INVESTIGATIONS OF THE 8 NOVEMBER 1980 EARTHQUAKE IN HUMBOLDT COUNTY, CALIFORNIA

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

CONTENTS

TABLES

FIGURES

PHOTOGRAPHS

INTRODUCTION AND BACKGROUND:

On 8 November 1980 an earthquake of magnitude 7.0 (M_L; U.C. Berkeley) struck the coastal region of Humboldt County in northern California at 0227.5 PST (table 1). The epicenter was approximately 60 km NW of Eureka, the county seat, and about 50 km due west of Patricks Point (fig. 1). Felt aftershocks continued for two days, and most seismic activity ceased within ten days after the main event. Ground shaking was sufficiently intense in Eureka to awaken most people, knock small items from shelves and topple some furniture (Modified Mercalli Intensity VI-VII). Several first-hand reports indicate intense shaking lasted 15-30 seconds, a sufficiently long time for some to get out of bed and go out of doors. The main earthquake was felt from San Francisco, California to Salem, Oregon. Six people were injured and damage was minor, considering the magnitude of the earthquake.

Many small earthquakes and two moderate earthquakes have occurred in this region over the past thirty years (fig. 1). The earthquakes of 21 December 1954 (M_L 6.5; epicenter 35 km northeast of Eureka) and 7 June 1975 (M_L 5.2; epicenter 35 km south of Eureka (fig. 1) caused significant damage in the region. The 1975 earthquake caused more damage than the larger 1980 earthquake, probably because the epicenter of the former was onshore and closer to populated areas.

Most aftershock epicenters spread out northeast and southwest from the main epicenter of the 1980 earthquake (Robert McPheason, 1980; oral communication). The offshore location of the main epicenter (fig. 1), the aftershock pattern, which trends almost perpendicular to the orientation of the major surface structures of the region, and the preliminary focal depth (14 km, table 1) indicate this seismic event is probably related to deformation of the Gorda plate where it is being subducted beneath the North American plate, rather than to rupture along a near-surface northwest-trending fault on the North American plate.

The Humboldt embayment, which lies southeast of the epicenter of the 1980 earthquake, is a complex Neogene basin associated with and north of the Mendocino tectonic triple junction (fig. 1). The basin contains a thick sequence of Neogene and Quaternary sediment folded and faulted into northwest-trending structures. Topographic lows, which coincide with structural lows, contain Holocene alluvial floodplain deposits that grade westward into marsh and estuarine deposits beneath shallow lagoons (Arcata and Humboldt Bays) separated from the open ocean by long bay-mouth spits. The Eel River floodplain forms the broad lowland at the southern end of the embayment.

The city of Eureka lies on a low tableland underlain by Quaternary marine deposits between Arcata and Humboldt Bays. Smaller communities, such as Arcata, Fields Landing and Ferndale lie along the margins of the low-lying regions of the basin. The alluviated lowlands, which occasionally are inundated by flood waters, are occupied by farms and are, therefore, sparsely populated. A few large lumber mills lie on lowland sites along the eastern margin of the basin and two lie on the low spit (North Spit) separating Arcata Bay from the ocean. Total population of the region is about 65,000.

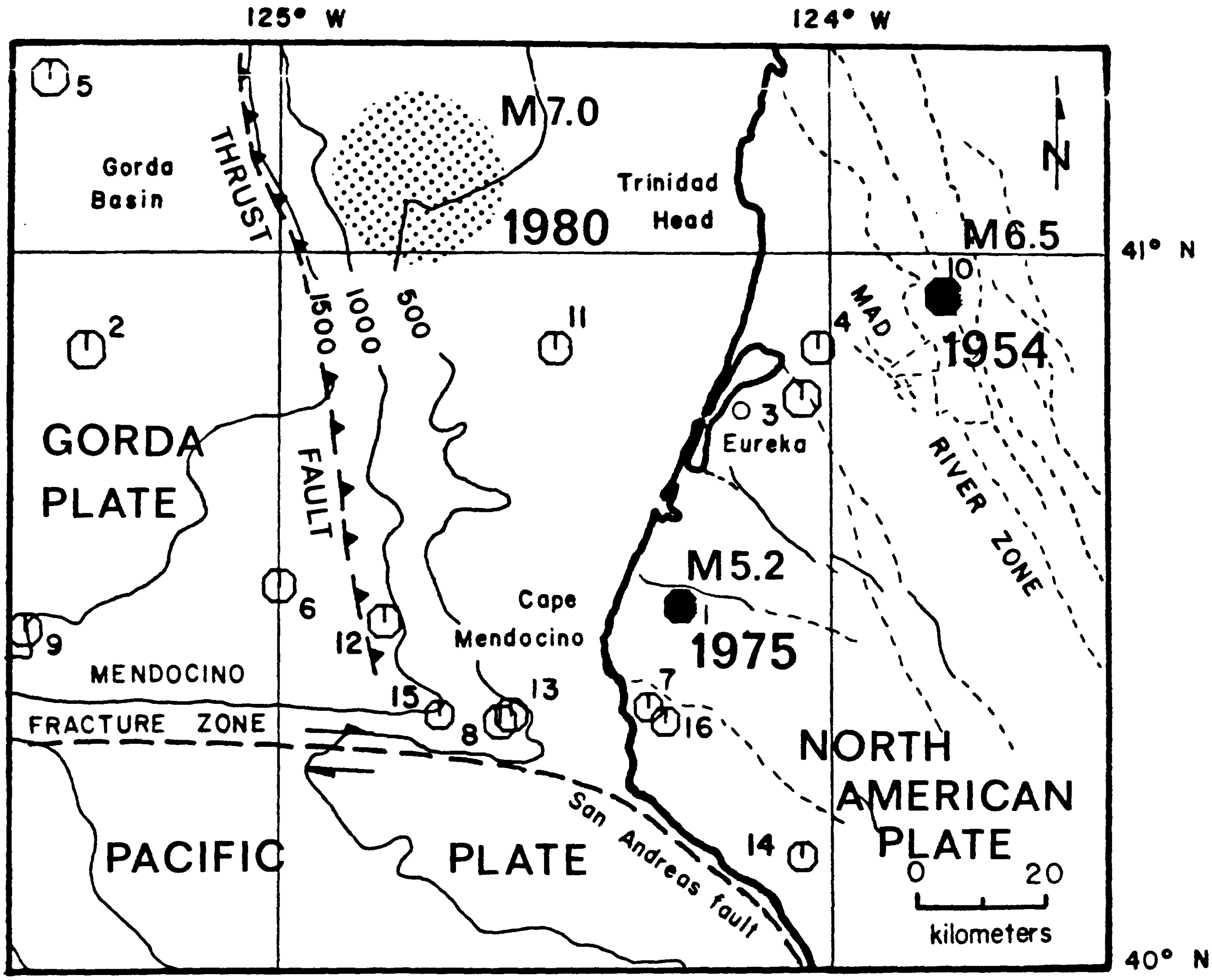
U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

NO. 45-80
DECEMBER 2, 1980

PRELIMINARY DETERMINATION OF EPICENTERS

DAY UTC	ORIGIN TIME UTC HR	MN	SEC	GEOGRAPHIC COORDINATES LAT	LONG	REGION AND COMMENTS	DEPTH KM.	MAGNITUDES GS MB	MSZ	SD	NO. STA USED
NOV	1980										
4	15	35	25.1	29.143 N	70.161 E	PAKISTAN	33 N	4.8		1.2	19
4	16	21	15.7	13.987 N	90.779 W	GUATEMALA	83	5.4		1.1	52
						FELT IN EL SALVADOR.					
4	18	41	17.8	4.468 S	102.986 E	SOUTHERN SUMATERA	78	5.1		1.0	20
4	20	25	58.8	53.803 N	160.707 E	NEAR EAST COAST OF KAMCHATKA	19	5.9	5.4	0.7	165
						FELT (IV) AT					
						PETROPAVLOVSK-KAMCHATSKIY.					
4	21	58	1.7	22.024 S	169.260 E	LOYALTY ISLANDS REGION	33 N	4.9		1.4	11
5	0	26	39.1*	6.275 S	146.567 E	EAST PAPUA NEW GUINEA REGION	54	4.4		1.2	8
5	7	22	7.1	20.144 S	175.750 W	TONGA ISLANDS	207	4.5		0.7	16
5	17	17	3.0*	23.841 N	108.686 W	GULF OF CALIFORNIA	15 G	4.8		1.1	9
5	18	15	4.3	2.750 S	122.028 E	SULAWESI	51	5.6	5.6	1.0	56
						FELT.					
5	18	51	56.3	2.723 S	122.190 E	SULAWESI	57	5.1		0.9	32
5	19	24	19.1	15.855 S	72.185 W	SOUTHERN PERU	73	4.9		0.8	11
5	21	48	14.76	38.175 N	79.901 W	VIRGINIA	4				15
						<BLA>. FELT IN BATH COUNTY.					
						MAG. 2.8 MBLG (BLA).					
6	1	34	27.5	43.722 N	86.091 E	NORTHERN SINKIANG PROV., CHINA	33 N	5.5	5.5	0.9	116
6	11	24	12.2	18.505 S	69.275 W	NORTHERN CHILE	132	4.7		1.1	16
6	16	11	56.6	17.609 S	178.911 W	FIJI ISLANDS REGION	543	4.6		0.9	25
7	2	37	57.9*	60.926 N	146.762 W	SOUTHERN ALASKA	33 N			1.1	9
						MAG. 3.3 ML (PMR).					
7	11	8	39.0	42.617 N	18.772 E	YUGOSLAVIA	10 G	3.9		1.0	23
						FELT.					
						MAG. 4.9 ML (TRI).					
7	12	36	51.5	24.061 N	122.288 E	TAIWAN REGION	33 N	5.5	5.4	0.9	104
8	2	6	58.4	36.479 N	1.605 E	ALGERIA	10 G	4.7		1.1	39
8	7	54	18.4	36.105 N	1.382 E	ALGERIA	10 G	5.3		1.0	79
						36 PEOPLE INJURED AND DAMAGE IN					
						THE EL ASNAM AREA.					
8	10	27	33.4	41.157 N	124.315 W	NEAR COAST OF NORTHERN CALIF.	14	6.2	7.4	1.1	214
						FIVE PEOPLE INJURED AND					
						CONSIDERABLE DAMAGE IN THE					
						EUREKA AREA. FELT FROM SAN					
						FRANCISCO TO SALEM, OREGON.					
						MAG. 7.0 ML (BRK).					
8	16	52	28.9*	40.381 N	125.574 W	OFF COAST OF NORTHERN CALIFORNIA	15 G	4.1	4.6	1.5	11
8	19	28	13.2	6.443 S	152.228 E	NEW BRITAIN REGION	33 N	4.4		1.3	10
8	20	25	58.6*	47.356 N	9.540 E	GERMANY	10 G			1.3	8
						MAG. 2.9 ML (GRF).					
8	21	35	40.6	24.457 S	67.643 W	CHILE-ARGENTINA BORDER REGION	83	5.2		1.0	49
8	21	50	15.7	63.345 N	145.054 W	CENTRAL ALASKA	33 N			1.2	11
						MAG. 4.2 ML (PMR).					
8	22	47	51.9*	40.531 N	125.179 W	OFF COAST OF NORTHERN CALIFORNIA	15 G	4.3		0.9	9
9	4	9	9.5*	40.586 N	125.299 W	OFF COAST OF NORTHERN CALIFORNIA	15 G	4.9	5.0	1.2	35
9	7	29	1.9*	30.333 N	113.690 W	GULF OF CALIFORNIA	15 G	4.8		1.1	18
9	8	42	41.0	35.069 N	22.958 E	CRETE	32	4.2	4.1	1.3	49
9	8	44	50.2*	52.365 N	175.186 E	RAT ISLANDS, ALEUTIAN ISLANDS	33 N			0.5	8
						MAG. 4.3 ML (PMR).					
9	14	11	7.3	16.970 S	72.736 W	NEAR COAST OF PERU	46	5.1		1.0	44
						FELT (III) AT AREQUIPA.					
9	16	14	10.7	5.482 N	126.460 E	MINDANAO, PHILIPPINE ISLANDS	108	4.9		0.7	24
9	23	24	9.3	59.924 N	153.097 W	SOUTHERN ALASKA	128			0.6	14
10	0	1	49.5	36.457 N	1.388 E	ALGERIA	10 G	4.9		1.0	30
10	16	24	41.8	31.565 S	67.442 W	SAN JUAN PROVINCE, ARGENTINA	33 N	5.6	5.4	1.1	38
						FELT (IV) IN THE SAN					
						JUAN-CORDOBA AREA.					
10	22	21	13.0	13.178 S	74.499 W	PERU	33 N	5.0		1.1	23
10	23	25	17.6*	10.461 S	119.460 E	SUMBA ISLAND REGION	33 N			1.0	9
ADDITION											
OCT											
25	11	00	05.0	21.900 S	169.861 E	LOYALTY ISLANDS REGION	33 N	5.8	7.2	1.3	76
						MAG. 7.1 MS (BRK).					

Table 1: List of moderate to large earthquakes recorded on the worldwide seismic network between 4 and 10 November 1980. The 8 November 1980 Humboldt earthquake (➤) and three aftershocks (➤) are marked. Preliminary Determination of Earthquakes data sheet No. 45-80, U.S. Geological Survey, Golden, Colorado.



Event Number	*Date*	*Magnitude* M_L	*Latitude* °N	*Longitude* °W	*Weighted Standard Error*	*Quality**
1+	June 7, 1975	5.2	40.51	124.27	0.88	A
2	Jan. 31, 1922	7.3	40.87	125.35	2.11	C
3	Jan. 22, 1923	7.2	40.80	124.05	1.39	B
4	June 6, 1932	6.4	40.87	124.02	2.43	C
5	July 6, 1934	6.5	41.25	125.42	1.34	C
6	Oct. 3, 1941	6.4	40.54	125.00	1.28	A
7	Aug. 18, 1948	5.0	40.37	124.33	1.91	D
8	Oct. 8, 1951	5.8	40.35	124.60	0.36	A
9	Nov. 25, 1954	6.3	40.48	125.46	1.52	A
10	Dec. 21, 1954	6.5	40.94	123.79	2.12	B
11	June 6, 1960	5.5	40.87	124.50	2.06	B
12	Apr. 6, 1961	5.5	40.49	124.81	1.52	B
13	Dec. 10, 1967	5.7	40.56	124.58	1.81	B
14	June 26, 1968	5.0	40.16	124.06	2.06	D
15	Feb. 27, 1971	5.3	40.36	124.71	1.65	C
16	Aug. 9, 1973	5.0	40.35	124.30	2.37	C

Figure 1: Map of Cape Mendocino area showing major tectonic features and epicenters of selected historical earthquakes. Stippled area is approximate epicentral region of 8 November 1980 earthquake (M 7.0). Data from the 1954 (M 5.2), the 1975 (M 5.3) and the 1906 San Andreas (M 8.3) eartnquakes are discussed in the text. Modified slightly from Smith and Knapp, 1980.

INVESTIGATION

This report documents observations made during postearthquake reconnaissance of western Humboldt County by the U.S. Geological Survey. This reconnaissance consisted of several traverses by automobile and on foot from 8 to 11 November, 1980, and a 1.7-hour flight in a small fixed-wing aircraft on 10 November, 1980 (Fig. 2). The purposes of the reconnaissance were to determine the nature and extent of earthquake damage and to make recommendations for further investigations. We were mainly interested in geologic effects such as ground failure (landslides and soil-liquefaction phenomena), surface rupture along faults, and areas with potential for high levels of ground shaking (alluviated lowlands).

Initial damage reports were obtained from Samuel Morrison (USGS, Arcata), Gary Carver (Humboldt State University), Thomas Stephens (Trinidad) and other staff members and students at Humboldt State University. While in the field we exchanged information with Richard Kilbourne (California Division of Mines and Geology), Jack Meehan (California State Architect's Office), Steward Smith and Robert McPhearson (Terra Corp., seismological consultants for the Pacific Gas and Electric Company), David Boore (USGS), Robert Nason (USGS) and other USGS personnel. We interviewed field crews from CALTRANS (California Department of Transportation) and numerous local citizens. Samuel Morrison (USGS), John Sarmiento (USGS) and Kohei Tanaka (Japanese Government) took part in the reconnaissance. This investigation, while not exhaustive, yielded a fairly complete account of the most significant earthquake effects.

Figures 3A, 3B and 4 are maps of the Humboldt Bay area showing sites discussed below. Following is a list of observations and site descriptions grouped according to subject: 1) structural damage, 2) landslides, 3) liquefaction-induced ground failure, 4) fault rupture and 5) intensity. The sites are numbered 1-25 from north to south on figures 3A, 3B and 4 and listed from north to south within each group below (site numbers occur in the left-hand margin before each entry). Except where otherwise noted, all these sites were inspected on the ground. A few sites that yielded negative results (i.e., no structural damage, landslides, liquefaction, or fault rupture) are included among the descriptions of sites with damage because damage occurred there during past earthquakes, or we judged it important to record that these sites were inspected.

STRUCTURAL DAMAGE:

Initial media reports indicated structural damage was relatively light throughout most of the region but fairly heavy locally at Fields Landing south of Eureka and on North Spit west of Eureka. Actually, the damage in these two areas was also light; the slightly higher damage that did occur in the Fields Landing area can be attributed to faulty design, poor building practices, or possibly to seismic amplification.

7 <u>Old Coast Highway Trinidad-Moonstone:</u>

The highway is cut by numerous old rotational slumps, which restrict the road to only one lane in places. Numerous sets of old crescentic cracks and small scarps cut the pavement. Only one of the features showed renewed movement that might be linked to the earthquake. At the observational turnout at Tepona Point, an asphalt patch over an old 25 cm scarp was displaced 1-3 mm, indicating recent downslope movement.

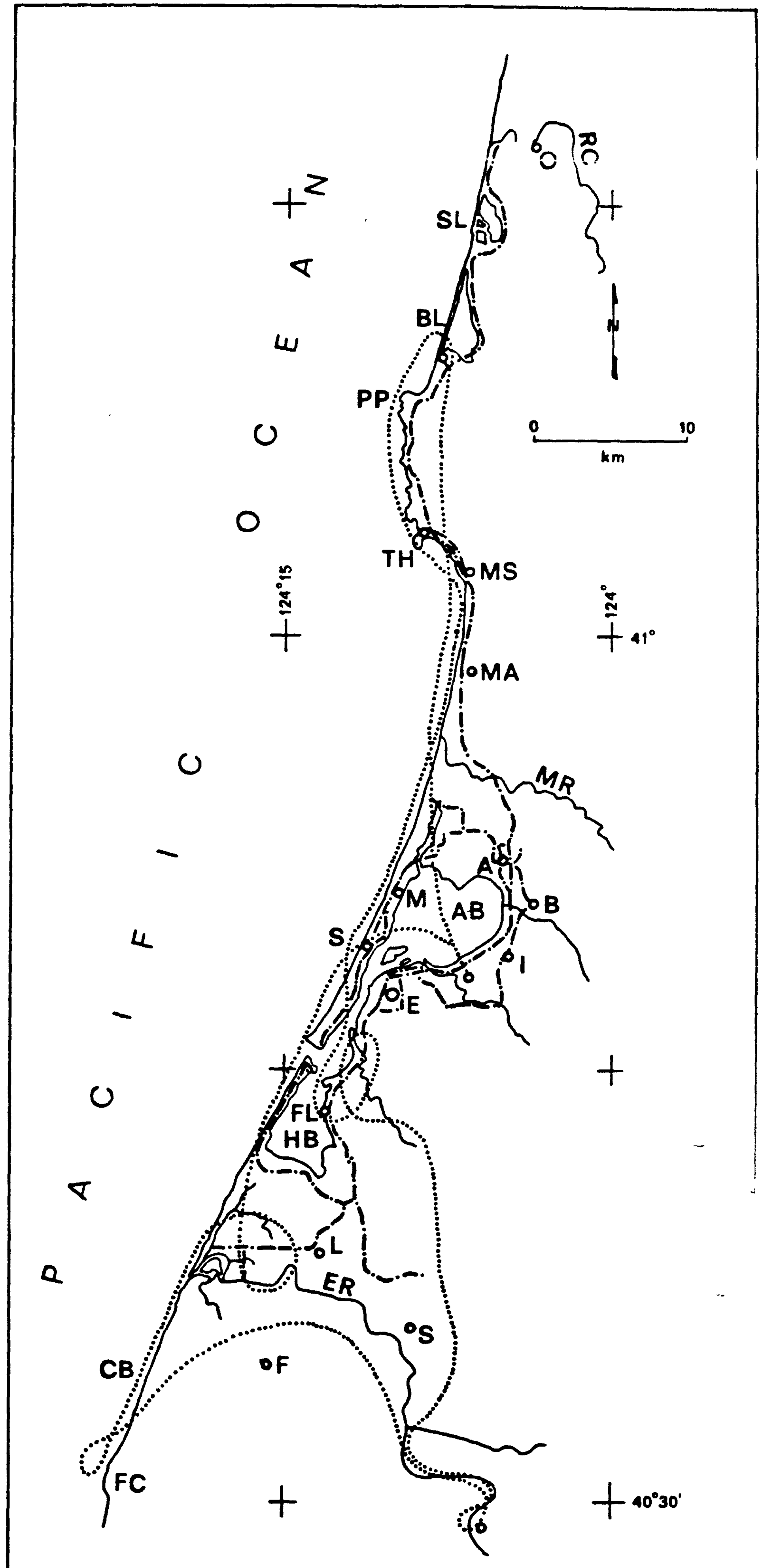


Figure 2: Map of part of coastal Humboldt County showing routes of post-earthquake reconnaissance by air (dotted line; 10 November 1980) and on the ground (dot-dash line; 8-11 November 1980). Solid light lines are shorelines and rivers.

-O: Orick
SL: Stone Lagoon
PP: Patricks Point
TH: Trinidad Head
MS: Moonstone
MA: McKinleyville airport
MR: Mad River
A: Arcata
M: Manila
B: Bayside
AB: Arcata Bay
S: Samoa
I: Indianola
E: Eureka
FL: Fields Landing
HB: Humboldt Bay
L: Loleta
ER: Eel River
S: Scotia
CB: Centerville Beach
FA: False Cape

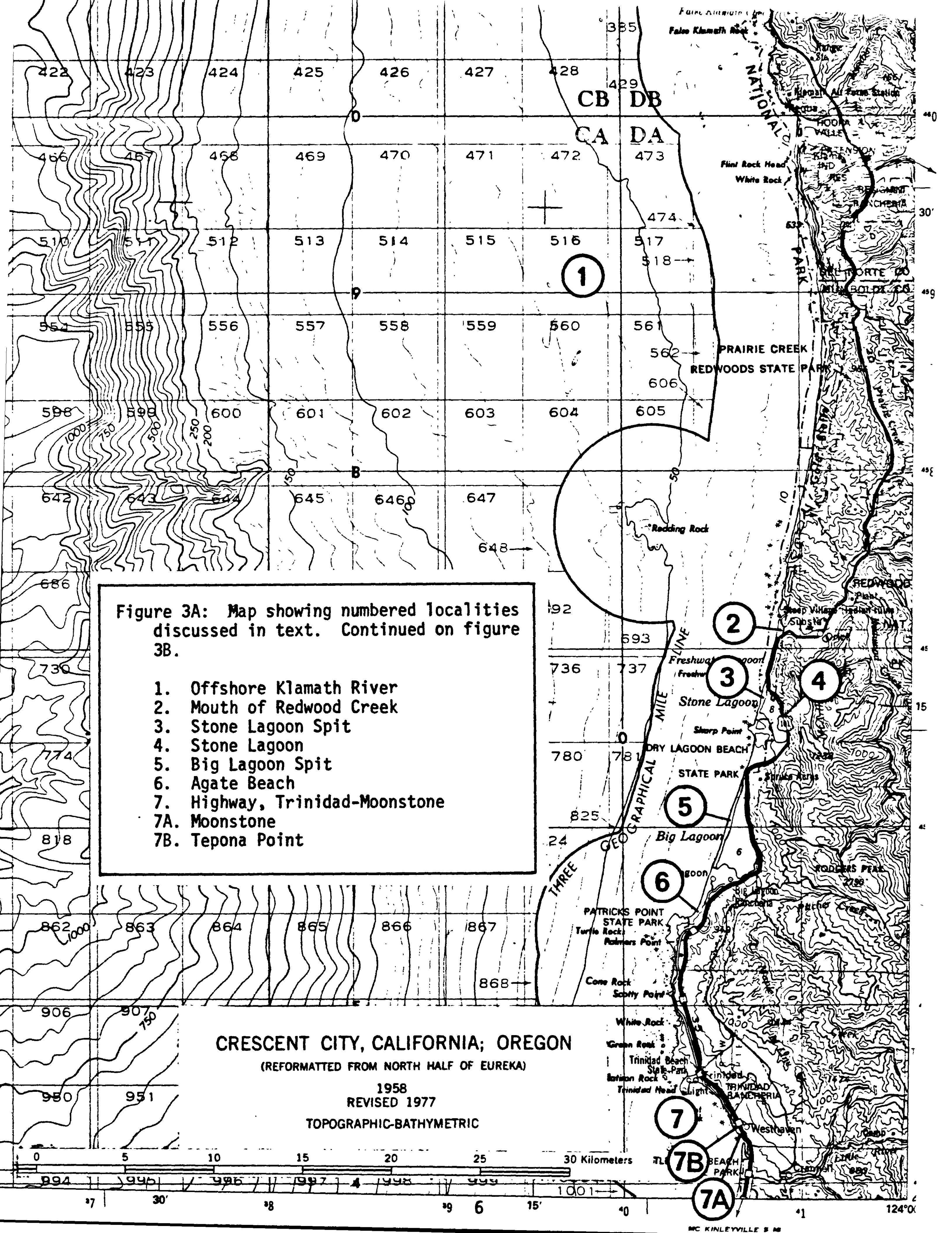


Figure 3A: Map showing numbered localities discussed in text. Continued on figure 3B.

1. Offshore Klamath River
2. Mouth of Redwood Creek
3. Stone Lagoon Spit
4. Stone Lagoon
5. Big Lagoon Spit
6. Agate Beach
7. Highway, Trinidad-Moonstone
7A. Moonstone
7B. Tepona Point

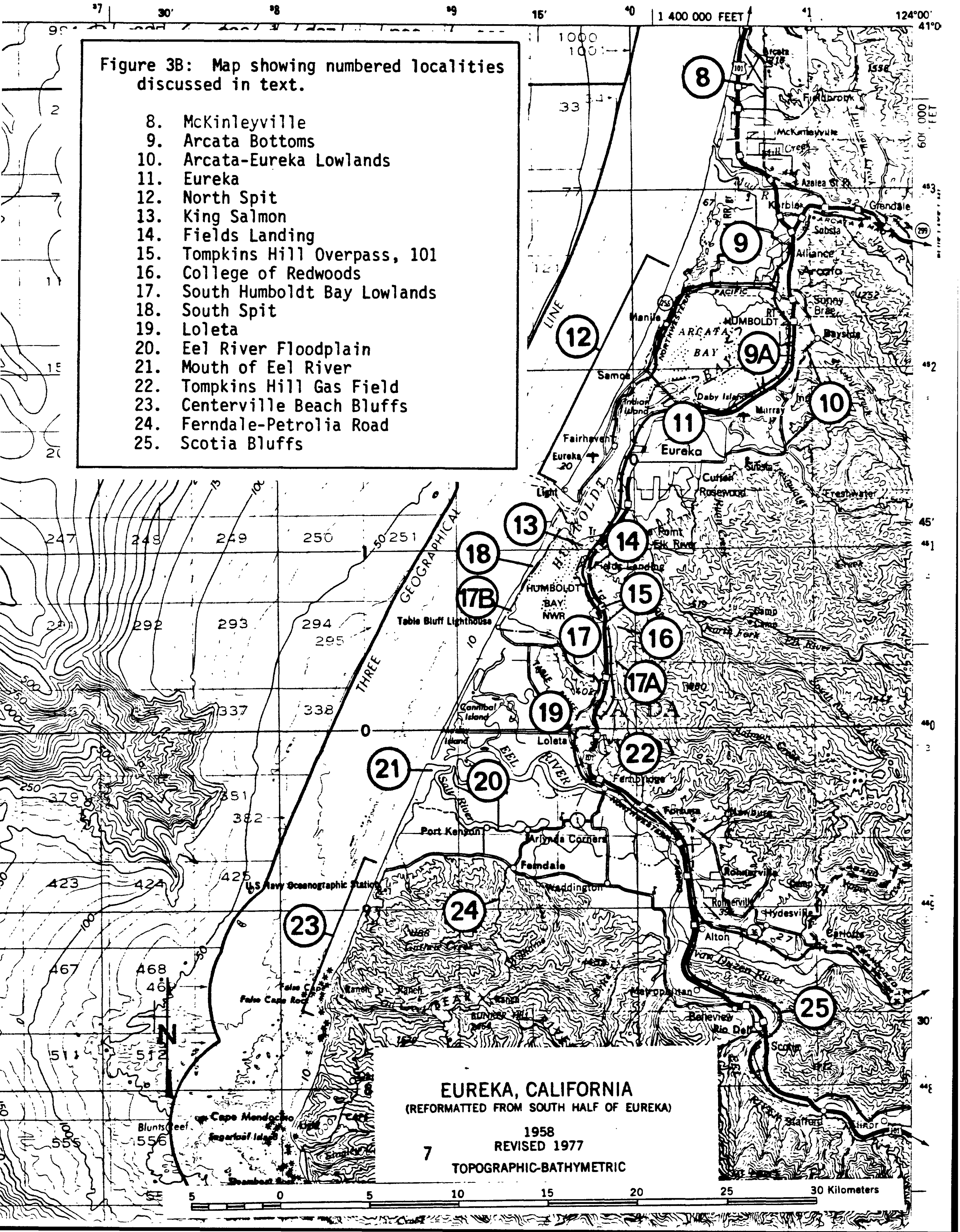


Figure 3B: Map showing numbered localities discussed in text.

8. McKinleyville
9. Arcata Bottoms
10. Arcata-Eureka Lowlands
11. Eureka
12. North Spit
13. King Salmon
14. Fields Landing
15. Tompkins Hill Overpass, 101
16. College of Redwoods
17. South Humboldt Bay Lowlands
18. South Spit
19. Loleta
20. Eel River Floodplain
21. Mouth of Eel River
22. Tompkins Hill Gas Field
23. Centerville Beach Bluffs
24. Ferndale-Petrolia Road
25. Scotia Bluffs

This section of highway runs along steep sea cliffs cut into Franciscan rocks and semiconsolidated middle Pleistocene marine deposits. Locally, engineered fills span gullies and reentrants in the cliff face.

9 Arcata Bottoms:

No bridge, road or levee damage was observed in this area. There were a few old chimneys damaged in the part of Arcata underlain by Holocene alluvial and estuarine deposits. No damage to new and most old chimneys was observed.

10 Arcata to Eureka via Indianola:

No damage occurred to roads, bridges or other structures, not even in narrow, alluvium-filled valleys or near alluvium/bedrock contacts.

11 Eureka

News media reported a few broken windows and goods fallen from store shelves, but we observed no damage. In south Eureka, mobile homes sitting on temporary, uncemented stacks of cinder blocks on a sales lot were not moved. Only one of many stacks of cement pipes in a pipe yard tipped.

12 Samoa Peninsula (North Spit):

This peninsula is a narrow Holocene baymouth spit separating Arcata Bay from the ocean. Early news reports indicated significant damage at two large lumbermills on the peninsula. Actually, both mills were virtually undamaged. Emergency switches shut down most of the equipment at the Crown Pacific mill at the time of the earthquake. A few pipe leaks caused by the shaking were quickly repaired and the plant was back in operation after two hours. At the Louisiana Pacific mill a cement block on the fourth floor of a large building fell and damaged some bleach tanks, and as a result, the mill was shut down for about eighteen hours. No other visible damage occurred at either plant, not even to tall chemical cracking towers or cement smoke stacks.

There was no visible damage to smaller structures (houses, etc.) on the peninsula at Samoa, Manila nor the Coast Guard Station. There was no visible damage (cracks, etc.) to roads, a parking lot or an old air strip on the peninsula.

In a large lumber-drying yard at Samoa only four of about two hundred stacks of loose and bundled lumber fell. Some stacks were about 8 m high and had bases 2-3 m wide. Similar lumber yards at Arcata and at Fortuna observed from the air also were virtually undisturbed.

13 King Salmon:

This peninsula is underlain by semiconsolidated Pleistocene marine deposits and locally by Holocene alluvial and estuarine deposits.

At the highway bridge near the entrance to the Humboldt nuclear power plant, the asphalt at one of the abutments was broken by two fresh cracks a few millimeters wide. These cracks were caused by a slight displacement of the bridge during the earthquake. The projected surface trace of the Buhne Point fault runs close to this bridge (fig. 4), but there is no compelling evidence that the observed cracks were associated with fault rupture. Cracks and bridge movement were reported at this site after the 7 June 1975 earthquake but were not confirmed by later examination (Harp, 1975).

In the trailer park near the south end of King Salmon, two recently paved streets were cracked near their northwest termini. The trend of the streets is N 55°W. One crack had a strike of N 35°E and was 5-10 mm wide; the other crack had a strike of N 80°E and was 3-5 mm wide. Ground cracks developed in this trailer park during the June 1975 and December 1954 earthquakes, and sand boils were reported in this area after the 1954 earthquake (Harp, 1975). The projected surface trace of the Bay Entrance fault runs north-south through King Salmon (Fig. 4), but there is no compelling evidence that the ground cracks are related to fault displacement. The cracks were probably caused by minor earthquake-induced settlement of artificial fill.

13A The Pacific Gas and Electric Company power plant at Buhne Point (fig. 4) was not damaged. The two conventional power units were shut down for about two hours when shaking tripped circuit breakers. No damage to the nuclear power unit, which contained fuel but was in a cold shut-down mode, was reported.

14 Fields Landing:

Initial news releases indicated that earthquake damage was heaviest in the Fields Landing area (fig. 5). This old community lies in a Quaternary fault zone on a broad headland (1-2 m elevation) underlain by unconsolidated Holocene alluvial and estuarine deposits that pinch out rapidly to the east where they lap onto exposed semiconsolidated Quaternary marine deposits. The projected surface traces of the Bay Entrance fault and the eastern Hookton Channel fault run through the northern part of the community (fig. 5). The relatively high levels of damage in Fields Landing indicated there might have been surface rupture or at least movement on these faults. However, no compelling evidence indicates that is the case. Furthermore, damage was far less than initially indicated. The slightly higher level of damage at Fields Landing was probably caused by minor ground settlement and possibly by higher levels of ground shaking due to focusing of seismic waves.

At least four wood-frame houses were shifted northward on their foundations and two of these fell partly to the ground (fig. 5). All were old and, though in good condition, had poor foundations consisting of vertical wooden supports on cement blocks with virtually no lateral bracing. None of these houses sustained severe damage to their superstructures. Nearby houses, some with similar foundations, were not damaged. Mobile homes sitting on cinder block supports did not shift during the earthquake.

At least two brick chimneys fell (fig. 5). The one at the back of the Whaler's Inn was old and had virtually no lateral support. The owner of Bochi's Crab Shack reported the chimney on the roof of his house fell and did slight damage to roof joists. A few other old brick chimneys with weak mortar were cracked.

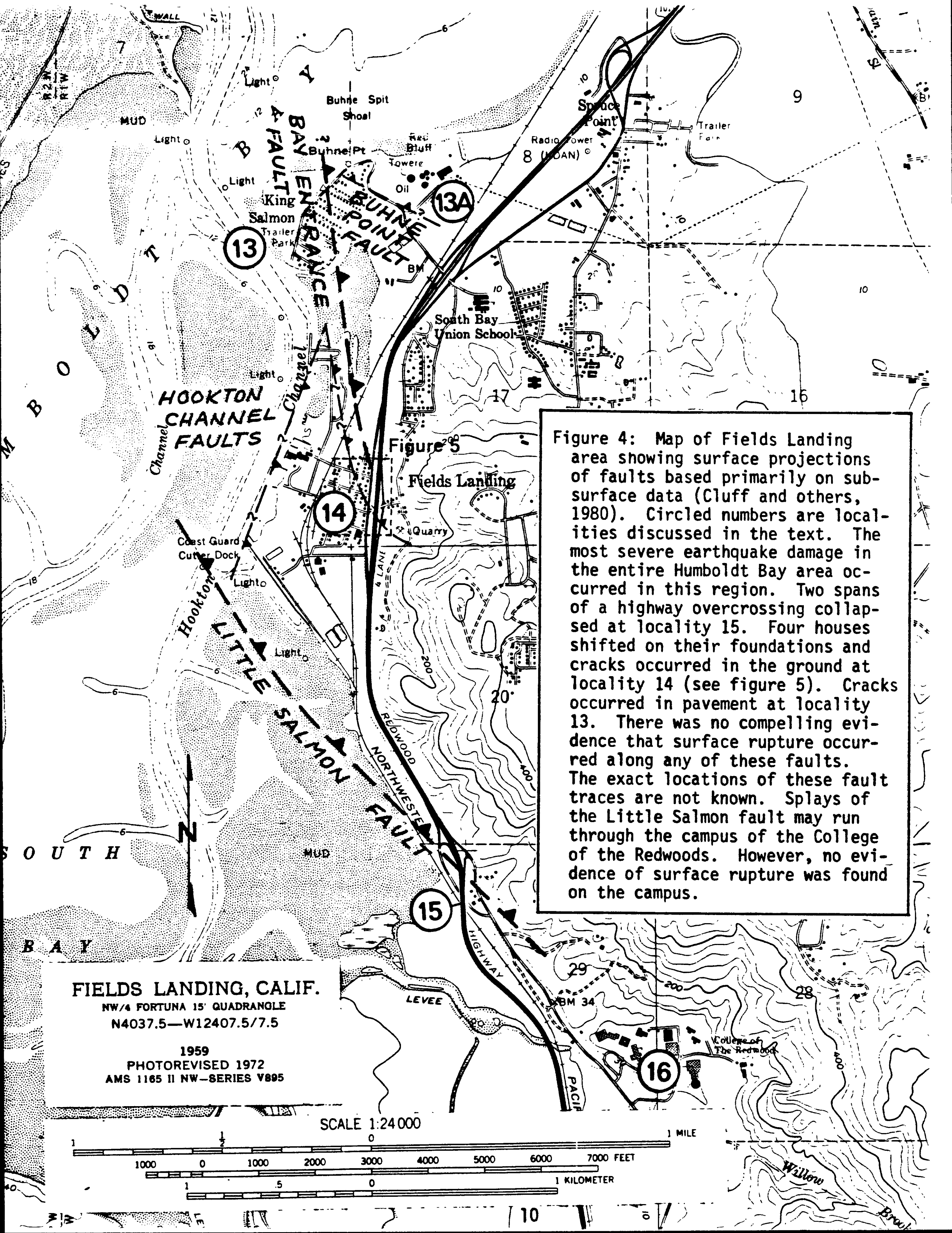


Figure 4: Map of Fields Landing area showing surface projections of faults based primarily on subsurface data (Cluff and others, 1980). Circled numbers are localities discussed in the text. The most severe earthquake damage in the entire Humboldt Bay area occurred in this region. Two spans of a highway overcrossing collapsed at locality 15. Four houses shifted on their foundations and cracks occurred in the ground at locality 14 (see figure 5). Cracks occurred in pavement at locality 13. There was no compelling evidence that surface rupture occurred along any of these faults. The exact locations of these fault traces are not known. Splays of the Little Salmon fault may run through the campus of the College of the Redwoods. However, no evidence of surface rupture was found on the campus.

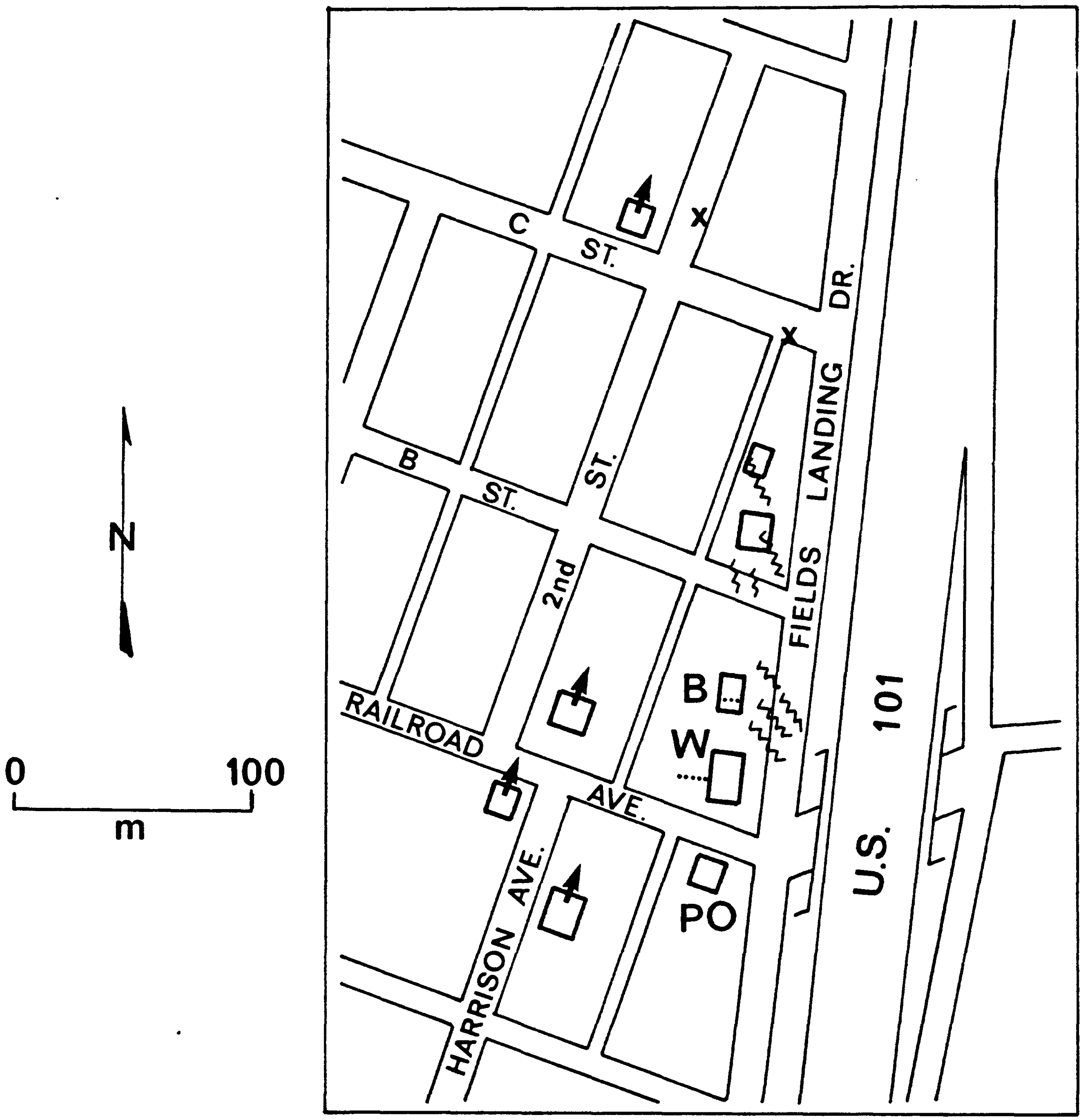


Figure 5: Map of eastern part of Fields Landing showing damage caused by 8 November 1980 earthquake. (101) Highway 101; (B) Bochi's Crab Shack; (W) Whalers Inn; (PO) combination post office, store and service station; (X) broken pipe in the ground; heavy rectangles are damaged houses and buildings with arrows pointing the approximate direction of shift on the foundations; wavy lines are cracks in the ground; dotted lines are fallen brick chimneys. This is the locality 14 in the text and on figures 3B and 4.

The two large (1.5 m x 1.5 m) windows in the combination Post Office/gas station/grocery store were broken (Fig. 5). Window frames in the Whaler's Inn, an old two story wood-frame building, were distorted slightly and one small window above an exterior door was broken.

Old cracks in the street and sidewalk in front of Bochi's Crab Shack (just north of Whaler's Inn) opened or shifted slightly (fig. 5). Some new cracks less than a millimeter wide were formed. The general trend of the cracks was about N 45°W.

One block north of the Whaler's Inn cracks opened beneath one house, damaging the porch (fig. 5). This crack ran across the yard and through a detached garage that was slightly damaged. Some of the cracks showed vertical displacement (west side down) of up to 1 cm. These cracks were probably caused by settlement of sandy fill.

Gas (?) and sewer pipes beneath two streets were broken (fig. 5).

Local citizens indicated that most fallen objects inside houses were knocked off north walls. All citizens interviewed in Fields Landing and in other parts of the region were wakened by the earthquake shaking, which lasted as long as twenty seconds, according to some.

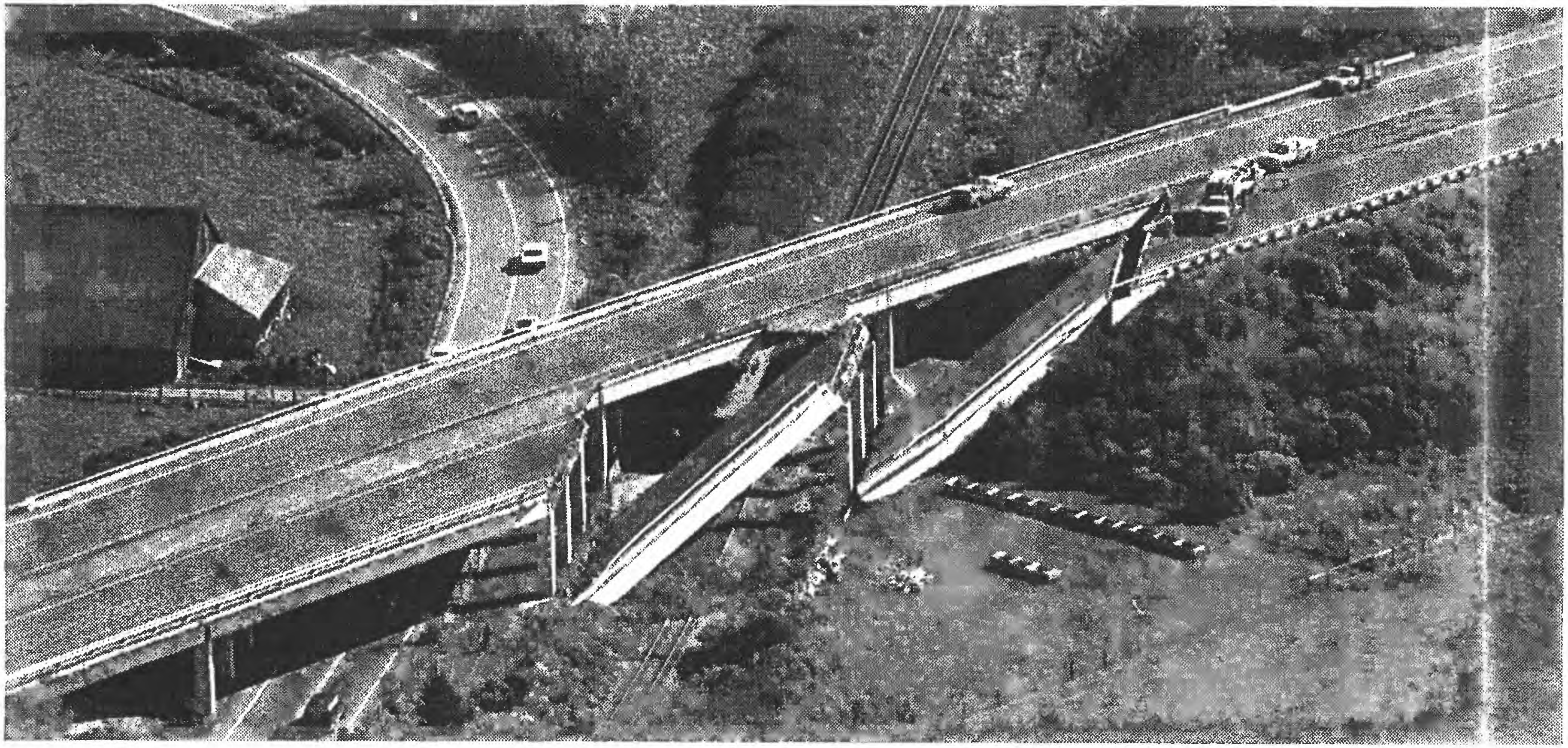
15 Tompkins Hill Road Overpass, U.S. Highway 101:

This overpass, located 2 km south of Fields Landing (figs. 3B and 4; Photos 1, 2 and 3), consists of eight reinforced-concrete spans each about 20 m long. Four end-to-end spans support two southbound lanes and four support two northbound lanes. The northern and southern extremities of this overpass are supported by cement abutments on earth-filled ramps. The joints between spans are supported by square (~1 m) concrete columns. At each joint between spans, the southern span rests on a concrete ledge only 15 cm wide on the end of the northern span (Photo 2). All joints between abutments and spans, and between spans are at an oblique angle (about 30°) to the centerline of the freeway. The spans are not anchored to the abutments nor to each other.

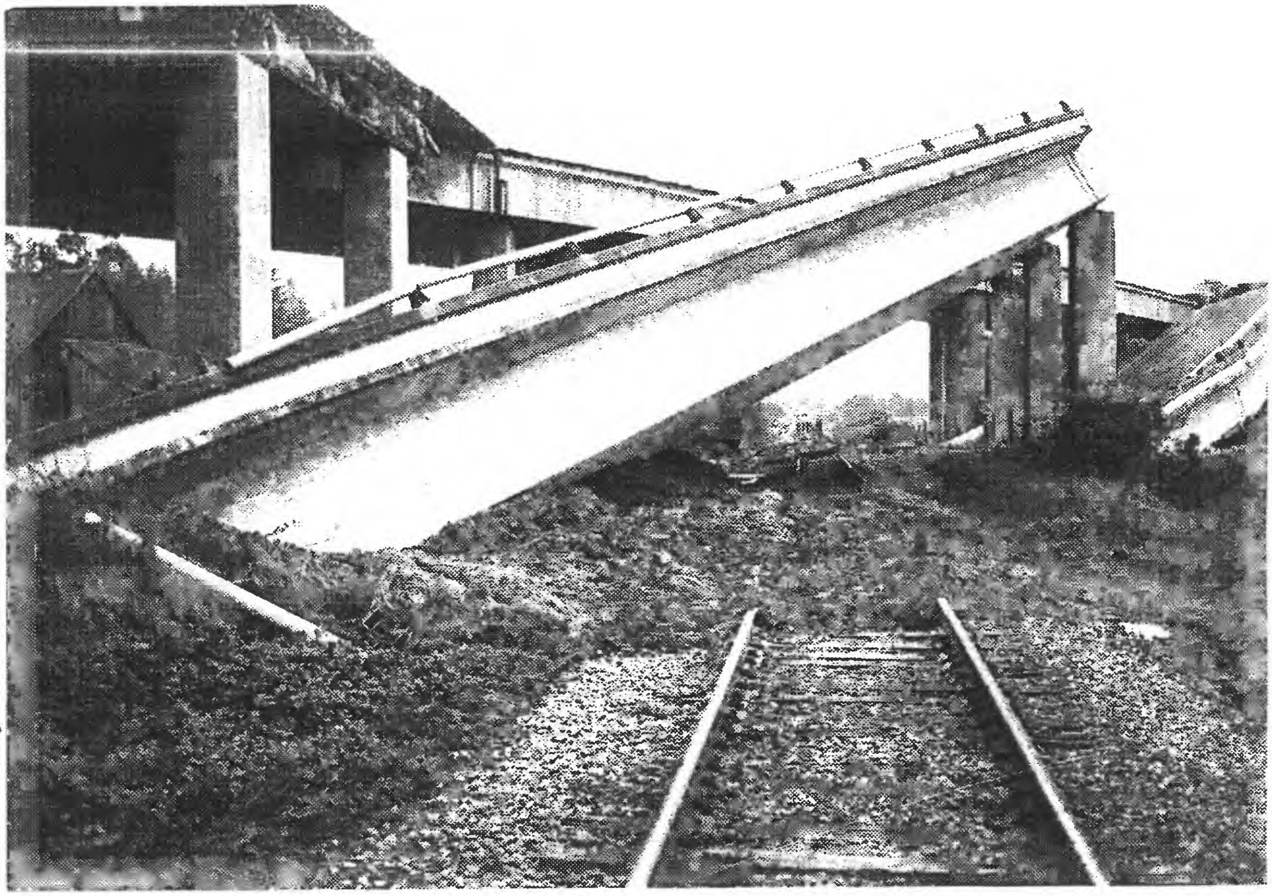
The north ends of the two southern spans in the southbound lanes came off their supports and dropped thirty feet to the ground during the earthquake (Photo 1). The only human injuries associated with the earthquake occurred when a car and pickup truck in the southbound lanes drove off the end of the span that remained in place and fell into the void created by one of the fallen spans. The south ends of the two fallen spans remained tilted against their supports. Pavement cracks opened along all joints between the spans that did not fall and along the joints at the abutments (Photo 3).

The cement columns and earth-filled abutments of this overpass structure were virtually undamaged except for hairline cracks near the base of one column, against which a fallen span was leaning (Photo 2). All columns remained vertical.

There was no visible ground failure in the vicinity of the overpass. Neither the road nor the railroad tracks beneath the overpass were damaged. Sand splashed over the tracks where the end of a fallen span hit the ground (Photo 2). The fallen span blocking the tracks was broken up and removed by CALTRANS crews, and railroad traffic resumed 11 November 1980.



Photograph 1: Aerial view of the Tompkins Hill Road overpass of U.S. Highway 101 (locality 15, Figs. 3B and 4) showing the two collapsed bridge spans in the south-bound lanes. Photograph courtesy of the Times-Standard of Eureka, California.



Photograph 2: Sand splashed across the railroad tracks where one of the spans of the Tompkins Hill Road overpass fell from its support, a ledge 15 cm wide (upper left). Note that all supporting columns are vertical and virtually undamaged. There was no evidence of ground failure in this area.

Photograph 3: Pavement cracks along a joint between a bridge span (right) and the north abutment (left) in the north-bound lanes of the Tompkins Hill Road overpass, U.S. Highway 101.

The six spans that did not fall were all sinistrally rotated a slight amount. This rotation was possible because of the oblique angle of the unanchored joints at the ends of the spans. The northern ends of the two fallen spans rotated westward enough to clear their narrow supports. This rotation could have been caused by east-west shaking or north-south transitory compression caused by shaking.

The surface projection of the Little Salmon fault runs beneath this overpass (fig. 4). However, there was no visible evidence of surface rupture along the fault. Neither the Tompkins Hill Road onramp nor the offramp show any signs of damage where they cross the projected trace of the fault, which, however, is not precisely located.

According to a CALTRANS employee, this overpass, which was built in the late 1960's, was slightly damaged in the 1975 earthquake and was scheduled for structural reinforcement in 1981.

A highway bridge at Orleans, 75 km northeast of Eureka, was reported to have settled during the earthquake. However, Lowell Allen, CALTRANS bridge inspector in Eureka, indicated he could not confirm this report and doubted the settlement was related to the earthquake. He stated that, except for the Tompkins Hill Road overpass, no earthquake-related damage had occurred to bridges along state highways in Humboldt County.

16 College of the Redwoods

Early reports of extensive damage at the College of the Redwoods (Fig. 4) were unsubstantiated. Books fell from office shelves and a few unstable items were knocked from counters in a chemistry laboratory. A student reported extensive damage to fallen clay pots in a crafts workshop. Jack Meehan reported that unsupported plate-glass panels enclosing an atrium in the library broke and many books fell from shelves. One sidewalk near the Field House (round structure at locality 16 in fig. 4) cracked and settled about 5.0 mm. No damage to any other building was observed.

During the 1975 earthquake a gas pipe broke on the third floor of the gymnasium (Field House) and tile walls were cracked (Harp, 1975).

Splays of the Little Salmon Fault may run through the campus (fig. 4). However, there was no visible evidence of surface rupture in roads, parking lots or buildings.

17 Highway, Fields Landing-South Spit

Along the old highway between Fields Landing and Beatrice, one set of crescentic cracks broke the pavement on the downslope shoulder of the roadway (locality 17A). The cracks were probably due to incipient earthquake-induced slumping of the highway fill.

19 Loleta

No damage was observed in this small town consisting mainly of old houses and buildings. An old brick dairy building with large cargo bays showed no damage. The steel railroad overpass south of town was not damaged.

(22) Tompkins Hill Gas Field:

No damage was reported nor observed in this gas field. However, R. Kilbourne reported that recording pressure-gauges on some gas wells in this field showed a pre-earthquake change in pressure and a large spike at the time of the earthquake. Our interview with the manager of this field revealed that the recording gauges could not "feel" pressure surges from the wells because the gauges are downstream from pressure regulators. The pre-earthquake shift recorded by some of the gauges were caused by adjustments to pressure valves by field operators. The recorded "pressure spikes" at the time of the earthquake were most likely caused by shaking of the gauge mounting and by equipment checks within an hour after the earthquake. Pounding on the box in which one gauge was mounted produced a "spike" on the recording.

Crescent City

Damage to a new pipeline was reported from Crescent City 108 km north of Eureka, but it is not certain that this damage was related to the earthquake. However, first-hand accounts indicate ground shaking was sufficiently intense in Crescent City to waken some people.

LANDSLIDES

(1) Offshore Klamath River:

Within a few days after the 8 November 1980 earthquake, commercial fishermen reported a new NW-trending, SW-facing scarp on the ocean floor about 15 km off the mouth of the Klamath River about 70 km north of Eureka (fig. 3A). Mike Field (USGS) confirmed the existence of this scarp and is investigating it further. No aftershocks occurred in this area so the scarp is probably related to submarine slumping associated with the main earthquake. Minor sea floor slumps and scarps are common off Humboldt County (Field and others, 1980). There were no reports nor evidence of seismic sea waves that might be related to local displacements of the sea floor.

(4) U.S. 101 East Shore Stone Lagoon:

Small rock falls with volumes of 1-2m^3 occurred in roadcuts (fig. 3A).

(6) Agate Beach:

Viewed only from the air. A few small rock falls and debris slides attributable to the earthquake occurred along the steep coastal bluffs. The largest failure had a volume of less than about 100 m^3 (Photo 4). Numerous older landslide scars and deposits along these bluffs showed no evidence of renewed movement. R. Kilbourne reported a wooden walkway along the sea cliff at Patricks Point State Park was damaged by a small landslide.

Photograph 4: Aerial view of a fresh debris slide on the coastal bluffs above Agate Beach (locality 6, Fig. 3A). The sediments exposed in the cliff face are semi-consolidated Pleistocene alluvial deposits unconformably overlain by marine sands.

(7) Old Coast Highway Trinidad-Moonstone:

At Moonstone (7A), a rockfall with a volume of about 10 m^3 occurred in a near-vertical roadcut in weakly consolidated Pleistocene sandstone (fig. 3A). One kilometer north of Moonstone another small landslide occurred in the same material. At Tepona Point (7B), one automobile-sized boulder had recently fallen from the sea cliff onto a talus pile composed of boulders of similar size.

See the section on structural damage for a description of slump scars in this segment of the old coast highway.

(17) Highway, Fields Landing-South Spit:

See the section on structural damage for a description of incipient earthquake-induced slumping of the road shoulder between Fields Landing and Beatrice (locality 17A, fig. 3B). No landslides were observed along the steep flanks of Table Bluff.

The South Spit was viewed from a vantage point just north of the Table Bluff lighthouse. About 700 m north of Table Bluff (17B), crescentic cracks occured on the bank of an irrigation or drainage ditch bordering the mud flat. These cracks may have been due to slumping of the bank caused by the earthquake. However, we did not visit this site on foot to confirm the recency of the failure.

(23) Centerville Beach, Coastal Bluffs:

Viewed from the air only. One fresh rockfall and several slides in poorly consolidated sandstone were observed along the steep coastal bluffs south of Centerville Beach (Fig. 3B). All of these slope failures were small; they involved only a few tens of cubic meters of material. The minor extent of earthquake-induced landsliding is surprising because landslide scars, hummocky topography, and tilted trees indicate slope failure occur frequently along these bluffs.

The 1906 earthquake triggered the largest landslide on the northern California coast just south of False Cape along these bluffs. This slide projected out into the ocean 0.4 km, forming a temporary headland (Youd and Hoose, 1978).

(25) Scotia Bluffs:

Viewed from the air only. The 1906 and 1975 earthquake caused large rockfalls that blocked the railroad along the steep bluffs on the north side of the Eel River (fig. 3B); (Harp, 1975; Youd and Hoose, 1978). The debris from these old rockfalls was clearly visible from the air on 10 November 1980. The only recently transported debris, however, consisted of a few boulders with an aggregate volume of less than 10 m^3 that were visible along the railroad tracks at the foot of the bluffs.

(24) Ferndale:

Richard Kilbourne reported that an earthquake-induced rock fall from a steep roadcut blocked the west lane of the Petrolia Road one mile south of Ferndale (fig. 3B).

LIQUEFACTION-INDUCED GROUND FAILURE:

(2) Mouth of Redwood Creek:

The sand spit at the mouth of Redwood Creek (fig. 3A) was traversed on foot along both flanks from its southern end to the mouth of the creek. No evidence of earthquake-induced liquefaction was found, even though the sediments on the east-facing flank are fine-grained, saturated sand that liquefied readily when tapped with a foot.

(3) Stone Lagoon Spit:

A half-kilometer traverse on foot revealed one small zone of small cracks across a subsidiary sand bar that protrudes into the lagoon at the northern end of the main spit (fig. 3A). These cracks, which were subparallel to the shoreline of the subsidiary bar, were several meters long and up to 3 cm wide. They were probably caused by local lateral spreading associated with liquefaction. However, no other evidence of liquefaction was found. Gary Carver and Tom Stephens, who traversed the entire spit, found no other evidence of liquefaction.

(5) Big Lagoon Spit:

Liquefaction-induced lateral spreads, cracks, and sand boils were observed in numerous places along a kilometer-long traverse on foot at the southern end of this spit (fig. 3A; photos 5, 6 and 7). Gary Carver and Tom Stephens reported similar features along the entire 5-km length of the spit . These liquefaction-induced features were confined to the east-facing flank of the spit along the shore of the lagoon, an area not subjected to heavy surf action. Along this flank are numerous cusps or reentrants several meters wide and several tens of meters long that are filled with soft, fine- to medium-grained sand. These reentrants are bounded by a steep slope a few decimeters high composed of firmer sand. The top of this slope is probably an old shoreline. According to Gary Carver, the last general overtopping of the spit by ocean waves was during a storm in 1941. The soft material in the reentrants was probably deposited subsequent to that time.

Lateral spreads and sand boils were confined to the reentrants. Cracks were concentrated in the reentrants also, but some cracks occurred on spurs separating the reentrants and between the reentrants and toward the crest of the spit. At one place cracks extended to the crest of the spit, a distance of 90 m from the shoreline. Some cracks also occurred in subsidiary sand bars that extend out into the lagoon from the spit. In all cases the cracks were approximately parallel to the local shoreline.

Photograph 5: A lateral spread on the east flank of Big Lagoon spit (locality 5, Fig. 3A). The lateral spread contains numerous internal scarps and cracks caused by differential displacement as the block moved toward the shoreline. The bounding scarp is about 10 m from the shoreline.

Photograph 6: Surface cracks associated with a lateral spreading on the east flank of Big Lagoon spit (locality 5, Fig. 3A).

Photograph 7: Sand Boils on the east flank of Big Lagoon spit consist of aprons of sand around a central vent. Scale is marked in 1 cm divisions. See Figs. 6A and 6B for grain-size diagrams.

The lateral spreads consisted of blocks of displaced material several meters wide and tens of meters long that were broken by numerous internal cracks, scarps and grabens (photos 5 and 6). Maximum horizontal displacements of the blocks were about one meter; maximum vertical displacements on the scarps were about half a meter. Surface slopes on which lateral spreads occurred were between 2° and 10°.

Sand boils, which formed where fountains of water and sand erupted from a subsurface layer of liquefied sand, consisted of vents surrounded by irregular aprons of fine- to medium-grained, well-sorted sand (photo 7). These aprons were a few centimeters to a few decimeters in diameter. A few vents had no sand aprons. The sand boils and vents occurred along cracks, some several tens of meters long.

Surficial material in areas of lateral spreads, cracks and sand boils is medium- to coarse-grained, gravelly sand. However, many of the sand boils had aprons composed of fine- to medium grained sand, indicating that liquefaction took place in material finer-grained than that at the surface. Grain-size curves for one sample each of surficial and sand-boil material are given in figures 6A and 6B.

9 Arcata Bottoms:

No evidence of liquefaction was observed in this area (fig. 3B), which consists of Holocene alluvial deposits grading westward into lagoonal deposits and dune sand.

12 Samoa Peninsula (North Spit):

No evidence of liquefaction was observed on this spit (fig. 3B), which consists of Holocene littoral and dune sand. Ground cracks and ground settlement occurred on this spit during the 1906 earthquake (Youd and Hoose, 1978).

9A Arcata Bay:

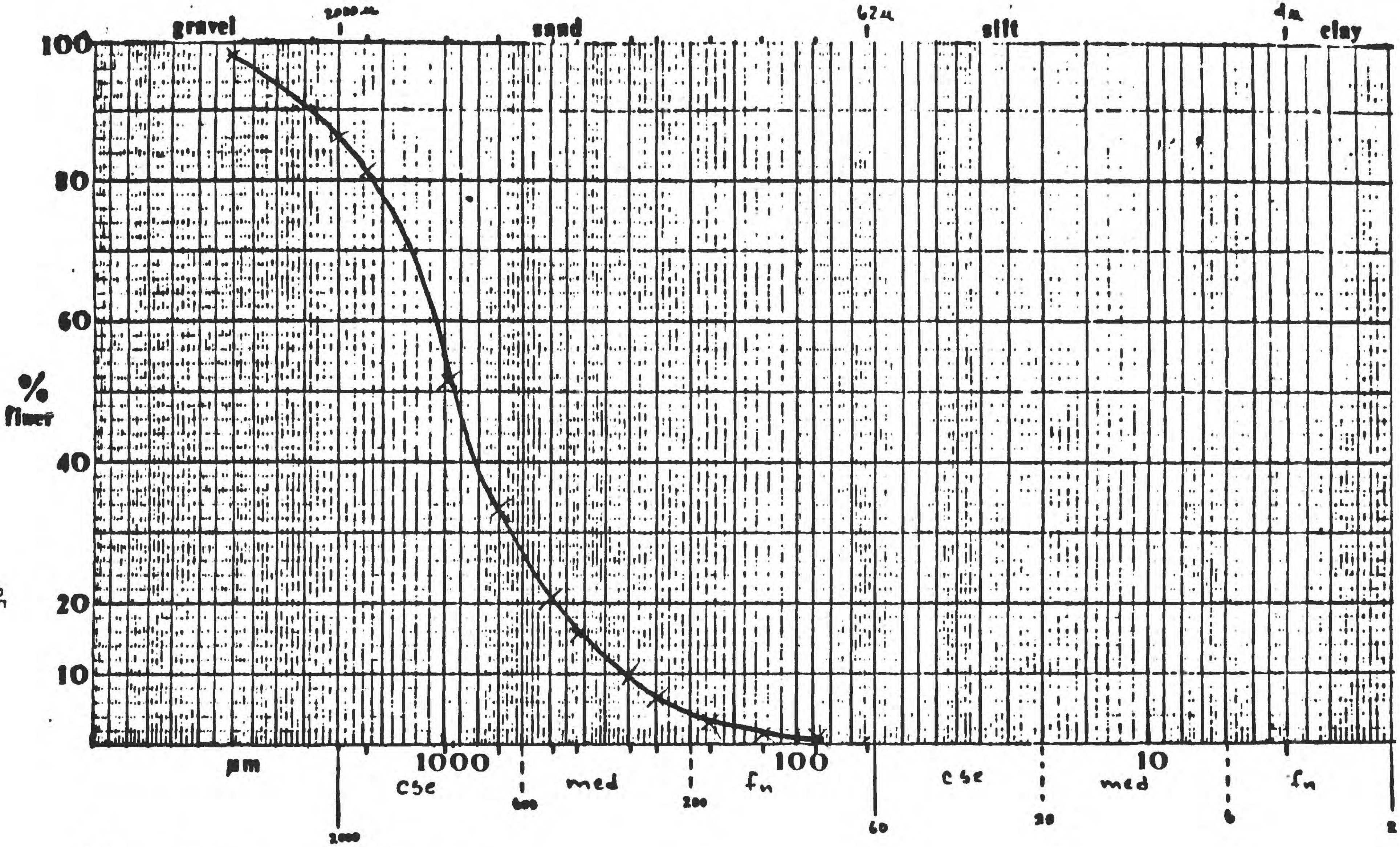
No evidence of liquefaction was observed along the southern and western margins of Arcata Bay, nor on the floodplains of Jacoby and Freshwater Creeks (fig. 3B). Some ground cracks, ground settlement and sand boils occurred in this area during the 1906 and 1954 earthquakes (Youd and Hoose, 1978).

13 King Salmon:

See the discussion of structural damage at King Salmon (figs. 3B and 4) for a description of small ground cracks that occurred here.

14 Fields Landing:

See the discussion of structural damage at Fields Landing (fig. 3B) for a description of the ground failure that occurred here. Ground fissuring and liquefaction occurred in this community during the 1906 earthquake (Youd and Hoose, 1978).



D_{60} 1.16 mm

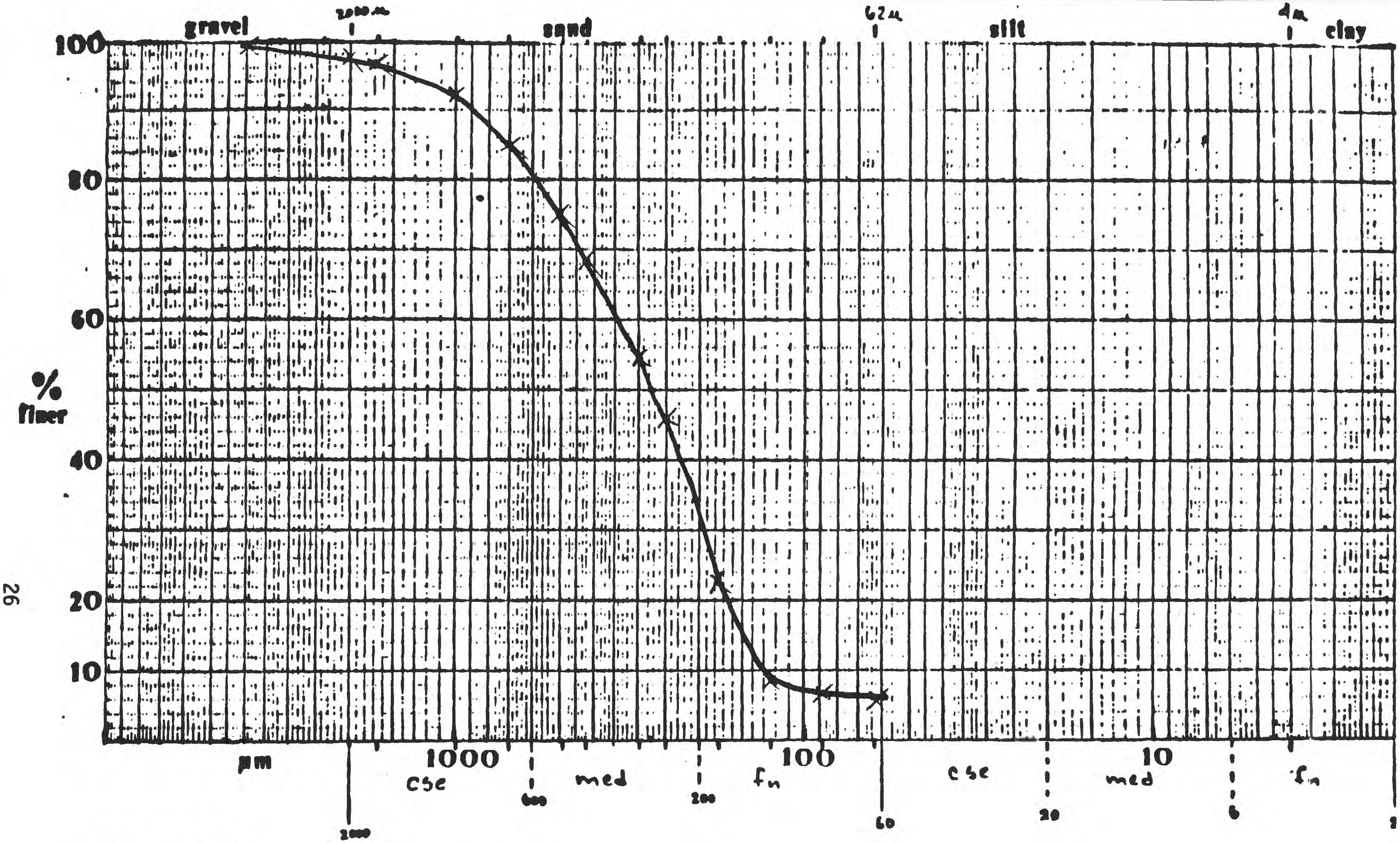
D_{50} 0.95 mm

D_{10} 0.30 mm

C_1 > 4.0 mm

$\frac{D_{60}}{D_{10}}$ = 3.9

Figure 6A: Grain-size frequency curve for a sample of surface sediment from the southern end of Big Lagoon spit (locality 5).



D_{60} 0.35 mm

D_{50} 0.28 mm

D_{10} 0.03 mm

C_1 3.6 mm

$\frac{D_{60}}{D_{10}} = 11.67$

Figure 6B: Grain-size frequency curve for a sample of sediment from a sand boil on the southern end of Big Lagoon spit (locality 5).

(18) South Spit:

On the east-facing flank of the South Spit (fig. 3B) between the low and high tide lines, one zone of fresh ground cracks was observed. This zone was 5 m long and 2 m wide. The cracks had strikes of about N 15°W. The maximum width of a crack was 8 mm. Numerous volcano-shaped mounds of sand (about 10 cm in diameter) resembling sand boils occurred on shallow tidal flats near the shore, but these were determined to be related to burrowing organisms.

No ground cracks nor other evidence of liquefaction were observed along the northern part of this spit.

(20) Eel River Floodplain:

No ground failure nor liquefaction features were observed on the ground or from the air. However, Gary Carver reported sand boils up to 2 m in diameter on the small spit on the south side of the mouth of the Eel River (locality 21, fig. 3B).

Extensive ground cracking and liquefaction occurred on the Eel River floodplain during the 1906 earthquake (Youd and Hoose, 1978).

FAULT RUPTURE

(8) McKinleyville Fault:

The McKinleyville fault is expressed as a gentle linear southwest-facing scarp on the southwest side of the Arcata airport at McKinleyville (fig. 3B). No cracks were observed in the roads that cross this scarp near the airport.

(13)-(16) Little Salmon-Bay Entrance Fault Zone:

This complex fault zone, which runs inland southeast from the Fields Landing area, consists of several northweastward dipping, high-angle reverse fault strands mapped from surface and subsurface data (fig. 4).

Splays of the Little Salmon fault may run through the west part of the College of the Redwoods campus (locality 16), where they are expressed as linear scarps and swales, and beneath the Redwood Highway (101) overpass at Tompkins Hill Road about 2 km south of Fields Landing (locality 15). No cracks were observed along the fault trace in this area.

The projected surface traces of the high-angle reverse Bay Entrance fault and Hookton Channel faults trend northward through Fields Landing and King Salmon (fig. 4). The ground cracks and broken pipes in Fields Landing (see the section on structural damage) lie near and roughly follow segments of these faults. However, there is no compelling evidence that these surface cracks, nor those at King Salmon, are related to fault rupture.

INTENSITY

We made no systematic study of intensity; however, our observations, newspaper accounts of damage and comments by local citizens provide sufficient information to assign some intensity values for the 8 November, 1980 earthquake.

Throughout the greater Humboldt Bay area (50-60 km from the epicentral area; fig. 1), people were awakened, some people ran outdoors (one man jumped out a window in panic), small items fell from shelves, some heavy furniture moved or fell, a few windows were broken, a few old chimneys cracked, but overall, structural damage was slight. These effects rate an intensity of V to VI on the Modified Mercalli Intensity Scale of 1931 (table 2). The fallen chimneys, damaged buildings and partially collapsed overpass in the Fields Landing area south of Eureka probably indicates slightly higher intensity (VII ?) in this local region, even though all these effects can be attributed to faulty design or old and substandard construction; similar design and construction are common throughout the Humboldt Basin, but damage was nowhere as great as in the Fields Landing area.

In Crescent City, California, (70 km from the epicentral area) some people were awakened and a few items fell from shelves. These effects rate a V on the intensity scale (table 2).

The U.S. Geological Survey in Golden, Colorado reported the earthquake was felt from San Francisco, California (415 km south of the epicentral area) to Salem, Oregon (470 km north of the epicentral area) (table 1). The slight effects in the outer limits of the felt zone would rate an intensity of I to II on the intensity scale (table 2).

SUMMARY

The main effects of the 8 November 1980 earthquake were secondary partial collapse of the Tompkins Hill Road overpass, four foundation failures at Fields Landing, a few broken chimneys, a few minor landslides, minor ground cracks in a few areas, and liquefaction-related features at two locations. No compelling evidence of ground rupture along local Quaternary faults was observed.

Structural damage, landslides and soil-liquefaction phenomena associated with the earthquake were minor, given the size (M_L 6.8-7.0) of the temblor; the smaller earthquakes of December 1954 and June 1975 caused considerably more damage. The depth and offshore location of the hypocenter probably account for the low level of earthquake damage in the Humboldt Bay area.

Modified Mercalli Intensity Scale of 1931 (Abridged and rewritten†)

I. Not felt. Marginal and long-period effects of large earthquakes (for details see text).
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.
IV. 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 outdoors; 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—CFR).
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—CFR). 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 C; partial collapse. Some 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—CFR.) 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.

Table 2: Modified Mercalli earthquake intensity scale of 1931 (1956 version). From Richter (1956; p. 137).

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