalled the start of a long series of intermittent service which lasted until May 9, 1964, at which time the plant was closed for inspection and repair (Logan, 1967). The plant is still in existance today and furnishes good steady power to ML & P and Chugach.

Both Elmendorf AFB and Fort Richardson's coal-fired steam turbines sustained structual damage due to seismic shaking in 1964. "Despite the widespread damages, central heating for the military bases was maintained with almost no interruption, and power was restored to large parts of both bases within 24-hours (Powers 1965; U.S. Army Alaska Command, 1964; Stephenson, 1964).

The military power plants are now fueled with natural gas but could be quickly converted to oil.

Analysis

The total Anchorage Municipalty power picture has changed considerably since the 1964 Alaskan earthquake. The picture has changed from a position, whereby, a large percentage of the power generation equipment was located within the city in 1964 to the present, whereupon the greater share is located outside of the Muncipality. At the same time, the trend within the city has been towards utilizing a smaller number of large capacity machines rather than a large number of small machines. This has the negative effect of making each large machine much more critical to the overall power quotient. On the other hand, this is more than off-set by the fact that most of the large machines are new and more reliable than the older small generators that are subject to more mechanical breakdowns.

First, when analyzing the impact of generating a large portion of the power outside of the Municipality, one finds it contains both negative and positive aspects. On the positive side, it is advantageous to have the generators located as far from the historic epicenter as possible to minimize damage. All of the out-of-town Chugach facilities fall into this category. Most important, the large bulk supplier at Beluga (the critical link in the Chugach system) is located the farthest distance away from the 1964 epicenter of all the Chugach generators. On the negative side, bulk power delivery is dependent upon long transmission lines leading to the Municipality, which makes it subject to interruption more from line loss than source loss. Experience has shown that power outages are caused by lines swinging and touching, thereby, tripping circuit breakers. Transmission lines, and insulators can also be broken due to tension caused by opposing sway of transmission towers. Whole sections of lines and towers can be destroyed by snow/landslides in mountainous terrain. Fortunately, transmission lines are designed to withstand high winds which inherently makes them somewhat earthquake resistant.

In the overall Anchorage Municipality transmission line scenario we also find some advantages and disadvantages. Regretably, some of the bulk power transmission lines from the south and north cross areas susceptible to avalanche and slides. Fortunately, these two routes furnish only a small amount of power. The big bulk supplier to the west (Beluga) uses parallel overhead transmission lines traversing the west side of Cook Inlet to a point opposite Point Woronzof, whereupon, submarine cables are utilized for the Inlet crossing to Anchorage. The earthquake damage to the overhead lines could be quickly found and easily fixed which is a decisive advantage. In the negative, however, repairing earthquake damage to the Inlet crossing submarine cables would require special long lead time equipment and the work can only be accomplished in the summer months. At the present time, Chugach has plans to upgrade the entire transmission system from its Beluga Plant.

This will include reinsulating the existing 138 kv transmission line from Beluga Power Plant to Teeland substation to 230 kv, and the construction of a 230 kv combination submarine cable-overhead circuit to Anchorage. Most noteworthy of these improvements is the additional submarine cable crossing which will be located in the Knik Arm separated by seven miles from the present Cook Inlet crossing. This additional crossing will provide redundancy for the critical and difficult to repair portion of the transmission system.

Power produced within Anchorage represents less of a transmission problem but the probability of generator damage due to shaking is somewhat greater due to being located closer to the historic epicenter. The 1964 Municipality generator damage was light with the loss of power being caused primarily by the interruption of natural gas fuel due to a landslide. Based upon this historical evidence coupled with the knowledge of ML & P's plant improvements/expansions, it is projected that the present ML & P generation system is even more survivable. Most of the bulk power is now generated at the ML & P Oil Well Road Plant which is located in a good soils zone less susceptible to slides and loss of natural gas than the older and smaller First Avenue and Post Road Plant. Loss of the older plant due to another earthquake induced landslide will have little impact on the overall ML & P generating capacity if the Oil Well Road facility survives.

Both of the military generating plants combined excess power would add very little to the overall Municipality's needs if all other civilian sources were out. In the reverse, the civilian sources could pick up the military load without much difficulty if the necessary inter-connects are in place. This is a departure from the 1964 setting, whereupon, the military bases and their generators at that time, represented a larger share of the total generating capacity.

For disaster response purposes, the Eklutna Hydro Project generation equipment and transmission system is postulated to react in a manner similar to the 1964 earthquake event although some postearthquake improvements have been made. Because of the tremendous growth in the total Anchorage area generating capacity, the Eklutna power represents a much smaller portion of the overall power available; therefore, it is not a critical link in the grid as it was in 1964. This rationale generally holds true for all the older generation capabilities.

The number of customers whose electric service would be out due to a major earthquake will be very similar to the number and type of damage experienced during the April, 1980, Anchorage windstorm. For earthquake study purposes, the actual electrical restoral actions taken, very nicely parallels earthquake restoral actions and can be used to postulate very realistic reaction times. The windstorm resulted in a loss of power for approximately 15,000 Chugach customers, 16,000 ML & P customers and both military bases sustained minor electrical damage. The outages were caused by a variety of factors from minor circuit breaker tripping to complete line loss due to fallen trees and poles. One high voltage incoming transmission line from the south was completely out. On the other hand, some electric service customers were never without power. Restoral moved very quickly with virtually all of ML & P's customers restored within 10-hours. The outage started at 1:30 a.m. and by 3:00 a.m., 16,000 ML & P customers were without service. By 5:00 a.m., service restoral was taking place and all ML & P service was restored by 11:30 a.m. Fortunately, most of the ML & P restoral was in the easy find, easy fix category of resetting protective equipment rather than physical damage. Restoral at both military bases was completed in nearly the same time frame. Most of the physical damage was concentrated in the Chugach portion of the Municipality, and the numbers alone were overwhelming. Nonetheless, restoral was quite rapid with Chugach first concentrating on the easy-to-fix problems that affected large numbers of customers. Next, the more difficult problems were handled that affected multiple customers, and last in priority were difficult to fix single service problems. Chugach received assistance from private contractors, other utility companies in the State, ML & P and the military. Within 18-hours, Chugach and private contractors had restored service to 7,500 of the original 15,000 who had lost service. Within 48-hours 3,700 additional customers had been restored and within 72-hours all but 1,000 mainly single customers were still without power. By the end of the fourth day, virtually all power had been restored to the homes.

Summary

Earthquake damage calculations for response planning purposes normally assummes a "worst case" situation in order to prepare for and be aware of a high level of expected damage. This is not a guarantee that the actual event will not exceed that level; but rather, it is the high side of a range thought to be realistic based upon historical evidence of other earthquakes. With this in mind the postulated electrical utility damage is summarized in the following paragraphs:

As in 1964, a complete power blackout can be expected immediately following the first shock. Minor damage to the power generation facilities located in Anchorage (including Eklutna) can be expected. After approximately 30 minutes to allow time for a plant damage assessment, the lightly damaged plants will be ready to furnish power to the transmission system. It is estimated that two thirds of the generation facilities within Anchorage will survive the shaking well enough to be put on-the-line within the first hour. The majority of remaining capacity should be restored rather quickly, spanning a time frame of several hours to 3-4 days. A small percentage of the potential capacity will require a long-term fix action amounting to several weeks.

The power generation facilities located outside of Anchorage are expected to survive with light to minor damage as they did in the 1964 earthquake event.

Minor shaking damage to the Beluga Station facility can be expected due to such things as toppling of unbraced equipment control racks. Restoration from this damage should be very rapid.

Damage to incoming transmission lines to Anchorage will have the greatest effect on the overall electric power supply and all are expected to sustain some damage. The lines from the north and south are highly susceptible to outages from landslides since they traverse mountainous terrain. They are also vulnerable to swinging and shorting to other lines which usually cause power outages. Ground motion can also cause tension breaks in the lines. The line from the north should be quickly repaired but the southern line could be out for a week or more. The overhead line route from Beluga to the west does not traverse mountainous terrain but the lines will be subject to swing and tension damage. This type of damage is easily found and normally causes only a short term outage. The Chugach upgrading projects including the additional Inlet crossing in the Knik Arm will provide needed redundancy. All repairs to the westerly line necessary to restore power should be accomplished in less than 12 hours.

Damage to the customer service distribution system within the Municipality will vary from undamaged to complete destruction in slide areas. See Figure 14 for location of ML & P substations. Numerous service poles (approximately seventy-five) and transformers (approximately thiry-five) will fall in poor soils areas due to extensive ground movement. Improvements to the distribution system coupled with the knowledge that the majority of the Municipality's expansion has been on better soils leads to the conclusion that service damage will be less on a percentage basis than in 1964. Restoral of all power to the lost service areas should take less than a week with majority of power restored within 24-hours.

TABLE 8

ANCHORAGE AREA POWER GENERATION

LOCATION	FUEL	ELECTRIC POWER IN MEGAWATTS: OUTSIDE OF ANCHORAGE	ELECTRIC POWER IN MEGAWATTS: IN ANCHORAGE	STANDBY FUEL (DAYS)	REMARKS
Chugach Electric		*			
Beluga	N. Gas	272.3		----	An additional 60 MW to be on line in late 1980.
Bernice Lake	N. Gas/Oil	47.Ø		1.9	
Cooper Lake	Hydro	15.Ø		----	
International Sta.	N. Gas/Oil		45.Ø	12	
Knik Arm	N. Gas/Oil		14.5		
Alaska Power Admin.	Hydro	32.Ø		----	
Municipal Light & Power		**			
1st & Post	N. Gas/Oil		85.Ø	1.3	Does not include 2.2 MW of diesel standby
Oil Well Road	N. Gas/Oil		151.Ø	1.9	Total ML&P on line in fall of 81 will be 276 MW
Elmendorf AFB	N. Gas/Oil		22.5	3.5	Also has 2 MW standby diesel
Fort Richardson	N. Gas/Oil		27.5	.5	
TOTAL		366.3	345.5		

* Chugach Electric purchases 9 MW of power from APA
** ML & P purchases 16 MW of power from APA

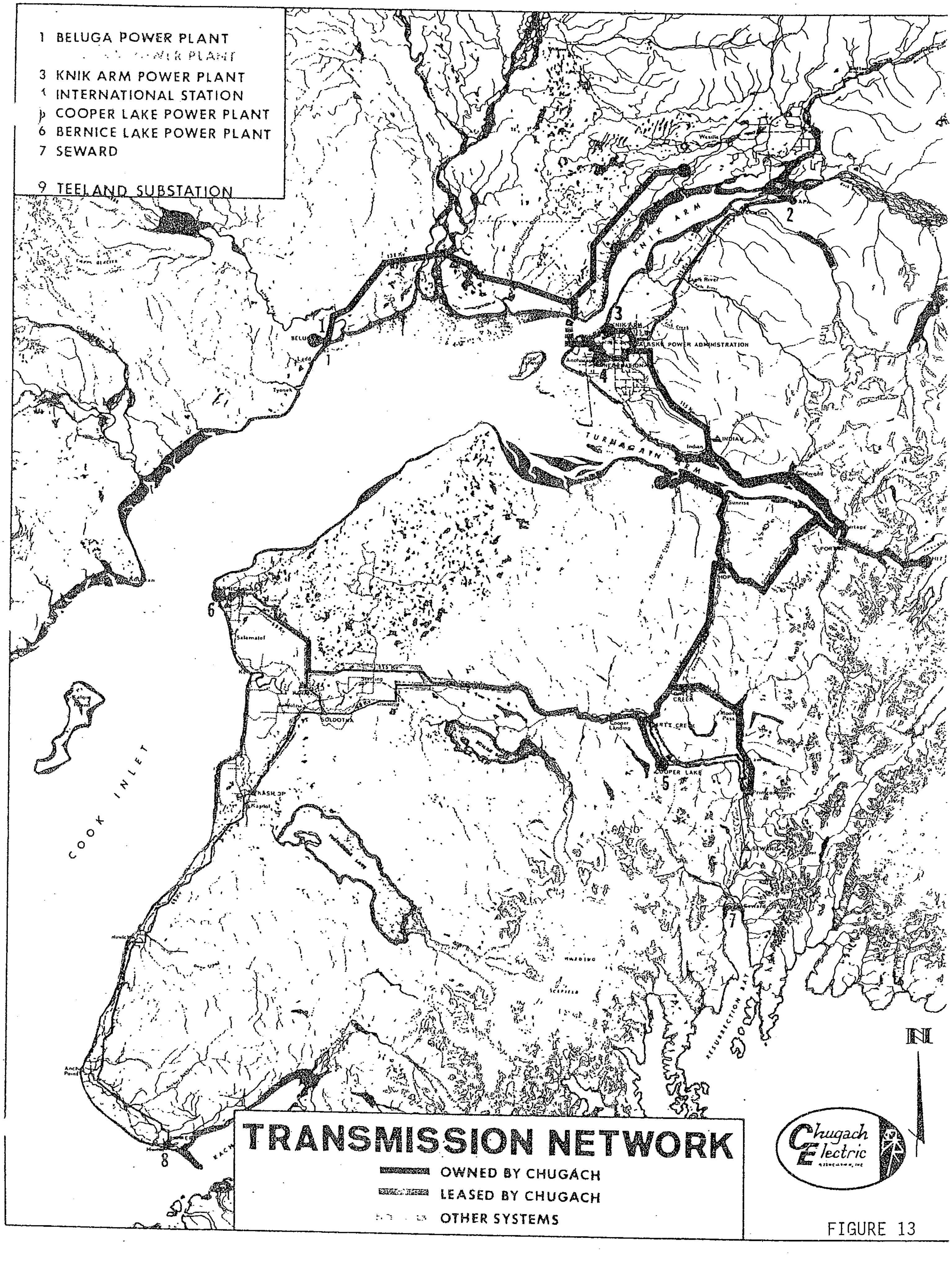
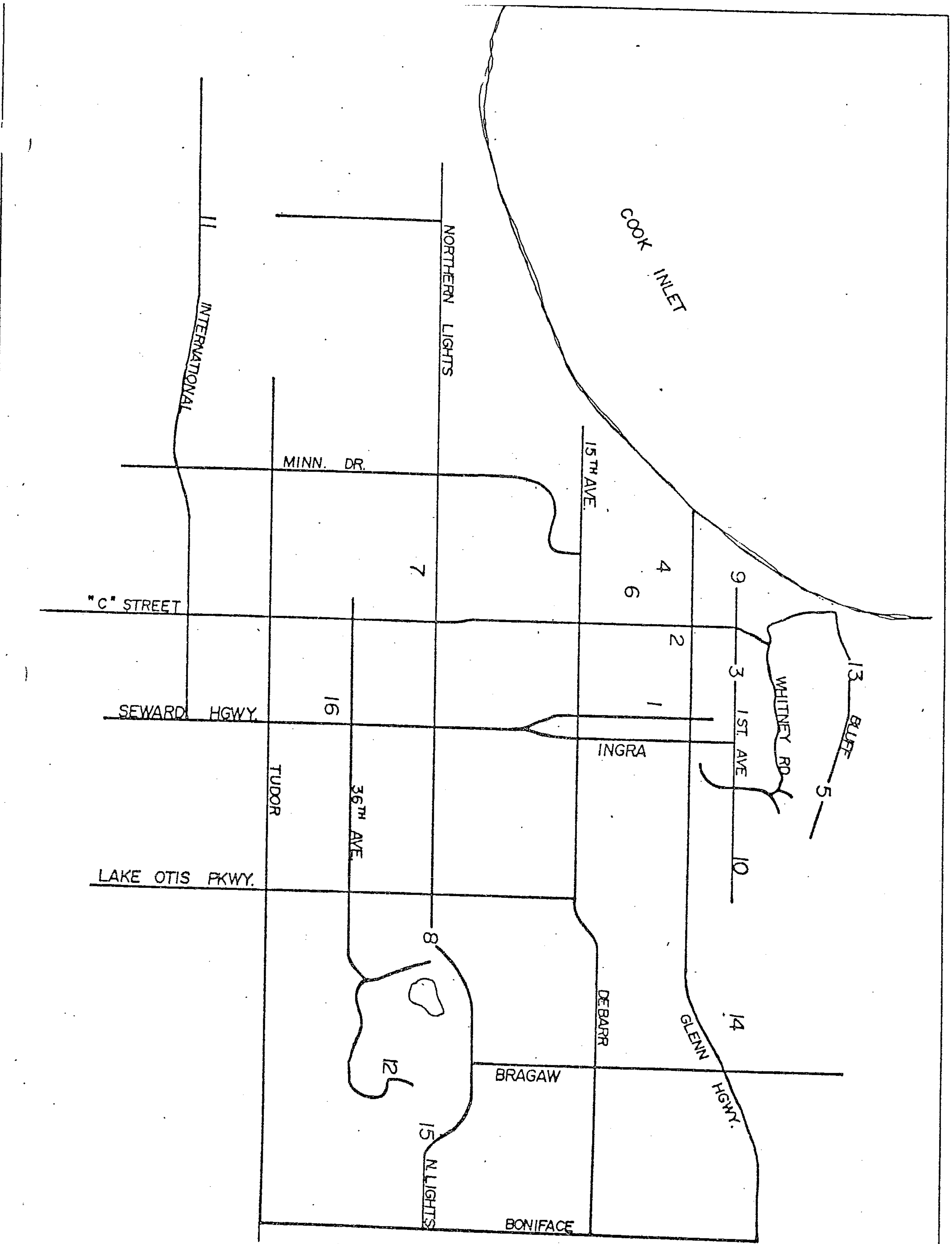

1 BELUGA POWER PLANT
3 KNIK ARM POWER PLANT
INTERNATIONAL STATION
COOPER LAKE POWER PLANT
6 BERNICE LAKE POWER PLANT
7 SEWARD
9 TEELAND SUBSTATION
KNIK ARM
TURNAGAIN ARM
COOK INLET
RESURRECTION BAY
TRANSMISSION NETWORK
OWNED BY CHUGACH
LEASED BY CHUGACH
OTHER SYSTEMS
Chugach Electric
N

FIGURE 13



MUNICIPAL LIGHT & POWER SUBSTATIONS

FIGURE 14

TRANSPORTATION

There are four modes of transportation which serve functions important to the Anchorage community: air, water, railroads, and highways. In this chapter, damage to these transportation systems, caused by the 1964 earthquake, is used as a basis to anticipate damage should a large magnitude earthquake occur in the near future. The modes of transportation are discussed as possible alternatives to each other, if one or more is disrupted by severe earthquake damage.

AIRPORTS

In the aftermath of the 1964 earthquake the air transport system of southcentral Alaska was the least damaged of the transportation systems. Major shipping ports were destroyed or severely damaged, and highway and rail links connecting these ports to Anchorage and other towns were made impassable by damage. This made Alaska extremely dependent on air service for importing supplies during the recovery period (Eckel, 1967).

During the 1964 earthquake "all three major airfields at Anchorage--Elmendorf AFB, Anchorage International Airport, and Merrill Field--escaped the huge landslides that wrought so much havac in parts of Anchorage (Hansen, 1965), but all sustained some degree of damage by earthquake vibration. Merrill Field, heavily used by Civil Air Patrol and by private planes, was back in full operation within an hour of the quake and served as a control center for all air traffic in the Anchorage area while control facilities at Elmendorf and Anchorage International were being repaired" (Eckel, 1967). The airfield at Elmendorf AFB remained operational during the quake but tower operations were moved to a temporary location until their tower was repaired (Eckel, 1967). Anchorage International Airport's tower collapsed due to vibration and was one of the greatest losses that directly affected the aviation system. A parked DC-3 was utilized for communications with Merrill Field tower and the International Airport was substantially operational within a few hours after the quake (Eckel, 1967). Runway damage was slight and was repaired quickly. Several buildings collapsed, including part of the terminal (Eckel, 1967; Norton and Haas, 1970).

Since 1964, several improvements have been made in the construction of air traffic control facilities. The most obvious is the new air traffic control tower at Anchorage International which was built in 1978. This tower has all the Instrument Flight Rules equipment and radar components at ground level, hence this equipment should be relatively safe even if the control tower were to collapse. Also the tower was constructed with earthquake movement in mind, so it should resist all but extremely severe motion. Elmendorf AFB has also constructed a new tower, in 1969, that is similar to the one at Anchorage International. Anchorage International has tentative plans to erect a new terminal building in 1982.

Emergency electric power for Anchorage International would be provided by four generators fueled by gasoline or diesel fuel. These would provide light to runways, taxiways and limited power to the terminal and other buildings. Emergency power to the control tower is provided separately by FAA's own system (State of Alaska, 1978).

Communications at Anchorage International is no problem, as there are four nets: ground control, security, field maintenance and airport manager. These sections have vehicle mounted and/or handheld radios. Communications at Merrill Field are similar to communications at the International Airport. The airport manager is able to communicate with the tower, maintenance, and in this case, the Anchorage Police Department.

the newly constructed FAA Traffic Control Center, located adjacent to Elmendorf AFB, has a diesel generator for standby power and has a maximum fuel supply of 17 days. They utilize the RCA satellite for their communications statewide, and if that system fails, can still communicate by telephone and microwave through Canada to outside satellite sources.

Road access to the airports could be restricted due to earthquake damage. However, damage to Anchorage roads caused by the 1964 earthquake was fairly light and did not present major problems to traffic flow except in the slide areas. Each of the three airports have alternative access routes. Hence it is expected that emergency traffic would have access to the airports within a few hours after a major earthquake.

An additional hazard to the airports is the risk of fire if fuel tanks and lines rupture. To reduce this risk, each airport has the capability of spreading foam over spilled fuel which prevents it from burning (Merrill Field is protected by Anchorage Fire Department). All agencies with fire fighting capability in Anchorage have a mutual aid agreement with each other, making the stockpile of foam available to each extensive Elmendorf AFB maintains 200,000 gallons of foam concentrate (mixes at 3 percent or 6 percent with water) and Anchorage Fire Department (AFD) keeps 600 to 700 gallons in storage. These supplies can be rapidly mobilized for use. In addition, Elmendorf AFB has crash units at their airfield, the largest of which carries 500 gallons of foam concentrate. AIA and the nearby Kulis Air

National Guard Base also have crash units with a large foam capacity. AFD has one fire engine which carries 75 gallons of foam concentrate. This can cover an area of several blocks. Two AFD tankers carry 50 gallons of foam concentrate each and about seven other fire engines carry 15 or 20 gallons.

A new potential source of damage at Anchorage International is the passenger arrival ramp providing automobile access to the second floor of the terminal. The earthquake response of this bridge-like structure has not been evaluated in this study. If this structure were to collapse it would be quite dangerous and could result in life loss.

Table 9 shows that there are some alternatives to the three major airports in Anchorage, if these should be made inoperable by an earthquake. Most important among these is the BLM owned Campbell Airstrip. It has a gravel airstrip almost a mile long and auxiliary power capabilities. Hence, it could serve fairly large airplanes equipped to land on gravel, in event of an earthquake disaster. Lake Hood is a major small plane airport able to handle wheel and float planes. To the north of Anchorage, in the Chugiak area, the Birchwood Airport is becoming increasingly important as a small plane airstrip serving Anchorage. Although it has a 4,000 foot asphalt runway, it has no lighting system and is restricted to daytime use. In addition to the airports mentioned above, there are several privately owned airstrips for small planes throughout the Municipality.

There are seven heliport locations listed in Table 9, including two hospital locations. In addition, large flat areas could be used as emergency landing pads for helicoptors, e.g., playgrounds and parking lots (U.S. Geological Survey, 1975). Lighting systems for these would have to be devised to allow nighttime use. Headlights of cars could possibly be used for this purpose.

Analysis

Airport runways are constructed to withstand the extreme forces exerted as large jets land and take off. This heavy duty construction also makes runways fairly resistive to seismic vibrations. Therefore, severe damage to runways is not expected in the event of another major earthquake. Since the three major airports are widely separated and located on different types of soil formations, it is unlikely that all three would be severely damaged in an earthquake unless the magnitude were much greater, or the epicenter much closer to Anchorage than those of the 1964 earthquake. If all three were to become inoperable for an extended period of time, Anchorage has alternative landing areas that could accept emergency air traffic. The air transportation mode is more flexible than other modes, largely because the size and takeoff-landing capabilities of aircraft vary so greatly. In addition, the rapid mobility of aircraft would allow quick replacement of damaged aircraft from outside the disaster area. Since damage is expected to be heavier to other modes of transportation, airlifts would again be of prime importance for moving emergency supplies and personnel to assist in recovery operations.

TABLE 9

ANCHORAGE AREA ' PORTS

NAME	RUNWAY LNGTH/WIDTH	ELEVATION	RUNWAY CONSTRUC.	AUX. POWER	OWNER-SHIP	LOCATION NEAREST CITY/TOWN ACCESS ROUTES DISTANCE	ATTENDENCE SCH.
50270.1A Girdwood	2100x80	150	Gravel	N	State	2mi NE of Seward 3mi NE Girdwood	Unattended
50324.A Hope	2000x65	200	Gravel	N	FS	Dirt road 1mi SE Hope	Unattended
50033.A Campbell Airstrip	5000x150	270	Gravel	Y	BLM	Lake Otis Rd. 5mi SE	Mon-Fri 0800-1700
50034.A Anchorage Int'l	10600x200 10897x150 4740x150	270	Tower 1978 ASPH	Y	State	Various 5mi SW	All
5035.2C Campbell SB	3500x400	20	Water	N	Private	Jewell Lake Rd 7mi SW	Unattended
5036.03A Rabbit Creek	1378x30	35	Turf/gravel	N	Private	Seward Hwy 8mi S	Unattended
50036.99A Lake Hood	2200x80	73	Gravel	N	State	Spenard Rd./No. Lgts Blvd. 3mi SW	Unattended
50037 C Lake Hood SB			Water	N	State	Spenard Rd./No. Lgts. Blvd. 3mi SW	Unattended
50069 A Birchwood	4000x100	96	ASPH	N	State	Dirt Road & AK Railroad 1mi W	Daylight hours
50036.1.A Sky Harbor	1800x70	340	Gravel	N	Private	O'Malley Rd. 8mi SE	Unattended
50036.5.A Bryant AAF	3000x100	378	ASPH	N	Private	Ft. Richardson	All
50184.45 A Chugiak Hill Top	1300x40	375	Turf	N	Private	Glenn Hwy Chugach 3mi N	Daylight hours
50176.01 A Eagle River Hardee Field	850x45	350	Gravel	N	Private	Glenn Hwy	Unattended

TABLE 9

ANCHORAGE AREA A   RTS

NAME	RUNWAY LNGTH/WIDTH	ELEVATION	RUNWAY CONSTRUC.	AUX. POWER	OWNER-SHIP	LOCATION NEAREST CITY/TOWN ACCESS ROUTES DISTANCE	ATTENDENCE SCH.
50176.02 A Eagle River Hardee Field	1350x75	660	Dirt	N	Private	Glenn Hwy 10mi N	Unattended
50035 A Merrill Field	4000x100 2469x60	136	Tower 1962 ASPH	Y	City	5th St. & 15th St. 00mi E	0800-1600
50036 A Elmendorf AFB	10000x200 7500x150	212	Tower 1969 Concrete	&	Private	Boniface 4mi NE	All
50036.02 A Fire Island	200x75	55	Gravel	Y	FAA	8mi SW	Unattended

ANCHORAGE AREA HELIPORTS

50033.1 H Providence Hosp.	H1 85x85 H2 115/115	130	ASPH	N	--------	Providence Dr. 3mi SE	All
50033.2 H Campbell BLM	100x90	235	TRID ASPH Treated	N	--------	Lake Otis 5mi SE	Mon-Fri 0800-1700
50033.3 H Lake Hood Public	75x75	80	ASPH	N	--------	Spenard Rd. 3mi SW	Unattended
50034 H Anchorage Int'l.	H1 100x100 H2 100x100	90	Gravel	Y	--------	Jewell Lake Int'l. Airport Rd. Spenard Rd. 5mi SW	All
50035.H Merrill Field	H1 250x200 H2 100x100 H3 200x200 H4 100x100 H5 100x100 H6 100x100	136	Gravel ASPH ASPH Gravel Gravel	Y	--------	5th Ave & 15th Ave. 0mi E	0800-1600
Elmendorf Hospital	H1 50x450	228	ASPH	N	---------	Glenn Hwy 4mi E	All
Bryant	H1 100x100	342	ASPH	Y		Glenn Hwy 7mi NE	All

PORTS

Alaska "...imports fully 90 percent of its requirements - mostly by water..." (Eckel, 1967). Prior to the 1964 earthquake, the major ports serving Anchroage were Seward and Whittier. The Port of Anchorage had less commercial importance because, unlike the first two, it is not ice-free year-round.

Damage caused by the 1964 earthquake cut the rail and highway links between the major ports and Anchorage. The port of Seward was totally destroyed by submarine landslides (which generated local waves) seismic sea waves, ground vibration and fire. The Alaska Railroad's port facilities were rebuilt on a new site which may be less suseptible to submarine landslides and associated sea waves. The port facilities at Whittier sustained a great deal of damage, but limited shipping service was restored by the time restricted train service from Anchorage resumed, 24 days after the earthquake (Eckel, 1967).

The Port of Anchorage is built on the mudflats of Knik Arm in the Ship Creek basin. This is a moist low-lying area that sustained considerable damage in 1964 from "earthquake vibrations and by related ground fractures and consolidation and settlement of sediments" (Eckel, 1967). The cement deck of the city dock received numerous hairline cracks and dropped below grade somewhat. Some storage tanks in the port area were destroyed or damaged (Eckel, 1967; Hansen 1965). "Petroleum pipelines and approach roads and rail lines were broken or twisted by settlement and vibration" (Eckel, 1967). Despite this and other damage, the Port of Anchorage came through the earthquake well, in comparison to the ports of Whittier and Seward. The Port of Anchorage escaped landslides, seismic sea waves, and fires (Hansen, 1965; Eckel, 1967). Port operations were resumed on a restricted basis within three days following the earthquake (Eckel, 1965; Anderson, 1970).

The relatively light earthquake damage and speed of recovery allowed the Port of Anchorage to capture most of the shipping business that had previously gone through Seward and Whittier (Eckel, 1967; Rogers, 1970). This includes the majority of cargo brought to Alaska, except that used in Southeast Alaska. The newly initiated use of larger ships, with the ability to cut through the ice pack, has made Anchorage a year-round port. Hence, the Port of Anchorae has greatly increased in importance to Alaska, as a whole. A discussion of the earthquake vulnerability of the Port and the operations there, is therefore in order.

Port of Anchorage

Due to the shallow water depth of the Port of Anchorage, deep draft cargo vessels (28 to 30 foot draft) must approach the Port through a dredged channel. This channel is wide enough for two freighters to pass, but only one ship at a time uses it. Freighters can approach the dock from either end. The approach is made against the tide so as to aid in slowing the vessel and improving steerage.

If an earthquake caused the sides of the channel to slide, there is likely to be enough room remaining to allow freighters to approach the dock. In the unlikely event that one end of the channel were blocked, ships could approach from the other end.

The dock itself is essentially floating on steel pilings sunk from 110 to 160 feet into the silt. The pilings alternate between groups of verticle and groups of paired diagonal (scissor) pilings. The dock has numerous 8 inch expansion joints, which allow the dock to expand and contract with seasonal temperature fluctuations as well as improved the structures seismic response capability. The dock is built to withstand great strain caused as large chunks of ice are forced against it by tidal flow in the wintertime. Ice typically increases the weight on the dock by 500,000 lbs. Although ADES has not obtained an estimation of the dock's ability to withstand strong earthquake vibrations from an engineering expert, it appears to laymen that this structure is well designed to withstand earthquake vibration (see Figure 15 for Port layout).

Parts of the dock were in existence during the 1964 earthquake. As mentioned above, the cement deck received hairline cracks. These were repaired by boring holes in the cracks and forcing epoxy glue into them. The grade drop was not much of a problem. Additions to the dock have been inclined at a slight angle so as to bring the newer portions up to grade.

The Operations and Maintenance Superintendent at the Port stated that postearthquake land surveys show 18 inches of seaward lateral movement caused by the 1964 event. However, he stated that, if this is true, the whole area must have moved as a mass since Port structures did not change their positions in relationship to each other. The Superintendent has ridden several tremors at his office on the pier. The building and dock simply role with the mud in which they are embedded. Worse vibrations are felt from the ice pushing the dock in the wintertime.

Soils studies conducted prior to construction of the Port show that the mud, with a few gravel lenses interspersed, is at least 250 feet deep under the dock. There is a firm till base underneath it, which slopes upward in the direction of planned additions to the dock./1

A tsunami capable of damaging dock facilities at Anchorage is considered an unlikely occurrence "because of the shallow, narrow configuration of...[Cook] Inlet and the complex tidal regime (Evans, 1972)." Winterhalder, Williams and England, 1979).

Port Operations

Two companies ship goods from Anchorage to Seattle, Sea-Land and Tote, the latter, began service to Anchorage in 1975. Each company sends two ships to Anchorage per week,and neither refuels its ships in Anchorage.

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1. The Municipality of Anchorage currently rates the port area as Seismic Hazard Zone 3, "moderate ground failure susceptibility" (Plate 2A, Seismically Induced Ground Failure, Anchorage, March 1979).

The operating methods and capabilities of the two companies differ considerably. Each Tote voyage from Seattle takes about 68 hours to arrive in Anchorage and carries 360 to 370 40-foot vans. Tote is limited by their loading method to carrying cargo on wheels. Vans and other vehicles are driven off the ship using bridges on wheels that are pushed into place between ship and dock by pickup trucks. The three such bridges are stored on trestles which connect the main dock to solid ground.

Sea-Land ships take three to five days to make the voyage from Seattle to Anchorage and carry about 360 to 370 35-foot container vans. All Sea-Land cargo must be in containers, even automobiles. Sea-Land uses cranes to off-load containers and set them into trailers which are then driven off the dock.

There are five large gantry cranes at the Port. Two cranes are rigged for Sea-Land containers. These cranes lift 27.5 tons and are powered by electricity (480 volts) which comes in at both ends of the dock. The other three cranes are owned by the Municipality. They have self-contained deisel/ powered backup generators and are therefore not dependent on an outside source of electricity. Each crane has a 300 gallon fuel tank which allows the crane to run for 10 hours. Two of the cranes can lift 40 tons (one was recently damaged and temporarily out of use) and the other can lift up to 7.5 tons. These cranes can be rigged to lift Sea-Land containers by attaching the right bridle.

The legs of all of the cranes are on tracks which run the length of the dock. When not in use, the cranes are secured against winds up to 100 miles per hour by four inch diameter pins between truck assembly and dock and by chains. This would provide some resistance against the cranes jumping their tracks during an earthquake. If a crane did jump track, the Superintendent of Operations and Maintenance estimates that it would take approximately one day to return it to the tracks. During the 1964 earthquake, the only damage to cranes was that counterweights fell off. This required another crane to put them back on. The most probable delay for repair of cranes would be the time required to obtain parts.

There are three heads for off-loading oil products. These contain valves and hoses, or hose hook-ups. Dock side valves must be turned off gradually, but there is also an off-dock valve house which contains quick turn shut-off valves. During off-loading there is a two-man valve watch. One man is stationed at the dockside valves and one at the valve house. These two are in radio contact with each other.

Some breakage of fuel lines and rupture of storage tanks occurred during the 1964 earthquake. Fire was prevented by the rapid response of Alaskan Air Command Civil Engineers, and fire department personnel, who foamed the spilled fuel to neutralize its flammability (Headquarters, Alaskan Command). The tank farm near the Port of Anchorage has expanded since 1964 and is quite extensive. If another earthquake strikes Anchorage with intensity similar to the 1964 quake, fuel line and tank ruptures are expected. The dock itself is equipped with heads for receiving fire extinguishing chemicals from onshore. While no foam is available at the Port to neutralize spilled pertoleum products, the Anchorage Fire Department, Elmendorf AFB, and the Airports have large quantities of foam on their crash units and large stockpiles of foam in storage (see Airport section above). The Anchorage Fire Department can respond to calls from the Port in from three to five minutes, and has a mutual aid agreement with all others with fire fighting capabilities.

The Port authority is geared toward handling any emergency that may arise; however, they have no specific emergency plans. They do have a call-back system for off-duty personnel, and key employees wear pagers.

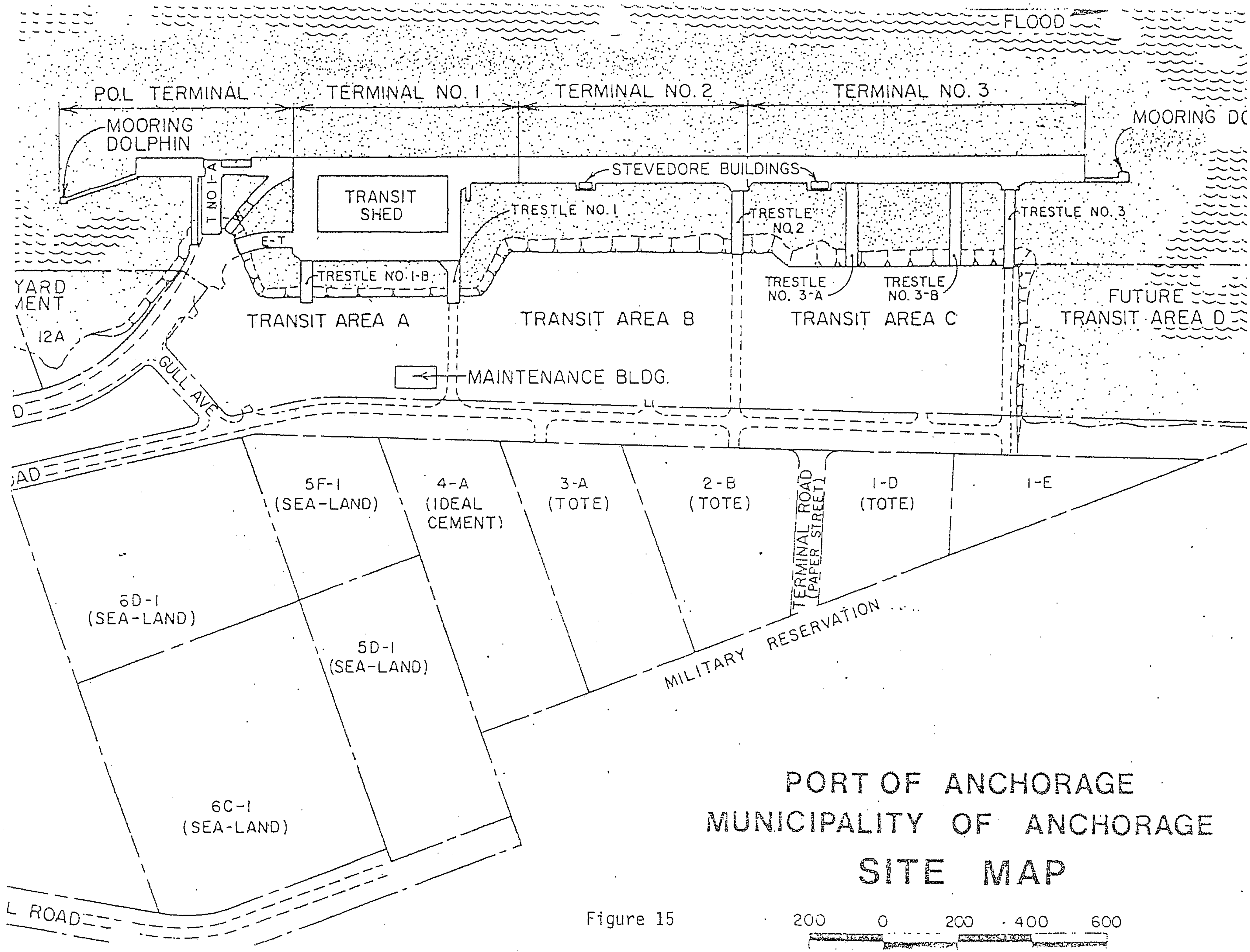
Analysis

If another earthquake were to strike Anchorage with proportions similar to the 1964 quake, somewhat less ground failure may be expected in the area. The port structure, itself, is not expected to be damaged severely enough to make it unusable. The Port authority would not require structural inspection of the dock prior to resumption of operations, unless the structure appeared to be dangerous (J. W. Brown, Operations and Maintenance Superintendent).

Shipping operations at the Port of Anchorage are not thought to be particularly vulnerable to earthquake. Since the cranes are well secured, the possibility of them jumping their tracks is not thought to be great. Usage of cranes is not dependent on the availability of electricity since the diesel/electric cranes can be rigged to off-load Sea-Land containers. The off- loading of Tote freight is not dependent on cranes at all.

In the unlikely event that the Port of Anchorage could not be used for a period of time following an earthquake, there are several alternatives. Two additional docks in the Ship Creek basin accept shallow draft barges (Kaiser Cement and Chugach Electric Association docks). Cargo could be transferred from deep draft freighters to barges and then off-loaded at one of these docks. Sky cranes could be used to transfer cargo between vessels. The Air National Guard has four sky cranes in Anchorage, which can carry 20,000 pounds each.

Another alternative is to bring the vessels in at the Port of Whittier, off-load them there and transport the freight to Anchorage via rail or highway. In the 1964 earthquake, the Port of Whittier was much more heavily damaged then the Port of Anchorage, due largely to the occurrence of tsunami and fire. The railroad and highway between Whittier and Anchorage were also heavily damaged and impassible for a period of time after the quake. However, the epicenter of another large earthquake could be located so as to damage Anchorage heavily, without severely damaging Whittier or the land transportation connections between them.



PORT OF ANCHORAGE
MUNICIPALITY OF ANCHORAGE
SITE MAP

Figure 15

RAILROADS

Alaska's single railroad, the Alaska Railroad, was extensively damaged during the 1964 earthquake. It "sustained damage of more than $35 million: 54 percent of the cost for port facilities; 25 percent, roadbed and track; 9 percent, buildings and utilities; 7 percent, bridges and culverts; and 5 percent, landslide removal" (McCulloch and Bonilla, 1970). The area of damage extended from Seward north to the bridge at Hurricane Gulch (mile 284.2) but was slight north of Matanuska (McCulloch and Bonilla, 1970). Most of the damage occurred from Anchorage to Seward. Major proportions of the damage occurred to the Railroad's port facilities at Seward (49 percent) and Whittier (5.5 percent), the rail line, including bridges and culverts, from Portage to Anchorage (24 percent), and from Seward to Portage (8 percent). Damage at the terminal in Anchorage contributed about 9 percent to the total damage (McCulloch and Bonilla, 1970).

While considerable damage to the Railroad's terminal and port facilities was due to vibrations and resultant ground failure, damage was greatly augmented in Seward and Whittier by seismic sea waves. Fuel tanks at these ports were ruptured by the waves and caught on fire (McCulloch and Bonilla, 1970).

Along the rail line itself, including bridges and culverts, a large part of the damage was due to "regional tectonic subsidence," which lowered 22 miles of railroad along the east end of Turnagin Arm as much as 5 1/2 feet (McCulloch and Bonilla, 1970). There was also damage from ground vibration, local differential subsidence, ground cracking and liquefaction of water saturated sediments which flowed toward depressions. "Landspreading" caused a great deal of lateral displacement of the railbed. Many bridges were damaged by compression and extension as the banks of streams and rivers moved toward the center of their channel (McCulloch and Bonilla, 1970).

McCulloch and Bonilla (1970) have identified six factors which influence the extent of ground mobilization. "Arranged in decreasing order of apparent importance these are:

1. The difference in foundation materials. - In areas of exposed till and bedrock, there was no damage, and in areas of young unconsolidated water-laid noncohesive sediments, all mobilization damage occurred.

2. The total thickness of the sediments. - Other things being equal, damage increased dramatically with sediment thickness. For example, damage to railroad bridges was slight on sediments less than 50 feet thick; moderate on sediments 50 to 100 feet thick; and severe where sediments were more than 100 feet thick.

3. <u>The depth of the ground-water table beneath the surface</u>. - In the most severely damaged areas the water table probably was about 10 feet or less beneath the surface.

4. <u>The distance to a topographically lower area</u>. - The amount of lateral spreading increased toward stream channels, gullies, borrow pits, or adjacent lower terraces.

5. <u>The slope of the ground surface</u>. - Steeper slopes, such as those on deltas and fans have a greater propensity for spreading.

6. <u>The proximity to the area of maximum strain release</u>. - The closer to the source of the seismic energy, the stronger was the ground motion."

Although the grain size of sediments is not specifically mentioned in this list, it was found that ground mobilization and resultant damage increased as the grains of sediment decreased in size. McCulloch and Bonilla found that this is a less important determinant of the "propensity for mobilization... than the severity and duration of ground motion which are related to the total sediment thickness" (McCulloch and Bonilla, 1970). That is, the deeper the sediments, the more they jiggled, and the longer they kept vibrating after seismic energy release ceased.

Kachadoorian (1968) stated that the Seward-Anchorage Highway generally suffered much greater damage from fracturing than adjacent sections of railroad track and bed. This occurred where the roadway was more often "constructed of well-graded (poorly sorted) compacted silt, sand and gravel..." and was paved. The railbed, on the other hand, consisted of coarse, loose sand and gravel (Kachadorrian, 1968).

In rebuilding the railroad, the first order of business was the repair of damage north of Anchorage to the Jonesville coal mines. This allowed coal shipments to resume to the power plants at Elmendorf AFB and Fort Richardson within ten days (Fugelstad, 1979). Next to be repaired was the line between Whittier and Anchorage. The first train rolled from Whittier to Anchorage 24 days after the earthquake (Fugelstad, 1979). Repairs of the line from Seward to Portage began in late June and were completed in a temporary fashion by September 13, 1964. Repair work on this section continued during the 1965 construction season and the new dock at Seward was completed in the summer of 1966 (Fugelstad, 1979).

Previous to the 1964 earthquake, most freight bound for Anchorage came via the ports of Seward and Whittier, thence by rail to Anchorage. In the interim in which the rail line and port facilities at Seward and Whittier were being repaired, the oil companies moved their operations to the Port of Anchorage and expanded their tank farms there. Negotiations had also been underway prior to the earthquake to begin weekly barge service direct to Anchorage. This service was begun sooner than planned because of the quake (Anderson, 1970). These changes began a trend and today Anchorage is the major port through which freight for southcentral Alaska and Fairbanks enters, consequently, the Alaska Railroad has lost much of its Seward to Anchorage freight business and a good share of its preearthquake revenues.

In estimating damage to the railroad that might result from a major earthquake today it must be considered that the rail line still follows essentially the same route that it did in 1964. Although much was learned about the earthquake vulnerability of various soil conditions and geologic formations, topographical constraints largely eliminated the possibility of rerouting the railroad (McCulloch and Bonilla, 1970). McCulloch and Bonilla (1970) suggest some ways damage might be reduced by changing engineering and construction practices. However, whether these suggestions are economical is not addressed. Safety connections have been installed between abutting spans on some of the Railroad's bridges to prevent the spans from falling from supporting piles during an earthquake (McCulloch and Bonilla, 1970).

Analysis

In the event of another earthquake of similar magnitude and duration as the one in 1964, the severity and distribution of damage to the railroad would depend on which fault ruptured, the location of the region of seismic energy release relative to the railroad and the duration of energy release. Some damage to bridges might be prevented due to the safety connections. The port facilities in Seward should survive better than in 1964 because they were relocated to a place less susceptible to subaqueous landslides and associated sea waves (Eckel, 1967). Although the rail lines going north and south from Anchorage are expected to be severed by damage, this would not disrupt supply shipments to Anchorage, as Anchorage now receives its goods at its own port. In addition the military bases at Anchorage are no longer dependent on coal for generating electricty and thus are no longer dependent on the railroad for their energy source. They have converted to natural gas. The gas pipeline from the Kenai production area to Anchorage survived the 1964 earthquake with only slight damage that did not interrupt gas service to the Anchorage (see the section of this report on natural gas).

Anchorage is less dependent on the Alaska Railroad as a supply route today than it was in 1964. Since the Port of Anchorage is less susceptible to earthquake damage than the railroad, southcentral Alaska should experience less economic disruption in the event of another major earthquake.

HIGHWAYS

Anchorage has only two highways by which it is linked to other communities and highways: the Glenn Highway to the north, and the Seward Highway to the south. These parallel the Alaska Railroad from Palmer to Portage and from Moose Pass to Seward, in some places running in close proximity to it.

In the aftermath of the 1964 earthquake the cost of repair or replacement of damaged portions of the Glenn Highway amounted to $724,769 with 94.2 percent for the roadway and 5.8 percent for bridges (Kachadoorian, 1968). Of the bridges along the Glenn Highway, only the Knik River Bridge was severely damaged (Kachadoorian, 1968). The most severe damage to the roadbed occurred in the area between the Eklutna and Knik rivers. There was also major damage from Moose River (mile 56) to mile 117, where the highway runs adjacent to the Matanuska River (Kachadoorian, 1968).

On the Seward Highway, damage required $14,871,167 for repair or replacement, 64.6 percent for the roadway, and 35.4 percent for bridges (Kachadoorian, 1968). Major destruction occurred to the roadway and bridges along Turnagain Arm from Indian Creek to Bird Point and from Girdwood to mile 75 where the highway turns away from Turnagain Arm to ascend through Turnagain Pass. Roadbed and bridges at Snow River Crossing (mile 175) and at the head of Resurrection Bay sustained severe damage or were destroyed (Kachadoorian, 1968).

The same geologic factors which influenced the extent of damage to the railroad, influenced damage to highways. In general, damage was most severe on "young unconsolidated wet water-laid noncohesive sediments" (McCulloch and Bonilla, 1970). Other soil conditions that contributed to the severity of damage were fine grain size of sediments, a shallow water table and thick sediments (over 100 feet thick) (McCulloch and Bonilla, 1970; Kachadoorian, 1968).

Partial liquefaction occurred in water-saturated sediments. It is thought that liquefaction was not complete because bridges remained flat or arched upward as stream banks moved inward. If liquefaction had been complete, the soil would have retained no strength and the bridges would be expected to sink (McCulloch and Bonilla, 1970).

Kachadoorian (1968) reports that at Snow River Crossing, piles for a bridge under construction did subside four feet. He reports that liquefaction was complete in most soils "at Snow River Crossing, Turnagain Arm, and on the Richardson Highway from mile 0.0 to 5.0."

Whether partial or complete, liquefaction added greatly to the amount of ground failure causing damage to the highway. Ground failure included lateral and vertical subsidence of foundations soils and fill, and fractures of the ground and highway. Portions of highway were laterally displaced as much as 13 1/2 feet at Snow River Crossing and 10 feet on the Turnagain Arm maximum subsidence by roadway, of 11 feet, occurred at Snow River Crossing (Kachadoorian, 1968).

Tectonic subsidence occurred at the head of Turnagain Arm which, in combination with local subsidence, lowered the roadway below spring high tide levels (Kachadoorian, 1968; McCulloch and Bonilla, 1970). This required the replacement of a few otherwise sound bridges between mile 75.1 and mile 105 on the Seward Highway (Kachadoorian, 1968).

Engineering characteristics found to influence the intensity of damage include the thickness of fill underlying the roadway. The thicker the fill the heavier the damage from local subsidence and fracturing (Kachadoorian, 1968). As noted in the section of this study on the railroad, the highway tended to be more heavily damaged than adjacent sections of railroad. This is due to differences in fill, the railroad fill being loose, coarse gravel, and the fact that the highway is paved (Kachadoorian, 1968).

Bridge damage was greater if the ties between substructure and superstructure of the bridge were broken. This allowed the deck and supporting piles to vibrate independently and bang against each other. In some cases the piles rammed through the deck (Kachadoorian, 1968). Hence, weak connections between substructure and superstructure or a top-heavy weight ratio between them contributed to damage to bridges.

In addition to damage caused by ground failure, avalanches and landslides covered parts of the Seward and Glenn Highways and required removal (Kachadooian, 1968). There was no damage to either highway from seismic sea waves.

Analysis

The distribution of earthquake vulnerable soils is the same today as it was in 1964. The Seward Highway follows the same route as it did in 1964, but the Glenn Highway has been relocated in the Knik River area. The new highway crosses very wet soils, and is most likely just as susceptible to seismically induced ground failure as the old highway, if not more so. If a major earthquake occurred in the near future, the extent and distribution of damage would depend on the location of the epicenter, the magnitude and duration of the quake. For instance, if a rupture occurred on the Castle Mountain fault of magnitude 8.0 (believed to be maximum possible magnitude for this fault) the proportion of damage to the Glenn Highway, as compared to the Seward Highway, would be greater than witnessed during the 1964 quake. For earthquake planning purposes, one should assume that both highways leading out of the Municipality would sustain major damage. To the north, the major road damage would likely start near Eklutna, and to the south, near Indian.

Summary and Conclusion

The extent of damage to various tranportation facilities that might occur during another major earthquake cannot be predicted, but the experience of the 1964 Good Friday earthquake gives some indication of the vulnerability of each facility.

The air transportation facilities were shown to be the least vulnerable to earthquake damage. If another major quake occurred, it would be assumed that small planes and helicopters would be immediately available for search and rescue missions, and reconnaissance of damage. Damage to runways, navigation aids and communications necessary to serve large planes is not expected to be severe enough to preclude runway use for more than a few hours. In addition, some alternatives to the three main airports in Anchorage exist.

The Port of Anchorage is likewise a relatively earthquake safe facility. Although it is located in soils moderately susceptible to ground failure, the docks are not on or immediately adjacent to a bluff. Hence ground failure would not be of the type which proved most damaging to Anchorage in 1964, i.e. landsliding. In 1964, tsunami was the seismic effect most damaging to dock facilities in southcentral Alaska. The Port of Anchorage was spared this effect and the chances of it occurring in the future are considered remote.

The sea-land freight routes from Seward and Whittier to Anchorage were extremely vulnerable to earthquake damage in 1964. Dock facilities at Seward and Whittier were severely damaged or destroyed, largely because of the occurrence of tsunamis. The Alaska Railroad was heavily damaged where railway and bridges crossed thick water-saturated sediments. The Seward Highway could not be used as an alternate route since the highway tended to be even more severely damaged than adjacent sections of railway. Today Anchorage is less susceptible to interruptions of supply lines due to earthquake damage, since it depends more heavily on its own port than the more earthquake vulnerable sea-land routes from Seward and Whittier. However, other railbelt communities are still dependent on goods brought in at Anchorage and shipped via rail. Since Anchorage contains close to half of Alaska's population (Muller, 1978), the increased self-sufficiency of Anchorage would greatly decrease the proportions of an airlift of goods should it be necessitated by earthquake damage to overland shipping routes. In addition, Anchorage airports have more air traffic capacity than other Alaskan airports and it therefore would be the most efficient distribution point for airlifted goods.

The distribution of earthquake vulnerable geologic features which serve as foundations for overland transportation routes remains essentially the same today as in 1964. Within this geologic framework the severity and distribution of damage caused by another earthquake would depend largely on the location of the region of seismic energy release, and the magnitude and duration of strong ground motion.

TSUNAMI

Large sea waves generated by earthquakes and other undersea occurrences are often correctly referred to as "tsunami," a Japanese word. Often times the word "tidal wave" is used but this is not an accurate designation of a seismically induced sea wave. Wind driven sea storm waves, seiches, and astronomic tidal waves are also sometime mistakenly referred to as tsunami. However, the precise usage of terms to describe the sea waves are of less importance to the emergency responder than knowing the response time one has and proper action to take.

Background

"Tsumanis may be generated by submarine volcanic explosions, by submarine landslides or subaerial landslides plunging into the water, or most commonly, by tectonic displacements of the ocean floor associated with earthquakes." (Ayre, 1975) Alaska, with its tremendously long coastlines and diversified geological setting, has the potential for tsunami, from all of the events mentioned above. The notable past seismic sea waves generated in Alaskan waters are list below:

Date	Origin	Damage
1901, December 30	Cook Inlet	Local
1925, February 23	Port of Valdez	Local
1936, October 27	Lituya Bay	Local
1946, April 1	Unimak Island	Local and Distant
1957, March 9	Andreanof Island	Local and Distant
1958, July 9	Lituya Bay	Local
1964, March 27	Prince William Sound	Local and Distant

The Great Alaskan Earthquake of 1964 caused a tsunami that brought nearly total destruction to one coastal village, and was by far the greatest cause for loss of human life. Of the 115 deaths attributed to the 1964 earthquake, 96 of these were due to drowning. (Committee, Lantis, 1970) Also, the economic impact to coastal communities in loss of fishing vessels, docks, canneries, and oil storage facilities is staggering. The number of U.S. population potentially endangered by a Pacific tsunami is listed below in Table 10.

TABLE 10

U.S. POPULATION POTENTIALLY ENDANGERED BY PACIFIC TSUNAMIS

Name of State	Total State Population/a	Towns/Cities Susceptible to Tsunamis/b	Total Population of Susceptible Cities/c	Population Endangered by/d	
				50' Tsunami	100' Tsunami
Washington	3,352,892	102	1,040,000	66,200	139,000
Oregon	2,056,171	60	67,900	22,500	39,400
California	19,715,490	152/e	5,748,800	389,500	713,000
Hawaii	768,561	123	511,500	89,400	214,500
Alaska	294,607	52	82,400	22,700	35,200
TOTALS	26,187,721	489	8,050,600	590,300	1,141,700

a - 1970 Census.
b - All or part of the city or town is within 100 feet above sea level and close to the shoreline.
c - From estimates of the 1970 population.
d - Population factored per study of topographic maps.
e - Not including urban area on San Francisco Bay, because they are not considered vulnerable.

(Office of Emergency Preparedness, 1972, Volume 3)

Generally speaking there is no absolute method to determine if an earthquake with its epicenter on the ocean floor has generated a tsunami. "It is commonly accepted that the earthquake must have a magnitude of 7 Richter or greater to be accompanied by a tsunami of significant magnitude. This does not mean; however, that earthquakes of lesser magnitude cannot generate local tsunamis which might be damaging in confined areas near the epicenter." (Ayre, 1975). In Alaska, a tsunami warning will be issued by the Alaska Tsunami Warning Center for coastal events 6.75 magnitude or above for a limited area depending on the actual magnitude and its location. A tsunami watch will be given for areas outside of the specified area. If it is found that a significant tsunami is generated, the warning could be extended to include the entire coastline. The Alaska Tsunami Warning Center would issue an immediate watch to the Western Aleutians for an event of 7.4 or greater in the Northern Kurile Island and Kamchatka Peninsula regions.

Warnings are originated by the Alaska Tsunami Warning Center, usually within 15 minutes of the occurrence, and is disseminated to civilian and military warning agencies and officials. Federal and State agencies immediately fan out the information to the threatened communities, who, in turn, sometimes warn adjacent communities. Locally, sirens, horns, loud speakers, and radio/TV (when available) warn the citizenry of the coming event. The Tsunami warning system is quite well conceived and effective for the the most part in the majority of even the smaller coastal communities. There are some gaps in the system for tiny communities or individual outlying coastal homes, especially along the Alaskan Peninsula and Aleutians. The great distances or isolation of these homes makes communications often nearly impossible.

There are also other times that warning may not be possible due to the event being very close to the community and the waves could strike within minutes after the earthquake. The only hope for the citizens in that situation is to pre-educate them through a public awareness program. Alaskans in coastal communities are told to evacuate to pre-designated high ground safety areas if a strong earthquake is felt with shaking lasting 30 seconds or more. Some communities have made instructional "tsunami" stickers available to their citizens which can be affixed to the telephone as a remainder. All coastal communities, especially those devastated in 1964, maintain an awareness of tsunami for exceeding that generally thought to be in the minds of people prior to 1964. The 1964 "proof" is of course foremost in this awareness but Federal, State, and local government public awareness efforts are certainly effective remainders.

Analysis

It is much more difficult to calculate probable deaths and injuries from tsunami than from earthquake for a variety of reasons. For one thing tsunami is a relatively rare occurrence in history (see Table 11), thereby, giving fewer examples to formulate mathematical models. Also, tsunamis are directional in nature, can be near or far, and can happen at high or low tide all of which effects the damage and casualties. Adding to this are factors such as the time of day; time of year; fishing fleet in or out of the harbor; large ships in or out of the harbor; fires; oil storage tank collapse, and many other variables.

TABLE 11

CASUALTIES AND DAMAGE IN THE U.S. FROM TSUNAMIS, 1900-1971

YEAR	DEAD	INJURED	ESTIMATED DAMAGE ($000)	CONSTANT $ 1957-1959=100 ($000)	AREA
1906	--	--	5	15	Hawaii
1917	--	--			American Samoa
1918	--	--	100	140	Hawaii
1918	40	--	250	350	Puerto Rico
1922	--	--	50	95	Hawaii California American Samoa
1923	1	--	4,000	72,860	Hawaii
1933	--	--	200	560	Hawaii
1946	173	163	25,000	38,000	Hawaii Alaska West Coast
1952	--	--	1,200	1,200	Midway Island, Hawaii
1957	--	--	4,000	4,000	Hawaii, West Coast
1960	61	282	25,500	25,000	Hawaii, West Coast, America Samoa
1964	122	200	104,000	103,000	Alaska, West Coast, Hawaii
1965	--	--	10	10	Alaska

1/Another sources shows 116 dead and $400,000,000 damage, but these larger figures may include deaths and damage directly attributable to the nearby acompanying earthquake.

2/Later estimated to be 119.

3/Damage reported, but no estimates available

(Ayre, 1975)

With a repeat of the 1964 Earthquake, it would be miraculous if the resulting tsunami did not cause deaths and injuries. For response planning purposes we are estimating less deaths and injuries than occurred in 1964 in spite of the fact that population has grown, thereby, exposing a greater number of people to the danger. Offsetting the population growth are the things which have been done to mitigate the effects of tsunamis. For example, the whole town of valdez has been relocated to a safe area, the tsunami warning network has been implemented and the local populations are reminded of tsunamis through public awareness. All of these mitigation efforts should decrease the deaths and injuries by at least 50 percent over the 1964 figures, resulting in a planning figure of approximately 50 people killed and 100 injured for a repeat of the 1964 event. However, the responder should be prepared to accept a doubling or tripling of those figures in case of a catastrophic happening, such as a tourist ship or loaded ferry boat sinking while in harbor.

In summary, tsunami can cause, as in 1964, a greater loss of life than the shaking/slide aspects of earthquakes. Much can and already has been done to mitigate against the tsunami effects for Alaskan coastal communities. Considering that the 1964 event is still fresh in the minds of coastal residents and coupling this with the efforts of the Federal, State, and local governments to reduce the effects of tsunami through warning and community action programs, it is felt that any future tsunami would be much less devastating in life loss than the 1964 event.

HOMELESS

The number of families made homeless due to a major earthquake in the Anchorage Municipality will be based primarily upon two factors, shaking/landslide damage and failure of natural gas and electric utilities. The number of people made homeless because of shaking/landslide will be considered constant for study purposes regardless of time of day or time of year. On the other hand, the number of homeless families due to loss of utilities will vary somewhat from winter to summer and this factor has been taken into consideration.

Data Collection

Statistical post disaster information from "The Great Alaska Earthquake of 1964, Human Ecology, 1970" was used extensively in this section. Other earthquake studies for Puget Sound, San Francisco, and Los Angeles, California were also used to form the estimated homeless figures.

Data on post shaking/landslide damage to family wood-frame dwellings is readily available on many major earthquakes; however, most studies identify the dollar loss and do not state the damage in terms of habitability of the structures. For the purposes of this study a 60 percent or greater loss is considered to be uninhabitable although one may well be able to occupy the structure for a short period of time. In other words, some homes experiencing 60 percent or more damage could still be safe and intact enough to shelter a family for several days; however, it is likely that some windows would be broken, doors may not open and shut properly, and some of the utilities would not be functioning. However, families living in houses damaged 60 percent or more would need temporary housing in a shorter period of time after a mid-winter earthquake. In the summer, more reaction time would be available to move families to temporary shelter.

A telephone survey of Anchorage was performed to determine how well the general population is prepared to cope with disasters. The results of this survey has been considered in our homeless estimates and is enclosed as Appendix 1.

Analysis

The 1964 Good Friday Earthquake resulted in much property damage to private residences and the first step in our analysis will be to review this event. TABLE 12 has been created from statistical information available after the 1964 earthquake (Committee on the Alaska Earthquake, Human Ecology, 1970).

TABLE 12

1964 EARTHQUAKE
ANCHORAGE RESIDENTIAL HOUSING DAMAGE

UNITS	PERCENT OF TOTAL	PERCENT OF DAMAGE	REMARKS
921	7.22	80-100	219 private homes 5 trailers 747 apartments
50	.40	60-80	
26	.20	40-60	
35	.28	20-40	
11,715	91.9	0-20	
12,747	100 percent		

It is interesting to note that the 1964 earthquake left 7.62 percent of the Anchorage residential housing uninhabitable (60 percent or more damaged). This is a high percentage as compared to other earthquakes but percentages are sometimes deceiving and require further analysis. Of the 971 units considered destroyed, only 219 were single family homes and most of these were located in the Turnagain slide area. Five mobile homes out of a city-wide total of 518 were destroyed. All of the remaining destroyed units were apartments of which 480 units were in big apartment houses containing 40 units or more. The overall distribution of the 971 units destroyed is private homes, 23 percent; mobile homes, .5 percent; and apartments 76.5 percent.

Based upon the "Anchorage 1979 Housing Stock" prepared by the Municipality of Anchorage Planning Department, there are 26,300 single family houses, 4,868 duplex units, 19,335 multi-family units, and 6,960 mobile homes. Thus, using this base figure of 57,463 units times the 7.62 percent damage figure of 1964, one could expect 4,380 units, that will be 60 percent or more damaged. This would further break down to 1,007 single family and duplex units combined, 3,351 apartments, and 22 mobile homes. However, these estimates can be modified downward considerably when considering the post 1964 Anchorage growth pattern. In the 1964 earthquake, most of the destroyed units were in the poor soils areas which represented a much larger portion of the city than today. As a matter of fact, a survey of the Anchorage slide areas shows a total of 677 housing units, 228 single family, 22 duplex units, and 427 apartments. These 677 housing units represent only 1.2 percent of the overall Anchorage housing stock. Considering that destruction in these poor soils areas will not be 100 percent, while on the other hand some units outside poor soils areas could be randomly destroyed perhaps by fire, it is not unreasonable to assume a 1.2 percent destruction factor (we will use 690 units) for all of Anchorage for response planning purposes.

Immediately following the disaster about 10 percent of the displaced families from shaking/slide damage will need shelter. This figure represents 69 families or about 220 people when using a 3.2 person average for a family.

Chart 1 depicts the three critical elements needed to form the basis of a homeless estimate, shaking/slide damage, electrical power losses, and natural gas losses. Chart 2 shows a day-by-day estimate of the estimated homeless when considering past earthquake histories coupled with Anchorage general population disaster preparedness and the time of year. Winter is considered as mid-January and summer as mid-July so as to depict the worst case to the best insofar as a loss of utilities is concerned. The loss of water and sewer were not considered in the homeless calculations although the loss of these important utilities could result in additional homeless after a period of time. Since we are dealing with rough estimates, it was felt that the overall numbers would not change significantly from sewer and water losses.

Immediately following an event similar to the 1964 earthquake, it is estimated that 690 housing units would be 60-100 percent damaged from shaking and landslides. Approximately 10 percent or 69 families will need emergency housing within hours following the earthquake. The other 90 percent will either stay with their homes, move in with friends or relatives, or live in recreational vehicles.

Initially, a city-wide blackout can be expected and many homes will temporarily lose natural gas service. By the end of 24-hours, approximately 14,500 electrical customers and 281 gas customers could still be without service. About one percent, or 173 families will seek public shelter due to loss of utilities in an otherwise intact dwelling in the first 24-hours after the event. This will be families with sick members, elderly or for any reason cannot be without total utilities. Also included in this one percent, are those families that do not have friends, relatives, or recreation vehicles to use for temporary shelter. The season will not have a great effect on the homeless numbers for the first 24-hours.

By the end of the second day, utilities restoral will allow many families to move back to their homes, whereas others tiring of "roughing it" without utilities will seek public shelter. Families will leave quicker in the winter because of being unable to keep their homes warm after 24-hours. Even with an offset from utility restoral, the second day will be the peak time of homeless; 360 families in the summer, and 866 in the winter.

The third, fourth and fifth days will show a rapid decrease in the number of families needing housing assistance due to the rapid utilities restoral allowing people to move back into their homes. Shaking and landslide homeless should remain about the same through this period. After four days, no more families will seek public housing due to utility outages since virtually all systems will have been restored.

Approximately on the eighth day the Disaster Assistance Center should open, and those families living in emergency housing and with friends will start to apply for temporary housing. The first week should be the heaviest workload with a subsequent leveling off over the next two weeks. Approximately 690 families should apply for temporary housing due to the earthquake by the end of 60 days Disaster Assistance Center operation.

CHART 1

ESTIMATED HOUSING UNIT DAMAGE AND LOSS OF UTILITIES

SHAKING/SLIDE

UNITS	PERCENT DAMAGED
690	60-100 (considered destroyed)
114	40-60
172	20-40
56,487	0-20

ELECTRIC POWER LOSSES

UNITS	TIME
14,500	24 hours after event
7,250	48 hours
1,813	72 hours
700	96 hours
virtually all restored	120 hours

NATURAL GAS LOSSES

UNITS	TIME
281	24 hours after event
187	48 hours
93	72 hours
15	96 hours
virtually all restored	120 hours

CHART 2

ESTIMATED FAMILIES/PERSONS NEEDING PUBLIC SHELTER OR HOUSING ASSISTANCE

DAYS AFTER EVENT	SHAKING/SLIDE S	SHAKING/SLIDE W	UTILITIES S	UTILITIES W	UNIT TOTAL S	UNIT TOTAL W	PERSONS S	PERSONS W
1st 24-hours	69	69	173	173	242	242	774	774
2	100	122	260	744	360	866	1152	2771
3	100	122	130	190	230	290	736	928
4	100	122	65	72	165	194	528	621
5	100	122	-0-	-0-	100	122	320	390
6	100	122	-0-	-0-	100	122	320	390
7	100	122	-0-	-0-	100	122	320	390
8*	200	225	-0-	-0-	200	225	640	720
9	300	325	-0-	-0-	300	325	960	1040
10	350	375	-0-	-0-	350	375	1120	1200
11	400	425	-0-	-0-	400	425	1280	1360
12	450	460	-0-	-0-	450	460	1440	1472
13	475	490	-0-	-0-	475	490	1520	1568
14	500	500	-0-	-0-	500	500	1600	1600
15	525	525	-0-	-0-	525	525	1680	1680
16	550	550	-0-	-0-	550	550	1760	1760
17	575	575	-0-	-0-	575	575	1840	1840
18	600	600	-0-	-0-	600	600	1920	1920
19	620	620	-0-	-0-	620	620	1984	1984
20	630	630	-0-	-0-	630	630	2016	2016
21	640	640	-0-	-0-	640	640	2048	2048
22	650	650	-0-	-0-	650	650	2080	2080
23	660	660	-0-	-0-	660	660	2112	2112
24	677	677	-0-	-0-	677	677	2166	2166
25	677	677	-0-	-0-	677	677	2166	2166
26	677	677	-0-	-0-	677	677	2166	2166

*Disaster Assistance Center Opens

S - Summer

W - Winter

COMMUNICATIONS

Insofar as this study is concerned, communications includes local and long distance telephone, commercial broadcast stations, dedicated radio networks (public and private) and amateur radio. A historical analysis of the 1964 "Good Friday" earthquake is included; however, the worthiness for extrapolation to the present, as far as damages are concerned, is very limited due to the vast changes in most communications technology since 1964. On the other hand, some aspects of communications have not changed that drastically and some helpful parallels may be drawn.

Data Collection

Historical information concerning the effects of the "Good Friday" earthquake on communications was obtained in part from documented sources and in part from interviews with individuals experiencing the event. Field inspection of telephone facilities were made of both the Alascom (long line carrier) and the Municipal Telephone Utility. A sampling of commercial broadcast stations were also visited.

Background

Radio communications is highly developed in Alaska because the great distances between communities and water expanses makes land line construction impractical. Furthermore, satellite telephone communications is used more so in Alaska than anywhere else in the Nation for the same reason. Other networks utilizing HF, VHF, and microwave transmissions criss-cross the State giving a myrid of communications capabilities. Unfortunately, most of these systems are independent of each other and systematic or preplanned interconnects are not available. However, before looking at the present systems for the Anchorage area it would be helpful to first see how Anchorage's communications survived the 1964 earthquake.

"Nearly all telephone communications were disrupted by loss of power soon after the onset of the earthquake" (Eckel, 1967). Most telephone systems are battery operated, thus some service was restored almost immediately to some portions of Anchorage. Damaged central office equipment, battery racks, and the distribution system caused temporary outages to the city telephone system. "By 6:05 p.m., limited service was restored within all four exchanges but not between exchanges. By 2:00 a.m., Saturday, installation of trunk lines had made some calls possible between exchanges" (Norton and Haas, 1970). Long distance service was lost immediately after the earthquake occurred. "The earthquake caused collapse of battery racks in the Anchorage ACS Toll building near Elmendorf AFB. The resulting shorting, small fires, and other damage, as well as the snapping of landline wires and the damage to cables, knocked out all civilian long distance service" (Norton and Haas, 1970). Anchorage was without civilian long distance telephone service until Saturday, and the void was partially filled by the RACES organization and other amateur radio operators. The long distance service restored on Saturday was for emergency use only and it was a week before service throughout Anchorage returned to 90 percent of normal (Norton and Hass, 1970).

Commercial radio and television broadcast stations were all knocked off-the-air due to the loss of commercial power and shake damage. "Radio Stations KFQD, KENI and KBYR, which were equipped with standby auxiliary generators, were back on the air within two hours. In fact, little more than 20 minutes after the major tremor had stopped, Chief Engineer Dennis O'Day of KFQD was broadcasting" (Norton and Haas, 1970). Public service announcements were made by all the stations utilizing hastily organized but ingenious methods of obtaining the input information from civil defense. From accounts afterward, it was discovered that these radio transmissions were very helpful in calming the general public. As well, there may have been a saving of lives and prevention of injuries by radio announcements warning of aftershocks and what to do to prepare for them.

Analysis

The long distance scenario has completely changed since 1964. The only common factors from 1964 to 1980 are parts of the old ACS building on Government Hill still being used today and parts of the terrestrial route paralleling the Alaska highway are still in service. Otherwise, the level of service has mushroomed upward and the equipment has made several quantum leaps forward in technology.

The toll center (now owned and operated by a civilian concern, Alascom) is located in the Government Hill section of Anchorage in a much expanded facility from what existed there in 1964. The building additions were constructed with earthquakes in mind. The toll center equipment has elaborate earthquake bracing to prevent toppling of equipment racks and the electronics is mainly of solid state design packaged to be much more rugged than the older mechanical switches. This combination, along with the care taken to brace their battery supplies, offer a much higher survival quotient than the 1964 plant.

It should be noted that this Government Hill facility is the critical link in the long distance chain as far as Anchorage is concerned. All city cable trunks, video cable, and microwave emissions flow in and out of this building. As well, all the switching equipment is located in this building. Unfortunately, there is no complete redundancy for this facility; therefore, if massive earthquake building destruction were experienced, Anchorage would be without high level long distance service for a long period of time. However, this complete destruction would be very unlikely, unless in the case of uncontrolled fire. Very limited long distance service could always be temporarily "hay wired" so that complete long distance isolation would not be experienced.

Emanating from the toll center are several alternative (microwave and video cable) to access the satellite earth stations, one in Eagle River, Alaska; and another near Talkeetna, Alaska. Microwave facilities are inherently earthquake resistive and/or easily restored to service. Restoral times are more dependent upon the distance for maintenance persons to travel than on the fix actions upon arrival. Satellite earth stations can also be easily and quickly restored if shaken out of alignment. There are several routes accessing the earth stations, thereby, affording alternate routing. For example, Bartlett Earth Station is fed via microwave from both Anchorage to the south, and Fairbanks to the north. If the southern route is disrupted, traffic can be routed from Anchorage to Fairbanks via another route which parallels the Glenn Highway and hence to the earth station from the north.

Traffic overload for both incoming and outgoing long distance trunks during an emergency (such as an earthquake) always presents a problem even if all equipment survives. In order to prevent this from happening, the Direct Distance Dial Telephone Companies of North America (includes Canadian and Mexican companies) have organized into an information system which advises members whenever an emergency condition exists in a certain city or area. All incoming calls to that city or area can then be restricted or blocked completely by the centers near where the calls originate. The system is so well developed that the restriction can be applied down to six digits. In other words, calls can be blocked to (907) plus the local exchange, such as 333, 349 or 272. Thus, if problems existed in one (907) central office but the others were operable, some incoming calls could be accepted for Anchorage exchanges. As well, other cities in the Alaska (907) could still receive normal long distance traffic.

The long distance system of 1980 is much more survivable than the 1964 system. The switching equipment components of today are packaged to withstand more vibrations than older equipments and the new additions to the toll center are built and braced with earthquakes in mind. Additionally, the satellite systems of today offer redundancy and ease of restoral far surpassing the 1964 long distance system. Looking at the overall, it is apparent that long distance communications would fare much better today than it did in 1964 with only short outages expected due to equipment failures. Traffic overloads from long distance calls are not expected to be a problem due to the administrative/procedural controls that would be activated automatically or upon request through the North American Direct Distance Dial Network.

The local telephone system has also greatly improved over the years. The largest improvement for survivability is in the inside plant area. Again, new technology, solid state packaging, and equipment rack bracing on inside plant expansions increase the survival potential to shaking. On the other hand, the outside plant or distribution system is still subject to damage on a nearly equal par to 1964. Above ground cables are susceptible to breakage due to poles swaying and trees falling over the cables. Service cable drops from poles to houses are also prone to this type damage. Underground cables usually fare nicely except in poor soils or slide areas.

Physically, it is expected that the intercity telephone system will do quite well. There will be some central office problems that should be quickly remedied but most central offices should operate almost uninterrupted. Traffic overload is expected to be the biggest problem to the local system even with pleas by public officials to restrict telephone use. With this in mind, one should plan that the local telephone system will not be useful for emergency response coordination for several days after the event.

Commercial radio and television broadcast capabilities will again be at the mercy of commercial power (See Power Section). There are four radio stations that have a backup emergency power source, KFQD, KENI, KBYR, and KHAR. Emergency messages will be passed to KFQD via the Emergency Broadcast System (EBS) equipment in the Anchorage EOC. It is in turn, broadcast to all other EBS stations capable of receiving. The other stations can either patch the message on-the-air or tape, edit, and rebroadcast it at a later time. It is assummed that all stations will go off-the-air immediately following the event due to loss of power. KFQD, the lead EBS station, will probably come back on the air much faster than the EOC will be able to mobilize and start passing public emergency messages to the station. Until such time as communications is established to the EOC, KFQD should broadcast general information (hopefully from prescripted sources), as how the general public should react. Status and damage reports can be aired as information lines are established being careful to insure the reports are from official sources so as not to exaggerate the situation with false rumors. The Anchorage EBS system is well conceived and developed and should perform well in an earthquake situation.

With the assumption that telephone communications would not be usable for the emergency responder for the first few days after the event, response agencies must rely upon radio communications. Furthermore, citizen band radio also cannot be relied upon because the many undisciplined operators utilizing this mode of communication will saturate all channels including the predesignated emergency frequency.

Anchorage is fortunate to have well developed radio systems in both the public and private sector. All of Anchorage's response agencies including police, fire, ambulance services, and public/private utilities have mobile radio capabilities which are accessible through the Anchorage EOC. Backup power generation or battery supplies are present in the base stations and there is redundancy in audio input lines. The Anchorage EOC has base station radios physically installed in the building in event of primary base station or repeater failure. Private utility companies, such as the Alaska Gas Company and the taxi companies, have many radio-equipped vehicles which can be made available for emergency use. Once the Anchorage EOC is activated and manned, communications between all local response agencies is possible and should be accomplished with little difficulty. A radio communication link from the Anchorage EOC to the State EOC also exists. A telephone hotline from the Anchorage EOC to the military at Elmendorf AFB is in existance and indirect radio communications is possible. In addition to RACES, the State has an HF radio link to the Federal government (CDNARS) which is specifically designed for emergency use. The Anchorage EOC has a complete RACES station with a large continent of local operators. There is also a very large 2 meter net with three local Anchorage repeaters plus a fourth repeater link to Fairbanks.

Overall, Anchorage has an excellent mobile radio capability which has been developed to a fairly high potential. Seismic events have been considered in the installations as indicated by the redundancy aspects of the systems. Emergency response planners can feel confident that emergency communications will be available for use after the earthquake event.

In summarizing the overall Anchorage communications picture, one can feel fairly certain that a good capability to communicate will exist shortly after the initial blackout. Commercial broadcast stations with backup power will come up first to transmit emergency instructions to the population. This will be followed quickly by mobile radio networks in the city, state, and military EOCs to handle the emergency response calls for assistance and to start utilities restoral. Communications to the outside will be handled by RACES, MARS, CDNARS, and the rapidly recovering commercial long distance telephone system. Intercity telephone may be possible almost uninterrupted in some exchanges although traffic overload may be a problem. Recovery for the entire local telephone system should be very rapid for most parts of the city. Barring any complete building collapses, communications should be almost back to normal within a week after the event.

APPENDIX 1

PREPAREDNESS INVENTORY

TELEPHONE SURVEY

ANCHORAGE, ALASKA 1980

Prepared for

ALASKA DIVISION OF EMERGENCY SERVICES

Prepared by

DOWL ENGINEERS

June 1980
W.O. #D12393

TABLE OF CONTENTS

PREPAREDNESS INVENTORY
TELEPHONE SURVEY
ANCHORAGE, ALASKA 1980

Three hundred thirteen Anchorage residents were contacted by telephone during a survey conducted by DOWL Engineers under contract with the Alaska Division of Emergency Services (ADES). The purpose of this survey was to collect data regarding the number of families within the Municipality that would be self sufficient (shelter, food, energy, etc.) for a limited time after an area-wide natural disaster. This information will be used by ADES to improve the State's emergency plans and services following events such as earthquakes, floods, high winds, etc. The questions asked during this survey were formulated by ADES with some input suggested by DOWL.

SAMPLING ASSUMPTIONS

The initial estimate of sampling requirements was agreed upon by DOWL and ADES based on the assumptions that 60,000 families resided in the Municipality, and that a standard error in the sample results of approximately five to six percent was sufficiently accurate for the purposes of ADES. These criteria dictated a random sample size of 300 families.

The assistance of the Anchorage Telephone Utility was engaged to ascertain the number and distribution of residences in the Anchorage area. Residence telephones are divided into four groups or wire centers -- North, South, East, and West (Figure 1). Table A shows the percentage of total Anchorage residence telephones in each wire center, and the corresponding number of residences contacted based on the required 300 completed questionnaires. In order to control the representativeness of the sample, a stratified random sampling technique was employed. This method of sampling entailed calculating the percent of total desired contacts necessary from each wire center to ensure a proportionate distribution of contacted residences throughout the city.

SAMPLING METHOD AND PROCEDURE

Two interviewers performed the survey. The survey period was from May 13, 1980 to May 20, 1980. Telephone calls were made from the hours of 1:00 p.m. to 3:00 p.m. and 5:00 p.m. to 9:00 p.m. weekdays, and from 1:00 p.m. to 3:00 p.m. on the weekend. The original plan was to call between the hours of 11:00 a.m. and 7:00 p.m.; however, the late morning and afternoon hours proved to be inefficient times to reach adult residents. Few residents were at home during these hours, and children generally answered the telephone in the late afternoon. Consequently, the bulk of the calls were made after 5:00 p.m.

Residences were selected randomly from the Anchorage Phone Directory by arbitrarily selecting phone numbers with the particular prefixes reserved for residences within the four wire centers, until the requisite number of contacts within each wire center had been made. Care was taken to avoid contacting people with the same last name to avoid biasing the survey, and to further assure the legitimacy of the sample. It was, however, impossible to reach the subpopulation of the city that maintains unlisted telephone numbers with this method.

The interviewing procedure was to record the name, address and telephone number of each contact, and to begin our interview with a three sentence script, as follows:

> "Hello, I'm with the state's Division of Emergency Services. We'd like to collect some information from Anchorage residents in order to improve the state's emergency services following area-wide natural disasters such as bad winds, earthquakes and floods. Would you mind answering a few short questions?"

If the person agreed to answer the questionnaire, the interviewer proceeded to ask each of the nine questions by stating the question and offering the various choices of required responses. A sample of the survey questionnaire is shown in Figure 2. The responses to the questionnaire were compiled at the end of the survey, and the results appear in the appendix.

SAMPLING STATISTICS

The current estimate of the number of families residing in the Anchorage Bowl based on figures supplied by the Anchorage Telephone Utility is 57,463. This number was assumed to be the size of the "total population" (N). Upon completion of our survey it was discovered that 313 families had been contacted rather than the original estimate of 300. This number is the "sample size" (n). An estimate of the "standard error" ($\underline{s}$), or the estimate of how nearly the results derived from the sample fits the true value within the total population was made using the following expression:

$$\underline{s} = \sqrt{\frac{N - n}{N}} \cdot \sqrt{\frac{1}{n}} \cdot s$$

Or

$$\underline{s} = \sqrt{\frac{57,463 - 313}{57,463}} \cdot \sqrt{\frac{1}{313}} \cdot s$$

$$= 0.056 \cdot s$$

$$= 5.6\% \cdot s$$

Where s is the estimate of the <u>population</u> standard deviation, not the <u>sample</u> standard deviation.

Basically, this expression estimates how closely the single sample of 313 contacts represents the total population. For example, there is a real or true number of families living in single family dwellings (S.F.D.) in the Anchorage Bowl. We have randomly sampled 313 families out of 57,463. We could have sampled many other combinations of families totaling 313, and obtained different percentages of the number of families living in single family dwellings for each random sample of 313 families. The estimate of standard error estimates how close <u>one</u> random sample represents the true population. That is, theoretically all the estimates of the number of families living in S.F.D. that could result from all possible combinations of random sampling of 313 families would produce a normal distribution ("bell shaped") curve with a mean value located near the true number of families living in S.F.D. within the total population. The variance and standard deviation of this normal distribution curve about its mean or "true" value estimates how much variation can be expected within the total number of random samples of 313 families. Therefore, the standard error can be used to estimate how much variation in the results of this survey can be expected around the true values of the total population.

The estimate of the percentage of families living in S.F.D. will be used to illustrate this procedure.

$N = 57,463$	Population Size
$n = 313$	Sample Size
$x = 180$	Number of Families in S.F.D.

$$\bar{x} = \frac{180}{313} = 0.575$$

Sample Mean (in this case percent of families in S.F.D.)

$$var_x = \frac{\Sigma x^2}{n} - (\bar{x})^2 \qquad \text{Sample Variance}$$

$$= \frac{180}{313} - \left(\frac{180}{313}\right)^2$$

$$= 0.24$$

$$VAR_x = \frac{n}{n-1} \cdot var_x \qquad \text{Population Variance}$$

$$s^2 = \frac{313}{312} \cdot 0.24$$

$$= 0.25$$

$$\underline{s} = \sqrt{\frac{N-n}{n}} \cdot \sqrt{\frac{1}{n}} \cdot s \qquad \text{Estimate of Standard Error}$$

$$= 0.056\ (0.50)$$

$$= 0.028$$

$$= 2.8\%$$

The above procedure shows that the average of all possible samples of 313 families indicates that about 57 percent of the total number of families live in S.F.D. However, to be 64 percent sure that this estimate is correct, one estimate of standard error ("standard deviation") on either side of this number must be included. That is, one can be 64 percent sure that the real number is between 54.2 percent and 59.8 percent (57 percent ± 2.8 percent). To be 95 percent confident two estimates of standard error on either side of the mean must be included. Therefore, one can be 95 percent sure that the true percentage of families living in S.F.D. is between 51.4 percent and 62.6 percent (57 percent ± 5.6 percent).

This procedure can be performed with all elements of the survey.

GENERAL COMMENTS

The following observations were made by the interviewers during the course of the survey. They are included as a matter of interest only, and are not to be taken for more than the subjective observations of the interviewers.

* * * * *

. . . Approximately one out of four telephone numbers dialed resulted in a completed questionnaire. Non-completion of questionnaires was due to the absence of residents from the home, telephone numbers no longer in service, and an occasional resident's refusal to cooperate with the interviewer.

. . . Most people were friendly and helpful except for about three who did not care to respond to a survey at all. Most people felt the calling caused them to think about their own family preparedness for emergencies. I found only a few who really felt they were adequately set up for caring for themselves if a disaster occurred.

. . . Whereas most people felt they had enough food in the cupboards and freezer to feed the family for two weeks, few felt they had sufficient water to last that length of time. Water appeared to be the weakest link in families being self sufficient should a disaster occur.

. . . Although a great many people had fireplaces as an alternate for heating the home, many felt it would be a poor alternate. Only a few homes had what they felt would really replace their main source of heat.

. . . Several people had standby electric generators and many more voiced the opinion that they either were getting or should get one. Others answered that question as if it were the first time they had ever even given it any thought. I'm sure it was this question (along with several others) that caused several people to tell me that this survey had given them much to think on.

. . . Many people were quite interested in how they could adequately store water and not have it go bad from sitting around. Many were also interested in just how much food and water it would require to be prepared for a two week period. Some were not aware of the possible water storages they already had in the house such as in the hot water tank, while others felt they were adequately prepared for water because they had a lake across the road from which they could get all the water they needed.

. . . Although many felt they had sufficient family plans made of what to do in case of fire, most had not made any plans as to what the family would do in case of other disasters. Many felt that it was hopeless to prepare since different disasters would require different responses.

. . . Most people said that they have a relative or friend with whom they could live in case of complete demolition of their home. Only a few said they would have nowhere to go. A few said they were with the military and that there was a place on base which would take care of them in case of any disaster, so they felt adequately prepared. One family who had lived through the bad winds and said they were solving the problem by leaving shortly to live in Colorado!

. . . Generally the residents found the questions straightforward enough to choose an answer without any discussion or qualifications. Question six, "Have you any personal emergency plans at home should there be a natural disaster?"; however, often caused some confusion as well as apparent tension in the respondent. Many residents stated that while they have given no serious thought about personal plans in the event of an area-wide disaster, they have instructed their children what to due in the case of fire. It is instructive to note that fire is a disaster about which information is heavily stressed in schools throughout the country. Dispensing information in the schools appears to be an effective way of reaching the entire family.

. . . Another point that surfaced during the sampling is that military personnel living off the bases expect to be cared for by the military. All those questioned had no emergency plans of their own, but felt confident in replying affirmatively to all the preparedness questions.

* * * * *

ACKNOWLEDGEMENTS

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Larry Hathaway, Planning Engineer, Anchorage Telephone Utility

APPENDIX

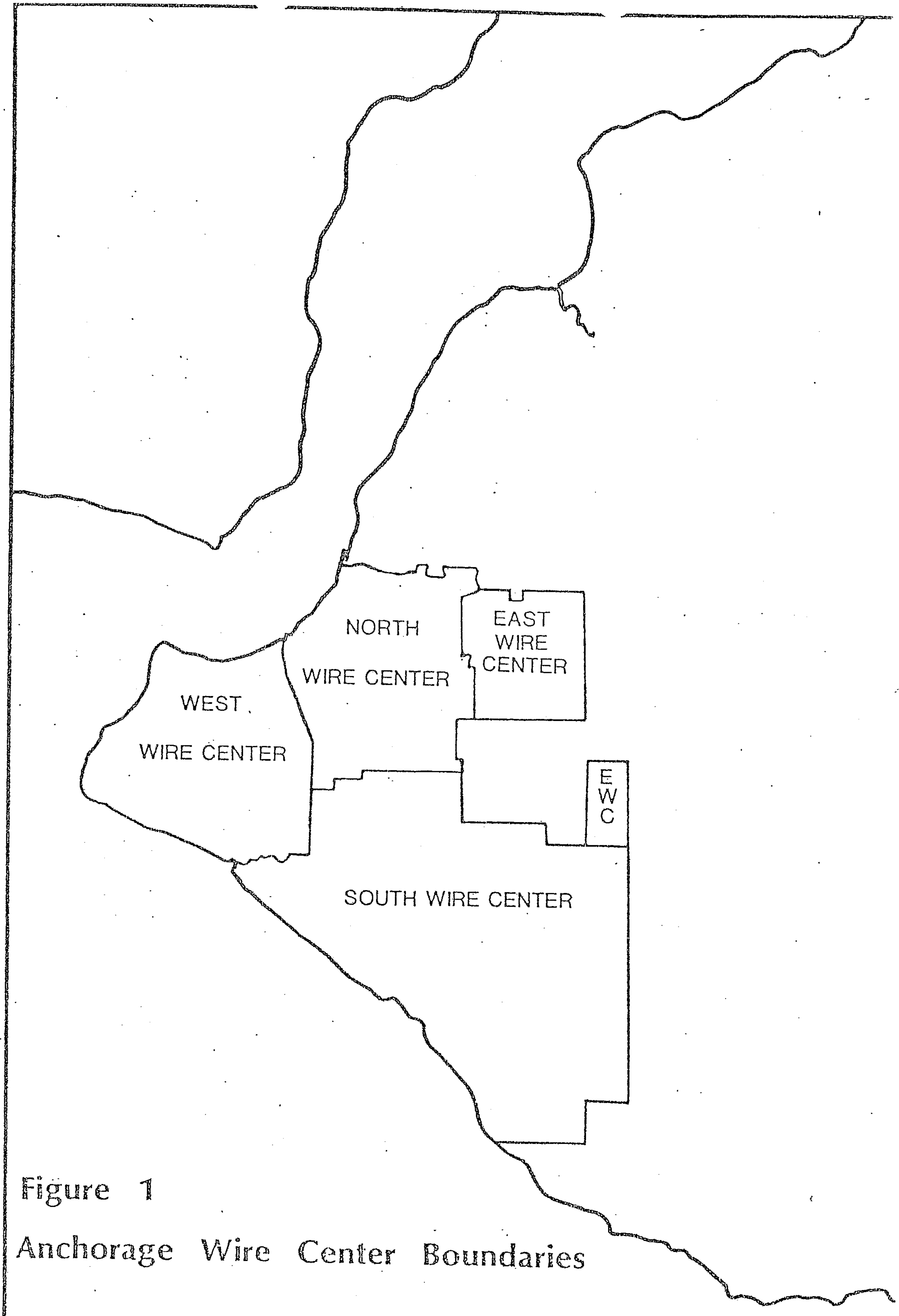

Figure 1

Anchorage Wire Center Boundaries

Table A

POPULATION DISTRIBUTION BY WIRE CENTER

	Number of Residence Telephones	Percent of Total Residence Telephones	Amount of Residences Contacted
North Wire	18,357	37	111
South Wire	11,071	22	66
East Wire	12,697	25	75
West Wire	8,053	16	48
TOTAL	50,178	100	300

Table B

WIRE CENTER RESIDENCE TELEPHONE PREFIXES

North Wire	South Wire	East Wire	West Wire
272	344	333	243
274	349	337	248
276	345		
277	267		
278			
279			

Figure 2

TELEPHONE SURVEY - ADES

NAME ______________________________

ADDRESS ______________________________

TELEPHONE ______________________________

1. TYPE OF DWELLING	SINGLE FAMILY	MOBILE HOME	MULTI-FAMILY

2. PRIMARY HEAT (FUEL SOURCE)	NATURAL GAS	FUEL OIL	ELECTRIC	OTHER

3. ALTERNATE HEAT (FUEL SOURCE)	a. OWN ONE		b. FUEL SOURCE				
	YES	NO	NATURAL GAS	FUEL OIL	ELECTRIC	FIREPLACE	OTHER

4. STANDBY ELECTRIC GENERATOR	a. OWN ONE			b. HOOKED UP		c. FUEL SOURCE		
	D Kn.	YES	NO	YES	NO	NATURAL GAS	GASOLINE	DIESEL FUEL

5. ALTERNATE SHELTER IN ANCHORAGE	a. OWN ONE		b. TYPE			
	YES	NO	PICK UP CAMPER	CAMP TRAILER	MOTOR HOME	OTHER

6. PERSONAL EMERGENCY PLANS AT HOME	YES	NO

7. STORED FOOD FOR 2 WEEKS	YES	NO

8. STORED WATER FOR 2 WEEKS	YES	NO

9. RELATIVES OR FRIENDS IN ANCHORAGE (with whom you can stay for an indefinite period)	YES	NO

Table 1

Type of Dwelling			
Single Family	Mobile Home	Multi-Family	Total
57% (180)	9% (27)	34% (106)	100% (313)

Table 2

Primary Heat (Fuel Source)					
		Fuel Source *			
Dwelling	Percent of Total	Natural Gas	Fuel Oil	Electric	Other
Single Family	57% (180)	76% (137)	7% (13)	15% (27)	2% (3)
Mobile Home	9% (27)	85% (23)	11% (3)	---	4% (1)
Multi-Family	34% (106)	53% (57)	4% (4)	38% (40)	5% (5)
Total	100% (313)	70% (217)	6% (20)	21% (67)	3% (9)

Table 3

Alternate Heat (Fuel Source)							
		Own One *		Fuel Source **			
Dwelling	Percent of Total	Yes	No	Natural Gas	Fuel Oil	Electric	Other
Single Family	57% (180)	78% (140)	22% (40)	---	1% (1)	2% (3)	99% (138)
Mobile Home	9% (27)	33% (9)	67% (18)	11% (1)	11% (1)	22% (2)	56% (5)
Multi-Family	34% (106)	41% (43)	59% (63)	2% (1)	---	9% (4)	90% (39)
Total	100% (313)	61% (192)	39% (121)	1% (2)	1% (2)	4% (9)	95% (182)

* Percentage of Dwelling Category

** Percentage of Affirmative Answers (Note: Some percentages in these responses may total more than 100% because some individuals have multiple systems.)

Table 4

Standby Electric Generator										
		Own One*			Hooked Up**		Fuel Source**		
Dwelling	Percent of Total	Don't Know	Yes	No	Yes	No	Natural Gas	Gasoline	Diesel Fuel
Single Family	57% (180)	0.5% (1)	14% (25)	85.5% (154)	56% (14)	44% (11)	24% (6)	76% (19)	4% (1)
Mobile Home	9% (27)	7% (2)	11% (3)	82% (22)	100% (3)	---	---	100% (3)	---
Multi-Family	34% (106)	8.5% (9)	9.5% (10)	82% (87)	70% (7)	30% (3)	20% (2)	60% (6)	20% (2)
Total	100% (313)	4% (12)	12% (38)	84% (263)	63% (24)	37% (14)	21% (8)	74% (28)	8% (3)

Table 5

Alternate Shelter in Anchorage							
		Own One*		Type**			
Dwelling	Percent of Total	Yes	No	Pickup Camper	Camp Trailer	Motor Home	Other
Single Family	57% (180)	31% (56)	69% (124)	30% (17)	28% (16)	26% (15)	16% (9)
Mobile Home	9% (27)	18% (5)	82% (22)	60% (3)	20% (1)	40% (2)	---
Multi-Family	34% (106)	25% (27)	75% (79)	52% (14)	22% (6)	15% (4)	11% (3)
Total	100% (313)	28% (88)	72% (225)	39% (34)	26% (23)	24% (21)	14% (12)

Table 6

Personal Emergency Plans at Home			
Dwelling	Percent of Total	Yes*	No*
Single Family	57% (180)	21% (38)	79% (142)
Mobile Home	9% (27)	22% (6)	78% (21)
Multi-Family	34% (106)	26% (27)	74% (79)
Total	100% (313)	23% (71)	77% (242)

* Percentage of Dwelling Category

** Percentage of Affirmative Answers (Note: Some percentages in these responses may total more than 100% because some individuals have multiple systems.)

Table 7

Stored Food - Enough for 2 Weeks			
Dwelling	Percent of Total	Yes	No
Single Family	57% (180)	80% (144)	20% (36)
Mobile Home	9% (27)	93% (25)	7% (2)
Multi-Family	34% (106)	64% (68)	36% (38)
Total	100% (313)	76% (237)	24% (76)

Table 8

Stored Water - Enough for 2 Weeks			
Dwelling	Percent of Total	Yes	No
Single Family	57% (180)	12% (22)	88% (158)
Mobile Home	9% (27)	4% (1)	96% (26)
Multi-Family	34% (106)	7% (7)	93% (99)
Total	100% (313)	10% (30)	90% (283)

Table 9

Relatives or Friends in Anchorage with whom You Strongly Feel You Can Stay for an Indefinite Period			
Dwelling	Percent of Total	Yes	No
Single Family	57% (180)	86% (155)	14% (25)
Mobile Home	9% (27)	81% (22)	19% (5)
Multi-Family	34% (106)	76% (81)	24% (25)
Total	100% (313)	82% (258)	18% (55)

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SUBJECT: Response Planning

TITLE: State of Alaska, Anchorage International Airport Emerency Control Plan, Edition Number 9

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Gives data about airport facilities, staff, fuel storage, etc. Briefing explanations of what airport staff responsible for emergency operations will do in case of various emergencies.

AUTHOR/DATE: Alaska District Corps of Engineers, Anchorage, Alaska June 1979

SUBJECT: Response Planning

TITLE: Emergency Employment of Army and Other Resources for the Alaska District: Natural Disaster Activities Under PL 84-99.

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: NPA Annex A to ER 500-1-1

DESCRIPTION: Discusses, for the Alaska District, the Corps of Engineers disaster preparedness and emergency operations dealing with flooding situations. Discusses eligibility criteria for obtaining assistance from the Corps by local and state governments. Discusses areas for which assistance is authorized.

AUTHOR/DATE: Alaska District Corps of Engineers, Anchorage, Alaska June 1979

SUBJECT: Response Planning

TITLE: Emergency Employment of Army and Other Resources for the Alaska District: Natural Disaster Activities Under PL 93-288

OTHER IDENTIFIERS: NPA Annex B to ER 500-1-1

DESCRIPTION: Provide guidance and instructions for the Alaska District in conduct of natural disaster relief operations under PL 93-288. Requires a mission assignment by FDAA. Discusses damage assessment and reports; upon which mission assignments are based among other things.

AUTHOR/DATE: Alaska District Corps of Engineers, Anchorage, Alaska June 1979

SUBJECT: Response Planning

TITLE: Emergency Employment of Army and Other Resources for the Alaska District: Emergency Communications

OTHER IDENTIFIERS: NPA Annex C to ER 500-1-1

DESCRIPTION: Purpose: To describe the communications facilities normally available to the Alaska District, and to prescribe a plan for emergency operations of wire and electronic communications during natural disasters or national emergencies.

AUTHOR/DATE: S.T. Algermissen, et al., 1972

SUBJECT: Seismology and Geolesy

TITLE: Preshocks and Aftershocks," The Grant Alaska Earthquake of 1964. National Academy of Sciences.

LOCATION: DOWL Engineers

DESCRIPTION:

AUTHOR/DATE: S.T. Algermissen, K.V. Steinbrugge, and H.L. Lagorio, 1978

SUBJECT: Structures

TITLE: Estimation of Earthquake Losses to Buildings (Except Single Family Dwellings)

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: (United State Department of the Interior, Geological Survey) Open-file report 78-441.

DESCRIPTION: Report deals with estimation of earthquake damage to various types of buildings for various hypothetical earthquakes. Develops methodology for taking building inventory which is dependent on land use classifications in San Francisco. Methodology includes necessary details to allow damage estimation.

AUTHOR/DATE: Anchorage Real Estate Research Committee, Fall 1979

SUBJECT: Current Data on the Anchorage Municipality

TITLE: Anchorage Real Estate Research Report

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Volume III

DESCRIPTION: Gives data for economic conditions in Anchorage and numerous aspects of the housing market.

AUTHOR/DATE: William A. Anderson, 1969

SUBJECT: Recovery

TITLE: Disaster and Organizational Change: A Study of the Long-Term Consequences in Anchorage of the 1964 Alaska Earthquake

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Disaster Research Center Monograph Series No. 6 Office of Civil Defense, contract OCD-PS-64-46

DESCRIPTION: Discusses disaster response following the 1964 earthquake with regard to several functional areas including search and rescue medical and health, security and control, etc. Categorizes various organizations in terms of whether long-term change was initiated by earthquake response and recovery activities and describes this change.

AUTHOR/DATE: William A. Anderson, 1970

SUBJECT: Recovery

TITLE: Disaster and Organizational Change in Anchorage. In the Great Alaska Earthquake of 1964: Human Ecology, by Committee on the Alaska Earthquake of the Division of Earth Sciences, National Research Council, 1970.

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Same study as described under Anderson, 1969 above.

AUTHOR/DATE: Norman L. Arno and Leonard J. McKinney

SUBJECT: 1964 Earthquake Damage and Effects

TITLE: "Harbor and Waterfront Facilities," in The Great Alaska Earthquake of 1964: Engineering

LOCATION: Anchorage Public Library

DESCRIPTION: Discusses earthquake damage to ports at several coastal towns in southcentral Alaska. Tsunamis caused nearly total damage where they struck. Discusses engineering post-earthquake reconstructed facilities.

AUTHOR/DATE: Robert S. Ayre, Dennis S. Mileti and Patricia B. Trainer, 1975

SUBJECT: Assessment of Earthquake Hazards

TITLE: Earthquake and Tsunami Hazards in the United States: A Research Assessment

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Program of Technology, Environment and Man Monograph #NSF-RA- E-75-005, Institute of Behavioral Science, University of Colorado

DESCRIPTION: The purpose of this book is to provide a basis for comparing costs and benefits of various lines natural hazards research and provides a "systematic appraisal of research needs." For earthquake and tsunami hazards, such things are discussed as problem dimensions, simulated loss management and research recommendations.

AUTHOR/DATE: Glen V. Berg and James Stratta, American Iron and Steel Institute, 150 East Forty-Second Street, New York, N.Y. 10017

SUBJECT: Structural

TITLE: Anchorage and the Alaska Earthquake of March 27, 1964

LOCATION: Corps of Engineers Library

OTHER IDENTIFIERS: 551.22

DESCRIPTION: An analysis of vibration damage to structures primarily in the Anchorage area.

AUTHOR/DATE: Richard A. Buck, California Seismic Safety Commission, 1977

SUBJECT: Response Planning

TITLE: The Puget Sound Earthquake Preparedness Project

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: The study presents information on potential hazards to people, structures and life line functions so that administrators of emergency services can plan responses to earthquake disaster.

AUTHOR/DATE: Richard A. Buck and Bruce P. Baird, 1978

SUBJECT: Recovery

TITLE: Staff Report to the Seismic Safety Commission on the Santa Barbara Earthquake, August 13, 1978

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Includes sections on the performance of emergency service agencies and utilities and transportation systems during Santa Barbara quake. Discussed damage and injuries, recovery, public reaction to the quake and lessons learned.

AUTHOR/DATE: D.J. Cederstrom, 1964

SUBJECT: Geology

TITLE: Geology and Groundwater Resources of the Anchorage Area, Alaska.

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: U.S. Geological Survey, Water Supply Paper 1773, 1964

DESCRIPTION:

AUTHOR/DATE: Frank K. Chang and Ellis L. Krinitzsky, December 1977

SUBJECT: Assessing Earthquake Hazards

TITLE: State-of-the-Art For Assessing Earthquake Hazards in the United States. Report 8: Duration, Spectual Content, and Predominant Period of Strong Motion Earthquake Records from Western United States.

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Miscellaneous Paper 5-73-1. Soils and Pavements Laboratory, U.S. Army Engineers Waterways Experiment Station, P.O. Box 631, Vicksburg, Miss. 39180

DESCRIPTION: "The purposes of this investigation were principally to assess the duration and spectual content of strong-earthquake accelerograms and, indirectly, to consider their applicability in earthquake design, correlations of duration with MM intensity for the near and far fields and for Richter magnitude have been obtained. Difference in duration for soil and rock sites was determined."

AUTHOR/DATE: Frank K. Chang, April 1978

SUBJECT: Geophysical Earthquake Research and Instrumentation

TITLE: State-of-the-Art for Assessing Earthquake Hazards in the United States. Report 9: Catalogue of Strong Motion Earthquake Records. Volume I, Western United States, 1933-1971.

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Miscellaneous Paper S-73-1. Soils and Pavements Laboratory, U.S. Army Engineers Waterways Experiment Station, P.O. Box 631, Vicksburg, Miss. 39180.

DESCRIPTION: Provides data on earthquakes occurring in Western States from 1933-1971, to be used for design earthquakes. Information is provided on "magnitude, type of fault, focal depth, site classification, peak acceleration, velocity, displacement, duration and distance from epicenter."

AUTHOR/DATE: S.H.B. Clark

SUBJECT: Geology

TITLE: Bedrock Geology - Chugach Mountains Near Anchorage

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: U.S. Geological Survey, Map MG-350, 1972

DESCRIPTION:

AUTHOR/DATE: Jerry L. Coffman and Carl A. VonHake, 1973

SUBJECT: Vulnerability

TITLE: Earthquake History of the United States

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: U.S. Department of Commerce, NOAA, Environmental Data Service, publication 41-1.

DESCRIPTION: Discusses earthquake risk in each region of the country. Recounts earthquakes that have occurred in each region.

AUTHOR/DATE: HQ 21st Composite Wing, Elmendorf AFB, May 1978

SUBJECT: Response Planning

TITLE: 21st Composite Wing OPLAN, Disaster Preparedness

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Long title: Elmendorf Air Force Base OPLAN 355-1, Disaster Preparedness Short Title: 21 CQMPW OPLAN 355-1

DESCRIPTION: Plan to retain military "ready" status in event of attack or natural disaster. Deals with disaster relief as a second priority.

AUTHOR/DATE: C.A. Cornell, 1968

SUBJECT: Seismology

TITLE: Engineering Seismic Risk Analysis

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Seismological Society of America Bulletin, January, (58) 5.

DESCRIPTION:

AUTHOR/DATE: Henry W. Coulter and Ralph R. Migliaccio, 1966

SUBJECT: Tsunami

TITLE: The Alaska Earthquake, March 27, 1964. Effects on Communities, Valdez

LOCATION: Alaska Division of Emergency Services Library

OTHER IDENTIFIERS: Geological Survey Professional Paper 542-C

DESCRIPTION: A description of the massive landslides, destructive sea waves, landslide displacement, and extensive ground breakage due to the earthquake at Valdez

AUTHOR/DATE: Doak C. Cox and George Pararas-Carayannis, March 1976

SUBJECT: Tsunami

TITLE: Catalog of Tsunamis in Alaska

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: World Data Center A for Solid Earth Geophysics, Report SE-1

DESCRIPTION: Brief description of history of tsunamis in Alaska. List of tsunamis and travel times of potential tsunamis to Sitka and Adak from quake anywhere in Pacific.

AUTHOR/DATE: Davies and Berg, 1973

SUBJECT: Seismology

TITLE: Crustal Morphology and Plate Tectonics in South Central Alaska

LOCATION: DOWL, Engineers

OTHER IDENTIFIERS: Seismological Society of America Bulletin, January, (63)

DESCRIPTION:

AUTHOR/DATE: T.N. Davis, S.A. Estes, L.R. Gedney, Alaska Earthquake Analysis Center, Geophysical Institute, University of Alaska, Fairbanks, October 1978

SUBJECT: Vulnerability

TITLE: Probability of Earthquake Occurrence in the Vicinity Chena Flood Control Dam near Fairbanks, Alaska

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: AEAC Seismological Report No. 7

DESCRIPTION: Study uses three methods to determine probability of an earthquake of a given magnitude within 50 miles of Chena Flood Control Dam during a 50 year period. Two sets of data are used.

AUTHOR/DATE: Department of the Army, Office of the Chief of Engineers, Washington D.C., January 1978

SUBJECT: Response Planning

TITLE: Emergency Employment of Army and Other Resources: Natural Disaster Procedures

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: ER 500-1-1

DESCRIPTION: Describes ways the Corps of Engineers is authorized to assist other Federal departments in times of dissater. Discusses Corp's disaster preparedness efforts and its procedures for reacting to potential disasters and actual disasters.

AUTHOR/DATE: The Earthquake Joint Planning Committee, Civil Defense and Disaster Board, July 1978

SUBJECT: Response Planning

TITLE: City of Los Angeles Earthquake Operational Plan

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Consists of "overviews of each [of the city's[1]] departments operational plan during...an earthquake disaster," with the purpose of improving "interdepartment operation and coordination of effort at all levels of command during an earthquake disaster."

AUTHOR/DATE: Edwin B. Eckel, 1967

SUBJECT: 1964 Earthquake Damage and Recovery

TITLE: Effects of the Earthquake of March 27, 1964 on Air and Water Transport, Communications, and Utilities Systems in South-Central Alaska.

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: One of a series of papers entitled, the Alaska Earthquake, March 27, 1964: Effects on Transportation, Communications and Utilities. U.S. Geological Survey Professional Paper 545-B

DESCRIPTION: Describes damage to air and water transport, communications and utilities systems, temporary replacement of losses and permenant repairs and changes to systems.

Harding-Lawson Study. See reference under Winterholder, Williams and England, 1979.

AUTHOR/DATE: Edwin B. Eckel, 1970

SUBJECT: Response Planning

TITLE: The Alaska Earthquake, March 27, 1964: Lessons and Conclusions

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: U.S. Geological Survey Professional Paper 546

DESCRIPTION: "A summary of what was learned from a great earthquake about the bearing of geologic and hydraulic conditions on its effects, and about the scientific investigations needed to prepare for future earthquakes."

AUTHOR/DATE: Executive Office of the President, undated

SUBJECT: Hazard Reduction

TITLE: The National Earthquake Hazards Reduction Program

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Report described several approaches to minimizing failure of man-made structures in the event of an earthquake. Discusses needed development of other aspects of hazard reduction such as earthquake prediction and public education.

AUTHOR/DATE: Working Group on Earthquake Hazards Reduction, Office of Science and Technology Policy, Executive Office of the President, 1978

SUBJECT: Hazard Reduction

TITLE: Earthquake Hazards Reduction: Issues for an Implementation Plan.

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Report gives background of Earthquake Hazards Reduction Act of 1977 (PL 95-124). Discusses formulation of policies to reduce earthquake hazards, the implementation of the hazards reduction program, and the roles of various organizations in hazard reduction.

AUTHOR/DATE: C.D. Evans, E. Buck, R. Buffler, G. Fisk, R. Forbes and W. Parker, 1972

SUBJECT: Vulnerability

TITLE: The Cook Inlet Enviornment: A Background Study of Available Knowledge. A report by the Resources and Science Service Center, Alaska Sea Grant Program, University of Alaska for the U.S. Army Corps of Engineers, Alaska District.

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Discusses the enviornment, resources and cultural activites in the Cook Inlet that would affect or be affected by petroleum resource development in the Inlet. Of specific interest, are sections on geology (page 1-7) and geologic risk phenomena (page IV-1) which include earthquake, tsunami and volcanic risk in the Inlet. (Winterhalder, Williams and England, 1972)

AUTHOR/DATE:	Federal Aviation Administration, Alaska Region July 1979
SUBJECT:	Planning
TITLE:	Alaska Region, Ten Year Plan, FY-1981-FY-1990
LOCATION:	Alaska Division of Emergency Services
DESCRIPTION:	The "Plan has been developed to address the issues safety, capacity, productivity, environmental compatibility and energy conservation..."

AUTHOR/DATE:	Federal Reconstruction and Development Planning Commission for Alaska, 1964
SUBJECT:	Soils
TITLE:	Response to Disaster, Alaskan Earthquake, March 27, 1964: Washington D.C.
LOCATION:	Alaska Division of Emergency Services
DESCRIPTION:	"Describes need for accurate knowledge of the geology and soil conditions of the earthquake, as well as judgement as to future slides and subsidence and as to precautions to minimize the occurrence" (from Harding-Lawson Annotated Bibliography).

AUTHOR/DATE:	Edwin M. Fitch, 1967
SUBJECT:	Recovery
TITLE:	The Alaska Railroad
LOCATION:	Bill Coghill at Alaska Railroad Anchorage terminal. Summary and Chapter on earthquake damage is at the Alaska Division of Emergency Services.
OTHER IDENTIFIERS:	Frederick A. Praeger, Publishers. Library of Congress No. 67-20477
DESCRIPTION:	History of the development of the Alaska Railroad. Has a chapter on 1964 earthquake damage and reconstruction.

AUTHOR/DATE:	T.C. Fuglestad, September 1979
SUBJECT:	Recovery
TITLE:	The Alaska Railroad and the Earthquake of March 27, 1965
LOCATION:	Alaska Division of Emergency Services
OTHER IDENTIFIERS:	Unpublished paper obtained from Alaska Railroad
DESCRIPTION:	Describes, in detail, the immediate process of reconstruction of the Alaska Railroad following the 1964 earthquake.

AUTHOR/DATE:	L. Gedney, and J. Van Wormer, 1973
SUBJECT:	Seismology
TITLE:	Seismically Active Structural Lineaments in South Central Alaska as seen on ERTS-1 Imagery
LOCATION:	DOWL, Engineers
OTHER IDENTIFIERS:	Interim Scientific Report, NASA Contract NAS 5-21833, November, 1973
DESCRIPTION:	

AUTHOR/DATE:	L. Gedney, 1976
SUBJECT:	Response
TITLE:	Written Communication
LOCATION:	DOWL, Engineers
DESCRIPTION:	

AUTHOR/DATE: Warren George, Paul Knowles, John K. Allender, James F. Sizemore and Duane E. Carson, 1973

SUBJECT: 1964 Earthquake Damage and Recovery

TITLE: Structures in Anchorage. In the Great Alaska Earthquake of 1964: Engineering, by Committee on the Alaska Earthquake of the Division of Earth Sciences, National Research Council, National Academy of Sciences, 1973.

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Gives description of seismically induced ground failure in the downtown area and the Fourth Avenue buttressing project, among other things.

AUTHOR/DATE: Charles E. Glass and David B. Slemmons, December 1978

SUBJECT: Assessing Earthquake Hazards

TITLE: State-of-the-Arts for Assessing Earthquake Hazards in the United States. Report 11: Imagery in Earthquake Analysis.

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Miscellaneous Paper S-73-1. Purchase Order No. CW-77-M-1371. Geotechnical Laboratory, U.S. Army Engineer Waterways Experiment Station, P.O. Box 631, Vicksburg, Miss. 39180

DESCRIPTION: Reviews "the...principles and methods of applying remote sensing for evaluation of earthquake hazards and seismic risk." Discusses case histories as examples. "The character of earthquake hazards is discussed in the context of lithologic, structural, vegetational, and topographic variations that are associated with different types of active geologic structures."

AUTHOR/DATE: John Graham Company/Boeing Computer Services, Inc., November 1975.

SUBJECT: Vulnerability

TITLE: Natural Hazards in the Alaska Environment: Processes & Effects

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Prepared in conjunction with a Land Systems Study for the Joint Federal-State Land Use Planning Commission.

DESCRIPTION: The report utilized existing information to compile a document on important hazardous natural phenomena statewide. The report explains the natural processes, characterizes the location and discusses the danger. It includes 1:2,500,00-scale maps of faults, epicenters, wildfire frequencies, volcanoes, areas of greater than 20 percent slope, and glacial outburst floods. Sections include: seismic hazards, mass wasting, land subsidence, shoreline erosion, volcanoes, surging glaciers, wildfire, sea ice, flooding, brown/grizzly bear and a summary.

AUTHOR/DATE: A. Grantz, I. Lietz, and G. Anderson, 1963

SUBJECT: Geology

TITLE: An Aeromagnetic Reconnaissance of the Cook Inlet Area, Alaska

LOCATION: DOWL, Engineers

OTHER IDENTIFIERS: USGS Professional Paper 316-G, 1963

DESCRIPTION:

AUTHOR/DATE: A. Grantz, 1966

SUBJECT: Geology

TITLE: Strike Slip Faults in Alaska

LOCATION: DOWL, Engineers

OTHER IDENTIFIERS: USGS Open-file Report, 1966

DESCRIPTION:

AUTHOR/DATE: J. Eugene Haas, Daniel J. Amaral, Reyes Ramos, Robert W. Kates, Robert A. Olson, Richard Olsen - no date

SUBJECT: Response Planning

TITLE: Early Human Response to the 1972 Managua Earthquake

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Recounts seismic history of Managua. Déscribes and analysis response to 1972 earthquake which were guided by no response plans as almost none existed.

AUTHOR/DATE: Robert M. Hamilton

SUBJECT: Hazard Reduction

TITLE: Earthquake Hazards Reduction Program - Fiscal Year 1978 Studies Support by the U.S. Geological Survey

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Geological Survey Circular 780

DESCRIPTION: Report describes Federal earthquake hazard reduction programs, the direction of earthquake research and its sources of funding.

AUTHOR/DATE: W.R. Hansen, 1965

SUBJECT: Soils

TITLE: Effects of the Earthquake of March 27, 1964, Anchorage, Alaska: U.S. Geological Professional Paper 542-A

LOCATION: Government Printing Office, Washington

OTHER IDENTIFIERS: The Great Alaska Earthquake of 1964: Geology. NAS Pub. 1601. Washington: National Academy of Sciences, 1971.

DESCRIPTION: Describes and analyzes the most damaging ground response, the translatory slides; describes characteristics of Bootlegger Cove Clay in relation to slides; and summarizes vibratory damaging effects.

AUTHOR/DATE: Wallace R. Hansen, Edwin B. Eckel, William E. Schaem, Robert E. Lyle, Warren George, and Genie Chance, 1966

SUBJECT: 1964 Earthquake Damage and Effects

TITLE: The Alaska Earthquake, March 27, 1964: Field Investigations and Reconstruction Effort.

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: U.S. Geological Survey Professional Paper 541

DESCRIPTION: "Summarizes the effects of the great Alaska earthquake and emphasizes field investigations made by the Geological Survey, the work of the Scientific and Engineering Task Force and the reconstruction by the U.S. Army Coprs of Engineers. Reviews the contributions of many geologists to solving geologic problems relating to pattern of sea-level changes, outlook for fisheries, effects on water supply and soil environments." (From Harding-Lawson Annotated Bibliography).

AUTHOR/DATE: Harding-Lawson Associates, 1974

SUBJECT: Structures

TITLE: Dynamic Response Analysis Community Hospital, Anchorage, Alaska

LOCATION: DOWL, Engineers

OTHER IDENTIFIERS: Report Prepared for DOWL Engineers, February, 1974

DESCRIPTION:

AUTHOR/DATE: Walter W. Hays, undated

SUBJECT: Hazard Reduction

TITLE: Program and Plans of the U.S. Geological Survey for Producing Information Needed in National Seismic Hazards and Risk Assessment, Fiscal Years 1980-84.

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Geological Survey Circular 816

DESCRIPTION: Discusses plans to obtain information needed to reduce earthquake hazards. For instance improved maps of earthquake zones are needed, improved methodogy for gathering information for mapping and post-earthquake investigations.

AUTHOR/DATE: R.B. Hofman, June 1974

SUBJECT: Geophysical Earthquake Research and Instrumentation

TITLE: The State-of-the-Art for Assessing Earthquake Hazards in the United States. Report 3: Factors in the Specification of Ground Motions for Design Earthquakes in California

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: U.S. Army Engineer Waterways Experiment Station, Soils and Pavements Laboratory, Vicksburg, Missippi. Contract No. DACW39-72-C-0032, ES561, Miscellaneous Paper 5-73-1

DESCRIPTION: Examines "bases and rationale for assessing the principal factors in earthquake ground motion," through use of design earthquakes. Data taken near source of energy release are scarce. Factors discussed are acceleration, peak acceleration at source, topography, absorption and transmission of seismic energy.

AUTHOR/DATE: G.W. Housner, 1956

SUBJECT: Seismology

TITLE: Intensity of Earthquake Ground Shaking Near the Causative Fault

LOCATION: DOWL, Engineers

OTHER IDENTIFIERS: Proceedings of the 3rd World Conference on Earthquake Engineering, Vol I, New Zealand, 1956

DESCRIPTION:

AUTHOR/DATE: G.W. Housner, 1969

SUBJECT: Seismology

TITLE: Engineering Estimates of Ground Skaking and Maximum Earthquake Magnitude

LOCATION: DOWL, Engineers

OTHER IDENTIFIERS: Proceedings of the 4th World Conference of Earthquake Engineering, Santiago, 1969

DESCRIPTION:

AUTHOR/DATE: G.W. Housner, 1979

SUBJECT: Response

TITLE: Personal Communications

LOCATION: DOWL Engineers

DESCRIPTION:

AUTHOR/DATE: Department of Housing and Urban Development, Federal Disaster Administration, Region X, December 1978.

SUBJECT: Response Planning

TITLE: Federal Earthquake Response Plan for The Puget Sound Area (Final Draft)

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: This plan deals with the procedures Federal agencies would follow, in the event of a catastrophic earthquake, to supplement the disaster response activities of local and State governments. The coordinating function of Federal agencies in the event that their offices are unuseable is planned.

AUTHOR/DATE: I.M. Idriss, and H.B. Seed, 1968

SUBJECT: Seismology

TITLE: An Analysis of Ground Motions During the 1957 San Francisco Earthquake

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Bulletin of the Seismological Society of America, Vol. 58, No. 6, December 1968

DESCRIPTION:

AUTHOR/DATE: J. C. Jennings, G.W. Housner, and N.C. Tsai, 1968

SUBJECT: Seismology

TITLE: Simulated Earthquake Motions

LOCATION: DOWL, Engineering

OTHER IDENTIFIERS: Research Report, Earthquake Engineering Research Laboratory, California Institute of Technology, Pasadena, April 1968

DESCRIPTION:

AUTHOR/DATE: Paul C. Jennings, editor, 1980

SUBJECT: Hazards Reduction

TITLE: Earthquake Engineering and Hazards Reduction in China: A Trip Report of the American Engineering and Hazards Reduction Delegation

LOCATION: Alaska Division of Emergency Services Library

OTHER IDENTIFIERS: Committee on Scholarly Communication with the People's Repulic of China Report No. 8, National Academy of Sciences

DESCRIPTION: Discusses seismic response of building design and construction types in China, and Chinese research in these areas. Also gives reports on the Tangshan Earthquake and Sungpan-Pingwu Earthquake of August 1976.

AUTHOR/DATE: Reuben Kachadoorian and George Plafker, 1967

SUBJECT: Tsunami

TITLE: The Alaska Earthquake, March 27, 1964 Effects on Communities, Kodiak Area

LOCATION: Alaska Division of Emergency Services Library

OTHER IDENTIFIERS: Geological Survey Professional Paper 542-F

DESCRIPTION: A description of the property damage and loss of life due to earthquake-induced seismic sea waves and regional tectonic subsidence at Kodiak and nearby communities.

AUTHOR/DATE: Reuben Kachadoorian, 1968

SUBJECT: 1964 Earthquake Damage

TITLE: Effects of the Earthquake of March 27, 1964, on the Alaska Highway System.

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: One of a series of papers entitled, the Alaska Earthquake, March 27, 1964: Effects on Transportation, Communications and Utilities. U.S. Geological Survey Professional Paper 545-C

DESCRIPTION: Describes extensive damage to highway system in south-central Alaska. Discusses correlation between extent of damage and the foundation soils and the engineering of bridges. Discusses several different kinds of damage.

AUTHOR/DATE: T.N. Karlstrom, 1964

SUBJECT: Geology

TITLE: Quaternary Geology of the Kenai Lowlands and Glacial History of the Cook Inlet Region, Alaska

LOCATION: DOWL, Engineers

OTHER IDENTIFIERS: USGS Professional Paper 443, 1964

DESCRIPTION:

AUTHOR/DATE: J.A. Kelleher, 1970

SUBJECT: Seismology

TITLE: Space-Time Seismicity of the Alaska-Aleutian Seismic Zone

LOCATION: DOWL, Engineers

OTHER IDENTIFIERS: Journal of Geophysical Research, January, (75)

DESCRIPTION:

AUTHOR/DATE: F.W. Kiefer, H.B. Seed, and I.M. Idriss, 1970

SUBJECT: Seismology

TITLE: Analysis of Earthquake Ground Motions at Japanese Sites

LOCATION: DOWL, Engineers

OTHER IDENTIFIERS: Bulletin of the Seismological Society of America, Vol 60, No. 6, December 1970

DESCRIPTION:

AUTHOR/DATE: W.J. Kockelman, 1976

SUBJECT: Response Planning

TITLE: "Use of USGS Earth-Science Products by County Planning Agencies in the San Francisco Bay Region, California"

LOCATION: U.S. Geological Survey; or Planning Department, Municipality of Anchorage

DESCRIPTION: The U.S. Geological Survey prepared a survey of user groups in California to determine how hazard data was being applied. They found that hazards data was used to map potentially hazardous conditions (including fault systems and unstable slopes and soils) in relation to critical facilities, including hospitals, schools and industrial facilities, transportation and utility systems. The Alameda County Emergency Operations Plan (1975) used the data for setting priorities for the repair and restoration of essential systems and services.

AUTHOR/DATE: E.L. Krinitzsky, June 1974

SUBJECT: Assessing Earthquake Hazards

TITLE: State-of-the-Art for Assessing Earthquake Hazards in the United States. Report 2: Fault Assessment in Earthquake Engineering

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Miscellaneous Paper 5-73-1 Soils and Pavement Laboratory U.S. Army Engineers Waterways Experiment Station, P.O. Box 631, Vicksburg, Miss. 39180

DESCRIPTION: "This report reviews the state-of-the-art for (a) identifying faults, (b) determining which faults may cause earthquakes, and (c) estimating the maximum earthquakes that can be produced by a given fault."

AUTHOR/DATE: Ellis L. Krinitzsky and Frank K. Chang

SUBJECT: Assessing Earthquake Hazards

TITLE: State-of-the-Art for Assessing Earthquake Hazards in The United States. Report 7: Specifying Peak Motions for Design Earthquakes

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Miscellaneous Paper 5-73-1. Soils and Pavement Laboratory, U.S. Army Engineer Waterways Experiment Station, P.O. Box 631, Vicksburg, Miss. 39180

DESCRIPTION: Discusses many factors that must be considered in estimating the maximum earthquake from a given source and its intensity at a given site. Peak values estimated by the process "can be used for rescaling selected strong motion records or alternatively for the generation of synthetic seismograms."

AUTHOR/DATE: J.C. Lahr, 1979

SUBJECT: Response

TITLE: Personal Communications

LOCATION: DOWL, Engineers

DESCRIPTION:

AUTHOR/DATE: J.C. Lahr, G. Plafker, et al., 1979

SUBJECT: Seismology

TITLE: Interim Report on the St. Elias Earthquake of 28 February 1979

LOCATION: DOWL, Engineers

OTHER IDENTIFIERS: USGS Open-file Report 79-670 USDOI

DECRIPTION:

AUTHOR/DATE: Margaret Lantis, 1970

SUBJECT: 1964 Earthquake Damage and Effects

TITLE: Impact of the Earthquake on Health and Mortality. In the Great Alaska Earthquake of 1964: Human Ecology, by Committee on the Alaska Earthquake of the Division of Earth Sciences, National Research Council, National Academy of Sciences, 1980.

LOCATION: Alaska Division of Emergency Services Library

DESCRIPTION: Discusses the causes of earthquake related deaths, geographic distribution and social characteristics of casualties. Discusses earthquake related injuries and illnesses.

AUTHOR/DATE: Richard W. Lemke, 1967

SUBJECT: Tsunami

TITLE: The Alaska Earthquake, March 27, 1964. Effects on Communities, Seward

LOCATION: Alaska Division of Emergency Services Library

OTHER IDENTIFIERS: Geological Professional Paper 542-E

DESCRIPTION: A description and analysis of the damage resulting from submarine landsliding, seismic sea waves, and oil-tank fires in one of the most devastated cities in Alaska.

AUTHOR/DATE: Malcolm H. Logan, 1967

SUBJECT: 1964 Earthquake Damage

TITLE: Effect of the Earthquake of March 27, 1964, on the Eklutna Hydroelectric Project, Anchorage, Alaska

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: One of series of papers entitled: the Alaska Earthquake, March 27, 1964; Effects on Transportation, Communications, and Utilities. U.S. Geological Survey Professional Paper 545-A

DESCRIPTION: Describes damage to Eklutna Hydroelectric Power System due to the earthquake. Major damage was to water intake structure at Eklutna Lake. There was minor damage to other parts of system especially where facilities were constructed on unconsolidated soils.

AUTHOR/DATE: J. Lysmer, H.B. Seed, and P.B. Schnabel, 1971

SUBJECT: Seismology

TITLE: Influence of Base Rock Characteristics on Ground Response

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Bulletin of the Seismological Society of America, Vol. 61, No. 5, October 1971

DESCRIPTION:

AUTHOR/DATE: N.D. Marachi, and S.J. Dixon

SUBJECT: Seismology

TITLE: A Method for Evaluation of Seismicity

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Proceedings of the International Conference on Microzonation, Vol. 1, 1972

DESCRIPTION:

AUTHOR/DATE: David S. McCullock and Manuel G. Bonilla, 1970.

SUBJECT: 1964 Earthquake Damage

TITLE: Effects of the Earthquake of March 27, 1964 on the Alaska Railroad

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: One of a series of papers entitled, the Alaska Earthquake, March 27, 1964: Effects on Transportation, Communications, and Utilities. U.S. Geological Survey Professional Paper 545-D

DESCRIPTION: Discusses extent and types of damage to rail system. Gives geologic conditions which determine the extent of damage and also vulnerability of certain bridge types. Gives some construction guidelines for avoiding earthquake damage to railroads, roads, utilities, etc.

AUTHOR/DATE: Edward A. McDermott, Director of OEP

SUBJECT: Civil Defense

TITLE: The role of the office of Emergency Planning in the Alaskan Earthquake, September 1964.

LOCATION: Corps of Engineers Library

DESCRIPTION: A Report to the President covering the 1964 earthquake damage and the action taken.

AUTHOR/DATE: Herbert Meyers, R.J. Brazee, J.L. Coffman, and S.R. Lessig, October 1976

SUBJECT: Vulnerability

TITLE: An Analysis of Earthquake Intensities and Recurrence Rates In and Near Alaska.

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: NOAA Technical Memorandum EDS NGSDL-3

DESCRIPTION: Gives inventory of Alaskan earthquakes and their intensities. Discusses maximum intensity for Alaska magnitude-frequency relationships and strong motion studies.

AUTHOR/DATE: R.D. Miller, and E. Dobrovolny

SUBJECT: Seismology

TITLE: Surficial Geology of Anchorage and Vicinity Alaska

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: USGS Bulletin 1098, 1959

DESCRIPTION:

AUTHOR/DATE: W.G. Milne, and A.G. Davenport, 1965

SUBJECT: Seismology

TITLE: Statistical Parameters Applied to Seismic Regionalizations

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Proceedings of the 3rd World Conference of Earthquake Engineers, (3)

DESCRIPTION:

AUTHOR/DATE: W.G. Milne, and A.G. Davenport, 1969

SUBJECT: Seismology

TITLE: Distribution of Earthquake Risk in Canada

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Bulletin of the Seismological Society of America, January, (59)

DESCRIPTION:

AUTHOR/DATE: Miriam Morrow, Anchorage Resource Information Service, September 30, 1978

SUBJECT: Socioeconomic and Business Data, Anchorage

TITLE: Anchorage Quarterly - A Review of Socio-economic Data June 30, 1978

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Volume I - Number 1

DESCRIPTION: Contains statistical information on Anchorage's population, consumer price index, food and building prices, health and education, crime and law enforcement, housing and real estate market, employment, unemployment and transportation.

AUTHOR/DATE: Miriam Morrow, Anchorage Chamber of Commerce December 31, 1978

SUBJECT: Socioeconomic and Business Data, Anchorage

TITLE: Anchorage Quarterly - A Review of the Socio-economic data Anchorage, Alaska December 31, 1978

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Volume I - Number 2

DESCRIPTION: An update to Volume I - Number 1 that contains additional items of interest such as population by subcommunity, nongovernment hospital facilities, medical doctors in practice, utility operations, and transportation and traffic.

AUTHOR/DATE Miriam Morrow, Editor Assisted by Rebecca Graham, June 30, 1979

SUBJECT: Socioeconomic and Business Data, Anchorage

TITLE: Anchorage Quarterly - A review of Socio-economic data, Anchorage, Alaska

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Volume I - Number 3

DESCRIPTION: An update to the previous volumes containing special interest items as age distribution by subcommunity and a general cargo and petroleum transportation summary.

AUTHOR/DATE: Miriam Morrow, Editor, Anchorage Chamber of Commerce, Business Information Center, December 1979

SUBJECT: Socioeconomic and Business Data, Anchorage

TITLE: The Anchorage Economic Compass: A Socio-Economic Profile

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Volume II

DESCRIPTION: An update to previous volumes. In addition to topics mentioned above, statistics showing level of business of finance sector is given and a section showing the level of tourism in the State is included.

AUTHOR/DATE: Frederick B. Muller, Division of Economic Enterprise, Department of commerce and Economic Development, 1978

SUBJECT: Socioeconomic and Business Data, Alaska

TITLE: The Alaska Economy: Year-End Performance Report 1978

LOCATION: Alaska Division of Emergency Services Library

OTHER IDENTIFIERS: Volume 7

DESCRIPTION: Discusses the importance and performance of various sectors of the economy and industries. Gives statistical summaries on these and socioeconomic characteristics of the Alaska population.

AUTHOR/DATE: Municipality of Anchorage, December 1978

SUBJECT: Civil Defense

TITLE: Civil Defense Emergency Operations Plan

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: This plan concentrates on event of nuclear disaster, but also refers to natural disasters.

AUTHOR/DATE: Committee on the Alaska Earthquake of the Division of Earth Sciences National Research Council, National Academy of Sciences, 1973.

SUBJECT: Response Planning (Reduction Measures)

TITLE: The Great Alaska Earthquake of 1964
Summary and Recommendations

LOCATION: Alaska Division of Emergency Services, Anchorage library. Library of Congress Catalog Card Number 68-60037

OTHER IDENTIFIERS: Available from Printing & Publishing Office, National Academy of Sciences, ISBN 0-309-01608-8

Final Report Series includes these volumes: Summary and Recommendations, Biology, Engineering, Human Ecology (Geography), Geology, Hydrology, Oceanography and Seismology.

DESCRIPTION: This summary description goes into some detail in listing the numerous recommendations that were made as they may relate to response planning efforts, or description of particular effects that relate to particularly vulnerable structures or systems. Recommendations of broad scope and general applicability are prepared to suggest important steps that should be taken in planning for minimizing losses from future earthquakes.

AUTHOR/DATE: Committee on the Alaska Earthquake of the Division of Earth Sciences of National Research Council, National Academy of Sciences. See dates for each volume below.

SUBJECT: 1964 Earthquake Damage and Effects, Response Planning

TITLE: The Great Alaska Earthquake of 1964

LOCATION: All but the Engineering volumes are in Alaska Division of Emergency Services Library

OTHER IDENTIFIERS: Library of Congress, Catalog Card Number 68-60037

DESCRIPTION: This is an seven volume set. The volume titles and dates published are as follows: Geology (Part A and Part B), 1971; Seismology and Geodesy, 1972; Hydrology (Part A and Part B), 1968; Biology, 1971; Oceanography and Coastal Engineering; 1972; Engineering, 1973; Human Ecology, 1970; Summary and REcommendations: Including Index to series, 1973. These volumes are collections of articles by many different authors and cover all aspects of the 1964 earthquake and recovery effort.

AUTHOR/DATE: Panel on the Public Policy Implications of Earthquake Prediction of the Advisory Committee on Emergency Planning, Commission on Sociotechnical Systems, National Research Council, 1975

SUBJECT: Earthquake Prediction

TITLE: Earthquake Prediction and Public Policy

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Discusses such aspects of earthquake prediction as constructive response to prediction, issuing predictions and warnings, economic, legal, and political implications, the problem of spreading the costs imposed by disasters equitably.

AUTHOR/DATE: Panel on Earthquake Prediction of the Committee on Seismology, Assembly of Mathematical and Physical Sciences, National Research Council, 1976

SUBJECT: Earthquake Prediction

TITLE: Predicting Earthquakes: A Scientific and Technical Evaluation with Implications for Society.

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Discusses methods and current capabilities of predicting earthquakes in the U.S. Also discusses social implications of prediction.

AUTHOR/DATE: Committee on Disasters and the Mass Media Commission on Sociotechnical Systems, National Research Council, 1980

SUBJECT: Disaster Media Coverage

TITLE: Disasters and the Mass Media: Proceedings of the Committee on Disasters and the Mass Media Workshop, February 1979

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: A collection of papers including such topics as "research needs and policy issues on mass media disaster reporting, "criticisms of disaster media coverage generally, several case studies of media coverge on specific disasters, and the medias role in disaster warning and assistance.

AUTHOR/DATE: N.M. Newmark, and E. Rosenblueth

SUBJECT: Seismology

TITLE: Fundamentals of Earthquake Engineering

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Englewood Cliffs, Prentice-Hall Inc., 1971

DESCRIPTION:

AUTHOR/DATE: Frank R.B. Norton and J. Eugene Hass, 1970

SUBJECT: 1964 Earthquake Damage and Effects

TITLE: The Cities and Towns: Anchorage. In The Great Alaska Earthquake of 1964: Human Ecology by Committee on the Alaska Earthquake of the Division of Earth Sciences, National Research Council, National Academy of Sciences, 1970.

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Describes recovery efforts undertaken by various private and governmental groups.

AUTHOR/DATE: Otto W. Nuttli, John J. Dwyer, July 1978

SUBJECT: Assessing Earthquake Hazards

TITLE: State-of-the-Art for Assessing Earthquake Hazards in the United States. Report 10: Attenuation of High-Frequency Seismic Waves in the Central Mississippi Valley.

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Miscellaneous Paper S-73-1. Purchase Order No. CW-77-M-2480. U.S. Army Engineer Waterways Experiment Station, Geotechnical Laboratory, P.O. Box 631, Vicksburg, Miss. 39180

DESCRIPTION: "This study was concerned with the attention of high-frequency earthquake waves in central Mississippi Valley...Most attention was devoted to a study of large waves, which are higher mode surface waves that produce the largest ground motion."

AUTHOR/DATE: Otto W. Nuttli, Robert B. Hermann, December 1978

SUBJECT: Assessing Earthquake Hazards

TITLE: State-of-the-Arts for Assessing Earthquake Hazards in the United States. Report 12: Credible Earthquakes for the Central United States

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Miscellaneous Paper 5-73-1. Purchase Order No. CW-77-M-2480. Geotechnical Laboratory, U.S. Army Engineer Waterways Experiment Station, Box 631, Vicksburg, Miss. 39180

DESCRIPTION:	"This report is concerned with the problem of estimating credible values of the peak velocity and accelteration of the ground motion for central United States earthquakes." Eight seismic zones are identified. "A maximum-magnitude earthquake is determined for each zone, as well as a magnitude-recurrence equation."

AUTHOR/DATE:	Gordon B. Oakeshott, Editor, 1975
SUBJECT:	Hazard Reduction
TITLE:	San Fernando, California, Earthquake of 9 February 1971
LOCATION:	Alaska Division of Emerency Services
OTHER IDENTIFIERS:	Bulletin 196, California Division of Mines and Geology, Resources Building, Sacramento, California
DESCRIPTION:	Consists of thirty-three separate papers on topics in geology and geophysics, seismology, damage, disaster response, and minimizing losses.

AUTHOR/DATE:	Prepared by the Office of Civil Defense. Office, Secretary of the Army - Department of Defense, May 1964
SUBJECT:	Civil Defense
TITLE:	The Alaskan Earthquake
LOCATION:	Alaska Division of Emergency Services Library
DESCRIPTION:	A preliminary report concerning the great earthquake that struck southcentral Alaska on Good Friday, March 27, 1964, and subsequent Civil Defense emergency operations.

AUTHOR/DATE:	E.L. Orme, H.R. Pulley and H.C. Pulley, California State Office of Emergency Services, undated
SUBJECT:	Response Planning
TITLE:	The Managua, Nicaragua Earthquake of December 23, 1972: An Emergency Response Evaluation
LOCATION:	Alaska Division of Emergency Services
DESCRIPTION:	This report is based on information gathered in Managua within a few days after the quake. Conclusions are drawn as to the need for emergency response plans and the aspects they should cover.

AUTHOR/DATE: D.L. Orphal and J.A. Lahoud, 1974a

SUBJECT: Seismology

TITLE: Attenuation Relationships

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Bulletin of the Seismological Society of America, October, (64) 5.

DESCRIPTION:

AUTHOR/DATE: D.L. Orphal and J.A. Lahoud, 1974b

SUBJECT: Seismology

TITLE: Prediction of Peak Ground Motion from Earthquakes

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Bulletin of the Seismological Society of American, October, (64) 5.

DESCRIPTION:

AUTHOR/DATE: R.A. Page, and J. Lahr, 1971

SUBJECT: Seismology

TITLE: Measurements for Fault Slip on the Denali, Fairweather, and Castle Mountain Faults, Alaska

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Journal of Geophysical Research, December, (76) 35.

DESCRIPTION:

AUTHOR/DATE: R.A. Page, 1972a

SUBJECT: Seismology

TITLE: Crustal Deformation on the Denali Fault 1942-1970

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Journal of Geophysical Research, January, (77)

DESCRIPTION:

AUTHOR/DATE: R.A. Page, 1972b

SUBJECT: Seismology

TITLE: Micro-Earthquakes on the Denali Fault Near the Richardson Highway

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: American Geophysical Union, January, (52)

DESCRIPTION:

AUTHOR/DATE: Ronald W. Perry, 1979

SUBJECT: Response Planning

TITLE: "Evacuation Decision Making in Natural Disasters," Mass Emergencies, Volume 4(1979) pp. 25-38.

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Reviews past studies of individuals' decisions to evacuate, especially before the impact of a disaster. Summarizes findings and organizes factors influencing individuals' decisions as a conceptual framework.

AUTHOR/DATE: G. Plafker, 1967

SUBJECT: Seismology

TITLE: Surface Faults on Montague Island Associated with the 1964 Alaska Earthquake

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: USGS Professional Paper 543-G, 1967

DESCRIPTION:

AUTHOR/DATE: G. Plafker

SUBJECT: Seismology

TITLE: Tectonics of the March 27, 1964 Alaska Earthquake

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: USGS Professional Paper 543-I, 1969

DESCRIPTION:

AUTHOR/DATE: George Plafker and Reuben Kachadoorian, 1966

SUBJECT: Tsunami

TITLE: The Alaska Earthquake, March 27, 1964 Regional Effects, Kodiak and Nearby Islands

LOCATION: Alaska Division of Emergency Services Library

OTHER IDENTIFIERS: Geological Survey Professional Paper 543-D

DESCRIPTION: Geologic effects of the March 1964 earthquake and associated seismic sea waves on Kodiak and nearby islands.

AUTHOR/DATE:	George Plafker, Reuben Kachadorrian, Edwin B. Eckel and Lawrence R. Mayo 1969
SUBJECT:	Tsunami
TITLE:	The Alaskan Earthquake, March 27, 1964. Effects on Communities - Various Communities
LOCATION:	Alaska Division of Emergency Services Library
OTHER IDENTIFIERS:	Geological Survey Professional Paper 542-G
DESCRIPTION:	A description of the damage, principally from waves, vertical tectonic movements, and seismic vibration, to inhabited places throughout the earthquake - affected part of Alaska.

AUTHOR/DATE:	L.D. Porter, J.T. Ragsdale and R.D. McJunkin, 1979
SUBJECT:	Structures
TITLE:	Processed Data from the Strong-Motion Records of the Santa Barbara Earthquake of 13 August 1978, Final Results, Vol. 2, Part III.
LOCATION:	Alaska Division of Emergency Services
OTHER IDENTIFIERS:	California Division of Mines and Geology, Special Report 144
DESCRIPTION:	The Feitas Bldg. in Santa Barbara had been instrumented to measure the buildings response to earthquakes. Data obtained during the 13 August 1978 earthquake is presented. It includes accelerograms, accelterations, velocities and displacements, response spectra, fourier amplitude spectra of accelerations, etc.

AUTHOR/DATE:	Charles T. Rainey, Cecil C. Byrd, Jr., Robert H. Black, and Frederick Goshe, January 1974
SUBJECT:	Response Planning
TITLE:	San Francisco Bay Area Earthquake Response Plan. Part One: Emergency Operations
LOCATION:	Alaska Division of Emergency Services
OTHER IDENTIFIERS:	Contract No. OEP-DAP-73-23 between State of California and the Federal Disaster Assistance Administration.

DESCRIPTION: "This plan is intended to provide State and local agencies, both public and private, with a common framework for developing detailed earthquake contingency plans that are specific to their individual areas of responsibility, and that are also compatible with and support one another.

AUTHOR/DATE: Charles T. Rainey, Cecil C. Byrd, Jr., Robert H. Black, and Kenneth H. Klemm, January 1974

SUBJECT: Response Planning

TITLE: San Francisco Bay Area Earthquake Response Plan. Part Two: Operational Data Manual

LOCATION: Alaska Division of Emergency Services (FEMA, Region X)

OTHER IDENTIFIERS: Contract No. OEP-DAP-73-23 between the State of California and the Federal Disaster Assistance Administration

DESCRIPTION: Consists of sections on each of nine counties in San Francisco area. Telephone numbers of all emergency services agencies are listed for each town. Staffing and capabilities of each agency is listed. Included are additional sections on area-wide communications, coordination, control; fire resources; law enforcement, medical and health resources and emergency welfare.

AUTHOR/DATE: Alaskan Command, R.J. Reeves, Commander in Chief

SUBJECT: Recovery

TITLE: Operation Helping Hand, The Armed Forces React to Earthquake Disaster

LOCATION: Corps of Engineers Library

OTHER IDENTIFIERS: 551.22

DESCRIPTION: A publication prepared by the Alaskan Command covering the assistance provided by all the Armed Services during the 1964 earthquake recovery operations.

AUTHOR/DATE: C.F. Richter, 1958

SUBJECT: Seismology

TITLE: Elementary Seismology

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: San Francisco, Freeman and Company, 1958

DESCRIPTION:

AUTHOR/DATE: George W. Rogers, 1970

SUBJECT: 1964 Earthquake Damage and Effects

TITLE: Economic Effects of the Earthquake. In The Great Alaska Earthquake of 1964: Human Ecology.

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Discusses role of Federal financial aid in the restoration of Alaska following the 1964 earthquake. Discusses the differential benefit or loss experienced by various communities following the earthquake. Discusses the recovery of the fishing industry.

AUTHOR/DATE: H.R. Schmoll, and E. Dobrovolny

SUBJECT: Geology

TITLE: Generalized Geologic Map of Anchorage and Vicinity, Alaska

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: USGS, Map I-787-A, 1972

DESCRIPTION:

AUTHOR/DATE: P.B. Schnabel and H.B. Seed

SUBJECT: Seismology

TITLE: Accelerations in Rock for Earthquakes in the Western United States

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Report No. EERC 72-2 University of California, Berkely, July, 1972

DESCRIPTION:

AUTHOR/DATE: H.B. Seed and I.M. Idriss

SUBJECT: Seismology

TITLE: Rock Motions Accelerograms for High Magnitude Earthquakes

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Earthquake Engineering Research Center Report No. EERC 69-7, University of California, Berkely, April, 1969

DESCRIPTION:

AUTHOR/DATE: H.B. Seed, I.M. Idriss, and F.W. Kiefer

SUBJECT: Seismology

TITLE: Characteristics of Rock Motions During Earthquakes

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Journal of Soil Mechanics and Foundations Division, ASCE, Vol. 95, No. 60, No. 1, February, 1970

DESCRIPTION:

AUTHOR/DATE: H.B. Seed, and I.M. Idriss

SUBJECT: Seismology

TITLE: Analyses of Ground Motions at Union Bay, Seattle During Earthquakes and Distant Nuclear Blasts

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Bulletin of the Seismological Society of America, Vol. 60, No. 1, February, 1970

DESCRIPTION:

AUTHOR/DATE: Shannon and Wilson, Inc., August 28, 1964

SUBJECT: Soils

TITLE: "Report on Anchorage Area Soil Studies, Alaska"

LOCATION: Alaska Resources Library, Federal Building Anchorage

OTHER IDENTIFIERS: A.D.C. #113-002

DESCRIPTION: The report is a detailed account of the soil conditions after the 1964 earthquake and detailed engineering accounts of recommended actions. Each major landslide was discussed in detail including the Fourth Avenue, L Street and Turnagain slides.

AUTHOR/DATE: David B. Slemmens

SUBJECT: Assessing Earthquake Hazards

TITLE: The State-of-the-Art for Assessing Earthquake Hazards in the United States. Report 6: Faults and Earthquake Magnitude.

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Miscellaneous Paper 5-73-1. U.S. Army Engineer Waterways Experiment Station, Soils and Pavement Laboratory, P.O. Box 631, Vicksburg, Miss. 39180. Contract No. DACW39-76-C-0009

DESCRIPTION: "The main goal of this report is to review geologic methods of determining the maximum probable earthquakes for active faults based on emperical relationships between magnitude, length of surface faulting, maximum fault displacement, and combinations of fault length and maximum displacement."

AUTHOR/DATE: William Spangle and Associates, Inc., 1978

SUBJECT: Response Planning

TITLE: Post-Earthquake Land Use Planning - Alaska Earthquake, 1964

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: "The Objective of the Alaskan case study is to determine the main factors influencing reconstruction decisions following the 1964 Alaska Earthquake." Reviews damage and reconstruction planning. Focuses on Anchorage, but has sections on Seward and Valdez as well.

AUTHOR/DATE: Karl Steinbrugge and Eugene E. Schader, August 1979

SUBJECT: Vulnerability

TITLE: Mobile Home Damage and Losses, Santa Barbara Earthquake, August 13, 1978

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: State of California Seismic Safety Commission SSC 79-06

DESCRIPTION: Examines mobile home insured losses and compares projected losses for mobile homes with those of conventional wood frame dwellings in the event of an earthquake.

AUTHOR/DATE: Turman R. Stobridge, Historian, U.S. Army

SUBJECT: Recovery

TITLE: Operation Helping Hand - The United States Army, Alaska and Alaskan Earthquake, 27 March 1964 - 7 May 1964

LOCATION: Corps of Engineers Library

OTHER IDENTIFIERS: 551.22

DESCRIPTION: A very good description of the earthquake relief efforts provided by the U.S. Army. Contains description of damage and assistance provided.

AUTHOR/DATE: James A. Tanaka, 1973

SUBJECT: 1964 Earthquake Damage and Effects

TITLE: "Airports and Air Traffic control Facilities." In the Great Alaska Earthquake of 1964: Engineering

LOCATION: Anchorage Public Library

DESCRIPTION: Finds that Bryant Army Airfield at Fort Richardson was the only major Alaskan airfield operational immediately after the quake. Anchorage International and Elmendorf Air Force Base were temporarily not operating due to losses of control towers and Merril Field lacked electricity.

AUTHOR/DATE: The Texas Coastal and Marine Council, December 1978

SUBJECT: Hazard Reduction

TITLE: Model Minimum Hurricane Resistant Building Standards for the Texas Gulf Coast.

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Discusses several types of natural hazards in addition to hurricanes, procedures for delineating hazard areas to which special building codes should apply and sets forth a model minimum building standard.

AUTHOR/DATE: U.S. Department of Commerce, March 1965

SUBJECT: Recovery

TITLE: Assistance and Recovery Alaska/1964

LOCATION: Corps of Engineers Library

OTHER IDENTIFIERS: 551.22

DESCRIPTION: A report covering the activities of the U.S. Geodetic Survey in conjunction with the Prince William Sound, Alaska, Earthquake of 1964 for the period, March 27-December 31, 1964

AUTHOR/DATE: U.S. Department of Commerce, February 1966

SUBJECT: Geophysical Earthquake Research & Instrumentation

TITLE: ESSA Symposium on Earthquake Prediction, Rockville, Maryland, February 7, 8, 9, 1966

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: This is a collection of short papers grouped under the topics of physical basis of earthquakes, instrumentation for measuring quakes and gathering other data relevant to earthquakes, earthquake engineering of man-made structures and geophysical and geological survey of earthquake fault zones.

AUTHOR/DATE: U.S. Department of Commerce, National Oceanic & Atmospheric Administration, Environmental Research Laboratories, 1972

SUBJECT: Response Planning

TITLE: A Study of Earthquake Losses in the San Francisco Bay Area: Data and Analysis.

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Report estimating the life loss and damage to facilities critical to disaster recovery and relief for a range of possible earthquakes in the San Francisco Bay Area. Focuses on hospital and health services.

AUTHOR/DATE: U.S. Department of Commerce, National Oceanic & Atmospheric Administration, Environmental Research Laboratories, 1973

SUBJECT: Response Planning

TITLE: A Study of Earthquake Losses in The Los Angeles, California Area.

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Report estimating life loss and damage to facilities critical to disaster recovery and relief for two possible earthquakes in the Los Angeles Area. Focuses on hospitals and health services.

AUTHOR/DATE: U.S. Geological Survey, 1975

SUBJECT: Response Planning

TITLE: A Study of Earthquake Losses in the Puget Sound, Washington, Area

LOCATION: Alaska Division of Emergency Services Library

OTHER IDENTIFIERS: Open-File Report 75-375

DESCRIPTION: "The purpose of this report is to provide the Federal Disaster Assistance Administration and the State of Washington with a national basis for planning earthquake disaster relief and recovery operations in the Puget Sound Basin."

AUTHOR/DATE: Alaska Earthquake Analysis Center, Geophysical Institute, University of Alaska Fairbanks, April 1979

SUBJECT: Vulnerability

TITLE: Summary of Alaskan Earthquakes, October, November, December 1978

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Alaska Earthquake Analysis Center, Seismological Bulletin No. 6

DESCRIPTION: Discusses location of seismic stations, seismicity of Alaska for each of last three months of 1978 and catalogs the earthquake that occurred. Gives summary of interesting occurrences.

AUTHOR/DATE: Erik H. Vanmarche, August 1979

SUBJECT: Assessing Earthquake Hazards

TITLE: State-of-the-Arts for Assessing Earthquake Hazards in the United States. Report 14: Representation of Earthquake Ground Motion: Scaled Accelterograms and Equivalent Response Spectra.

LOCATION: Alaska Division of Emergency Services Library

OTHER IDENTIFIERS: Miscellaneous Paper S-73-1. Purchase Order No. DACW39-78-M-3907. Geotechnical Laboratory, U.S. Army Engineer Waterways Experiment Station, P.O. Box 631, Vicksburg, Miss. 39180

DESCRIPTION: "Alternative representation of earthquake ground motion for the purpose of seismic analysis and design are reviewed and critically examined, with emphasis on the relation between earthquake time histories and response spectra. Errors attributable to scaling earthquake records on peak acceleration are presented." The pitfall of...using "standard" design response spectra are pointed out, and methodolgy is proposed for developing site-specific design response spectra based on appropriate accelerograms from past earthquakes.

AUTHOR/DATE: Roger M. Waller, 1966

SUBJECT: Tsunami

TITLE: The Alaska Earthquake, March 27, 1964 Effects on Communities, Homer

LOCATION: Alaska Division of Emergency Services Library

OTHER IDENTIFIERS: Geological Survey Professional Paper 542-D

DESCRIPTION: A description of the damage caused by landmass subsidence, earthflows, landslides, seismic waves, and submarine landslides resulting from the earthquake in the Homer area, Alaska.

AUTHOR/DATE: R.M. Waller, D.J. Cederstrom, and F.W. Trainer

SUBJECT: Geology

TITLE: Data on Wells in the Anchorage Area, Alaska

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: USGS Hydrological Data No. 14, 1961

DESCRIPTION:

AUTHOR/DATE: Jack L. Walper, March 1976

SUBJECT: Assessing Earthquake Hazards

TITLE: State-of-the-Art for Assessing Earthquake Hazards in the United States. Report 5: Plate Tectonics and Earthquake Assessment.

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Soils and Pavements Laboratory, U.S. Army Engineer Waterways Experiment Station, P.O. Box 631, Vicksburg, Miss. 39180 Miscellaneous Paper 5-73-1

DESCRIPTION: Explains distribution of earthquakes in terms of continental drift theory.

AUTHOR/DATE: R.L. Weigel

SUBJECT: Seismology

TITLE: Earthquake Engineering

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Englewood Cliffs, Prentice-Hall, Inc. 1970

DESCRIPTION:

AUTHOR/DATE: Martha Richardson Wilson, M.D., 1964

SUBJECT: 1964 Earthquake Damage and Effects

TITLE: Effect of the Alaska Earthquake on Functions of PHS Hospitals. In Public Health Reports, Volume 79, No. 10, October 1964.

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Describes the damage at Alaska Native Medical Center and how the staff handled problems caused by the damage.

AUTHOR/DATE: Basil W. Wilson and Alf Torum, May, 1968

SUBJECT: Tsunami

TITLE: The Tsunami of the Alaskan Earthquake: Engineering Evaluation

LOCATION: Corps of Engineers Library

OTHER IDENTIFIERS: Technical Memorandum No. 25, May 1968
US Army Corps of Engineers, Coastal Engineering Research Center

DESCRIPTION: A technical engineering evaluation of the Tsunami caused by the 1964 Alaskan Earthquake.

AUTHOR/DATE: Harding-Lawson Assoc., E.C. Winterhalder, T.L. Williams, Jay M. England, June 1979

SUBJECT: Assessing Earthquake Hazards

TITLE: Geotechnical Hazard Assessment Municipality of Anchorage

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: H-LA Job No. 5502009.08. A report prepared for Municipality of Anchorage, Pouch 6-650, Anchorage, Alaska

DESCRIPTION: Discusses the geology of the Anchorage area, "The degree of risk from seismic activity," various types of seismic hazards, secondary hazards resulting from earthquakes and non-seismic hazards to the Anchorage area.

AUTHOR/DATE: Fergus J. Wood, Editor Vol. II A: Research Studies - Seismology and Marine Geology Part A Engineering Seismology

SUBJECT: Structures

TITLE: The Prince William Sound, Alaska, Earthquake of 1964 and Aftershocks

LOCATION: Alaska Division of Emergency Services

OTHER IDENTIFIERS: Library of Congress Catalog Card NO. 66-60055

DESCRIPTION: Technical studies analyzing the effects of the 1964 earthquake and accompanying landslides upon various types of building construction found in Alaska, primarily in the Anchorage area.

AUTHOR/DATE: M. Wyss, and J.N. Brune

SUBJECT: Seismology

TITLE: The Alaska Earthquake of 28 March 1964--A Complex Multiple Rupture

LOCATION: DOWL Engineers

OTHER IDENTIFIERS: Bulletin of the Seismological Society of America, Vol. 57, No. 5, p. 1017-1023

DESCRIPTION:

AUTHOR/DATE:	Peter I. Yanev, Editor. December 1978
SUBJECT:	Structures
TITLE:	Earthquake Engineering Research Institute Reconnaissonce Report: Miyagi-Ken-oki, Japan Earthquake, June 12, 1978
LOCATION:	Alaska Division of Emergency Services
DESCRIPTION:	Consists of reports of damage caused by Miyagi-Ken-oki, Japan earthquake to city of Sendai. This city has about a million people, 20 story buildings and numerous other sophisticated modern structures. Subjects covered are seismicity, strong-motion records, liquefication, landslides, engineering and archetectural aspects and social and government response.

AUTHOR/DATE:	M.K. Yegian, July 1979
SUBJECT:	Assessing Earthquake Hazards
TITLE:	State-of-the-Arts for Assessing Earthquake Hazards in the United States. Report 13: Probabilistic Seismic Hazards Analysis.
LOCATION:	Alaska Division of Emergency Services
OTHER IDENTIFIERS:	Miscellaneous Paper S-73-1. Contract No. DACW39-78-M-2652. Geotechnical Laboratory, U.S. Army Engineer Waterways Experiment Station, P.O. Box 631, Vicksburg, Miss. 39180
DESCRIPTION:	Reviews probabilistic seismic hazard analysis using Bayes theorum. Seismic history used to obtain parameters needed for the analysis. It is emphasized that geologic and geophysical information should also be used. Practical applications emphasizing structural and geotechnical engineering are discussed.

AUTHOR/DATE: Daniel Yutzy and J. Eugene Haas, 1970

SUBJECT: Recovery

TITLE: "Disaster and Functional Priorities in Anchorage." In the Great Alaska Earthquake of 1964: Human Ecology pp. 90-95

LOCATION: Alaska Division of Emergency Services

DESCRIPTION: Analyses behavior of Anchorage residents immediately after the 1964 earthquake in terms of seven community processes. Preservation of life was given most immediate attention, restoration of utilities and communications followed, and then maintenance of public order. Economic and leisure activities were suspended.