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SHEAR VELOCITIES AND NEAR-SURFACE GEOLOGIES AT ACCELEROGRAPH SITES THAT RECORDED THE SAN FERNANDO EARTHQUAKE

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This study seeks accurate near-surface shear-wave velocity data at several sites in the Los Angeles area. These data currently are being used to correlate both seismic velocity and strong-motion indices with local near-surface site conditions. Included is a compilation of refraction seismic survey and geotechnical data on thirty-three sites selected within the Los Angeles, California area. The sites were chosen on the basis of two criteria: (1) their relative closeness to strong motion accelerographs that recorded the 1971 San Fernando earthquake; and (2) their geologic representativeness. The main areas of concentration for these surveys were Wilshire Boulevard, Downtown Los Angeles, and Pasadena. Using the refraction technique, shear wave velocities and layer thicknesses down to approximately 70 feet were determined. Geotechnical data on geology, age, lithology, and depth, from several sources, were compiled for each site. Also provided is a summary of new field techniques developed and applied during the study. Results for this work phase are included in Appendix A.

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Abstract

Thirty-three shallow geophysical surveys were conducted at sites affected by the San Fernando earthquake of February 9, 1971. These surveys yielded shear wave velocities and layer thicknesses down to approximately 70 feet. Geotechnical data on geology, age, lithology and depth, from several sources, were compiled for each site.

Also contained is a summary of new field techniques that were developed and applied during the course of the study.

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Introduction

This report contains a compilation of refraction seismic survey and geotechnical data on 33 sites selected within the Los Angeles, California area. The sites were chosen on the basis of two criteria; (1) their relative closeness to strong motion accelerographs that recorded the 1971 San Fernando earthquake, and (2) their geologic representativeness. The main areas of concentration for these surveys were Wilshire Blvd., Downtown Los Angeles, and Pasadena.

Using the refraction technique, shear wave velocities and layer thicknesses down to approximately 70 feet were determined.

The previous report, by Duke et al. (1971) at U.C.L.A., provided seismic velocity and geologic data for sites, numbered 1 through 30, in the San Fernando earthquake area. The same basic refraction techniques used in the previous study for measuring shear-wave velocities were utilized in the present program conducted in the Summer of 1975. To provide continuity between the two reports, the sequencing of site numbers in this report begins with Site 31. Appendix A provides the results of this phase of the work.

The primary purpose of this study is to obtain accurate near-surface shear-wave velocity data at several sites in the Los Angeles area. These data are currently being used to correlate both seismic velocity and strong-motion indices with local near surface site conditions.

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Procedure

The seismic refraction technique is based upon the principle that horizontal shear waves traveling through the ground are reflected and refracted by soil layers of different velocity. Although other methods to determine velocity exist, such as down-hole and cross-hole surveys, the refraction method has the advantage of requiring less manpower and less field equipment.

The basic procedure is one that has been used previously at U.C.L.A. to obtain geophysical site data. It consists of horizontal blows to a heavy wooden plank from a 25-pound wooden mallet. The plank is laid out so that it is perpendicular to the geophone line. The front wheels of an automobile are then placed on the plank to insure maximum ground contact. The energy pulses from the transverse shots are then picked up by horizontal geophones which, in turn, are recorded by an oscillograph. For a more complete description of the technique References 3 and 4 may be examined.

In the process of conducting the present surveys, two new techniques were examined and applied:

- conducting surveys on asphaltic surfaces
- examining the effect of impact intensity on records

The new techniques were examined because (1) their application would make the surveying of an asphalt-paved site possible, and (2) they would preclude, in some cases, the need for larger energy sources. Results are given in Appendix B.

Analysis

The records obtained in the field refraction surveys consisted of a series of 12 traces and a time break from an oscillograph camera. The camera recorded a time mark for every hundredth of a second.

Since most sites were noisy, it was frequently difficult or impossible to distinguish a clear onset. As a result, for some records the first distinguishing wave form of a trace had to be used in place of the onset. In most cases this peak or trough was very close to the onset, and in all cases it was as close to onset as possible. Since the frequency content of a wave form changes with distance from the source, the velocity resulting from using peaks or troughs will vary somewhat from that resulting from using true onsets. However, a careful comparative study showed that the error involved is considerably less than that involved in determining items from the records or drawing a straight line through the corresponding points when plotted on a travel time graph.

The points derived from the records in the above manner were plotted on a time-distance graph. When a series of straight lines was drawn through the plotted points, the apparent velocities of the resulting layers were computed as the inverse of the slopes of these lines. It was estimated that a precision of from 4 to 6 percent was obtained for the velocities. Critical distances also were read off to the intersections of straight line segments, with a precision estimated to be about 20 percent.

These graphs contained information from shots at both ends of the shot line. Thus, both up-dip and down-dip apparent velocities and intercept times were found. This information and the computerized algorithm of Mooney (1973) yielded the thickness of each layer at both ends of the shot line and the true layer velocities. For a more complete descripti[illegible]iques in seismic surveying, see Reference 6.

Results

The general locations of the sites are presented in Figures 1A and 1B. The sites range geographically as far north as the OSO Pumping Plant in Gorman down to the Long Beach State University in Long Beach. Figure 1A presents a Los Angeles Vicinity map which includes those sites outside the Downtown and Wilshire areas. Figure 1B is an insert to Figure 1A and locates sites in Downtown Los Angeles and along the Wilshire Blvd corridor. These figures are meant to serve as general location maps. To obtain the exact locations, the site maps in Appendix A or the corresponding map and grid numbers of the Thomas Bros. Maps (Table 1) should be used.

General information about the location of each site is contained in Table 1. In this table, the sites are given sequence numbers which correspond to the numbers in Figures 1A and 1B and in the site sheets given in Appendix A. The sequencing of site numbers begins with Site 31. A total of 33 sites were surveyed. In addition, page and grid numbers of the Thomas Bros. Maps for Los Angeles are given. These can be used to locate the site with respect to individual streets.

Information about the length and geophone spacing of each survey is also contained in Table 1. The horizontal lengths range from 100 to 360 feet, the value depending on the local site conditions. For most of the downtown and Wilshire sites, the average length was approximately 120 to 130 feet. Longer spreads could not be obtained because of local noise problems (i.e., passing traffic). For sites located away from the metropolitan area, lengths ranging from approximately 165 feet to 360 feet were attained. In general, the spacing of the geophones was set at 10 or 15 feet. By using the shorter spacings, more detailed information was gained about the thinly bedded strata close to the ground surface.

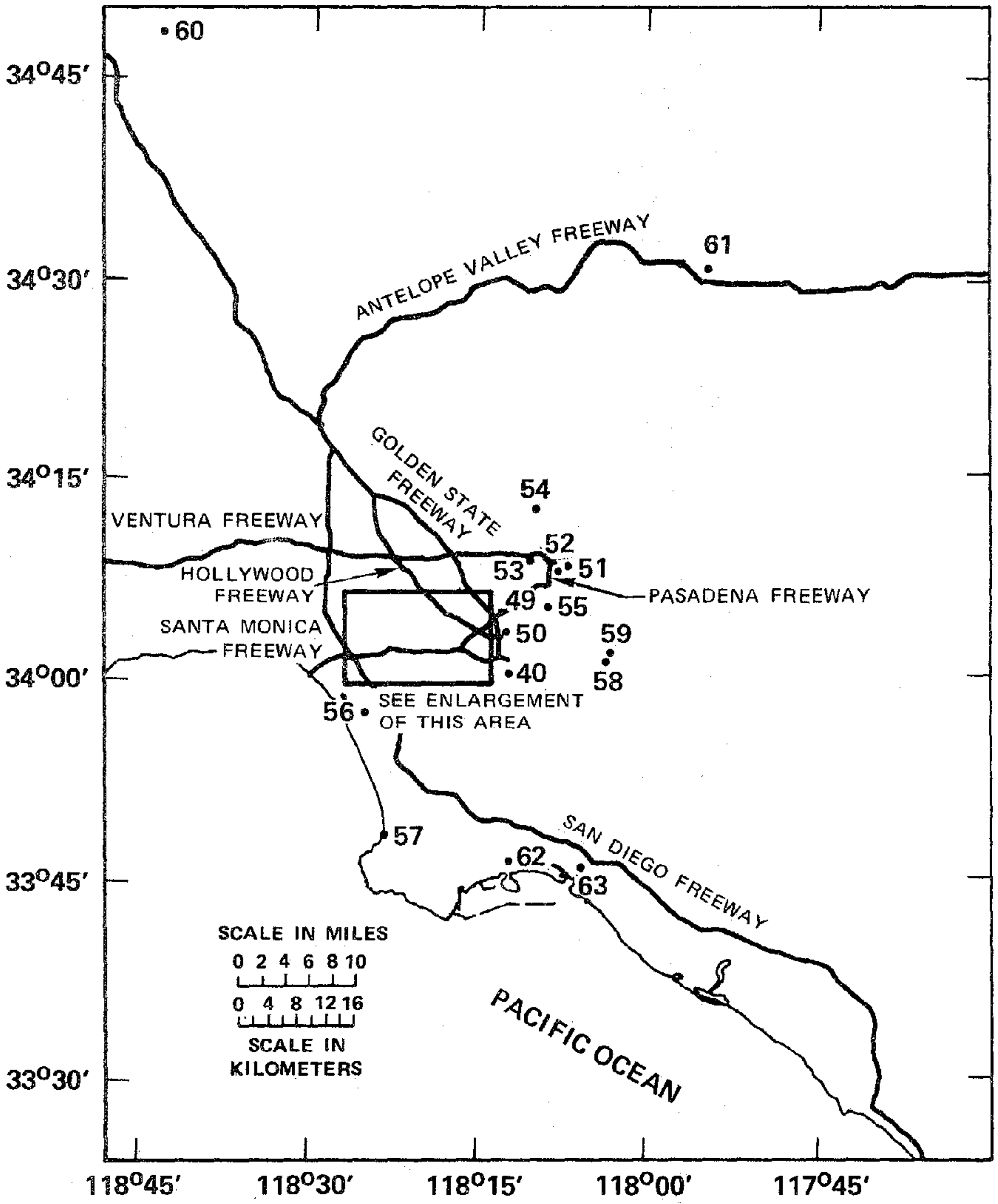

Figure 1A. Site Locations for Los Angeles and Vicinity.

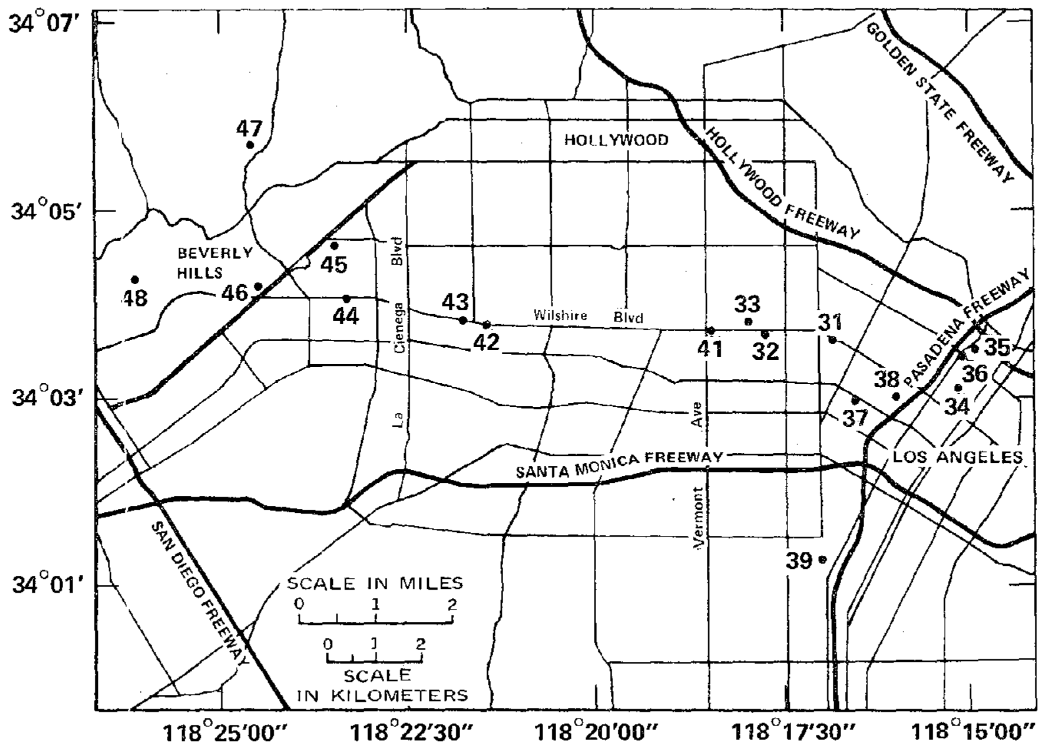

Figure 1B. Site Locations for Central Los Angeles.

TABLE 1

SITE INFORMATION

SITE NO.	LOCATION	MAP[1] NO.	MAP[1] LOCATION	SPREAD LENGTH ft	SPREAD SPACING ft
31	MacArthur Park, L.A.	44	A2	130	10
32	Ambassador Hotel, L.A.	43	F2	120	10
33	Normandie Ave. and Sixth St., L.A.	43	E1	120	10
34	Grand Ave. and Third Place, L.A.	44	D3	195	15
35	First St. and Hope, L.A.	44	D2	130	10
36	Figueroa St. and Third St., L.A.	44	C2	200	10
37	Olympic Blvd. and Valencia St., L.A.	44	B3	180	10
38	750 S. Garland, L.A.	44	B3	120	10
39	Von Kleinsmid Center, U.S.C., L.A.	44	A6	270	15
40	Loma Vista Ave. and 49th St., Vernon	53	C3	182	14
41	3710 Wilshire Blvd., L.A.	43	E2	180	15
42	Wilshire Blvd. and Spaulding, L.A.	42	F2	130	10
43	Wilshire Blvd. and McCarthy Vista, L.A.	42	F2	130	10
44	Wilshire Blvd. and Palm Dr., Beverly Hills	42	C1	120	10
45	435 Oakhurst Dr., Beverly Hills	33	C5	120	10
46	Santa Monica Blvd. and Linden Dr., Beverly Hills	42	B1	120	10
47	Beverly Dr. and Sutton Way, Beverly Hills	33	B4	120	10

[1] These numbers and locations correspond to those listed in the Thomas Bros. Maps for Los Angeles and Orange counties.

TABLE 1 (Cont'd)

SITE INFORMATION

SITE NO.	LOCATION	MAP NO.	MAP LOCATION	SPREAD LENGTH ft	SPREAD SPACING ft
48	U.C.L.A., Westwood	32	E6	360	30
49	Zonal St. and San Pablo St., L.A.	45	B2	130	10
50	Pomeroy St. and Mark St., L.A.	45	A2	120	10
51	Cal Tech Athenaeum, Pasadena	27	C5	165	15
52	Cal Tech Millikan Library, Pasadena	27	C5	180	15
53	Cal Tech Seismological Laboratory, Pasadena	26	E6	100	10
54	Flintridge Riding Club, Pasadena	19	D4	240	15
55	900 S. Fremont, Alhambra	37	A5	180	15
56	Westchester Rec. Center, Westchester	56	A2	240	10
57	Malaga Lane, Palos Verdes Estates	72	D2	120	10
58	Whittier Narrows Dam	47	C6	165	15
59	Legg Lake Rec. Center	47	C5	200	15
60	OSO Pump Plant, Gorman	141	---	200	20
61	Pearblossom Pump Plant, Pearblossom	185	B7	220	20
62	Ocean Blvd. and Cedar Ave., Long Beach	75	C5	120	10
63	Long Beach State Univ., Long Beach	76	C3	130	10

Table 2 provides detailed descriptions of the local geology of the sites. The geology and age were obtained from relevant geologic maps (References 7,8,9,10,12,13) and soil logs. A description of the geologic maps is provided in Appendix C. The lithology data were obtained directly off of soil logs supplied by Le Roy Crandall and Associates, Los Angeles, and the United States Geological Survey. Also obtained in this way were the thicknesses of fill or the depths to specified layers. Note that, in most cases, two sets of numbers are given in Table 2. The numbers in parentheses were taken from the geophysical surveys while the others were taken from available soil logs. The purpose of presenting both numbers was to provide a means of checking geophysical data with geotechnical data. In most cases, as may be seen, the agreement was quite good.

The layer velocities and thicknesses for each site are given in Table 3. Due to noise problems, the largest number of layers that could be detected was four. In some cases, only the thickness of the first layer could be defined. Note, however, that velocity information for each layer is available despite a lack of bottom boundary information.

TABLE 2

LOCAL GEOLOGY

SITE NO.	LOCATION	GEOLOGY	AGE	LITHOLOGY	DEPTH[1]
31	MacArthur Park, L.A.	Fill over Old Alluvium over Puente Fm.	Holocene over Pleistocene over U. Miocene	Silt, Sand & Clay over Siltstone	(3') of Fill; 20'-30' (36') to Puente Fm.
32	Ambassador Hotel, L.A.	Old Alluvium over Puente Fm.	Pleistocene over U. Miocene	Silt, Sand & Clay over Siltstone	15'-20' (15'-20') to Puente Fm.
33	Normandie Ave. and Sixth St., L.A.	Recent over Old Alluvium over Puente Fm.	Holocene over Pleistocene over U. Miocene	Silt, Sand & Clay over Siltstone	(9') to Old Alluvium; 25'-30' (27') to Puente Fm.
34	Grand Ave. and Third Place, L.A.	Old Alluvium over Fernando Fm.	Pleistocene over Pliocene	Silt, Sand & Clay over Siltstone	(15') to Fernando Fm.
35	First St. and Hope, L.A.	Compacted Fill over Puente Fm.	Holocene over U. Miocene	Fill over Siltstone	(8') of Fill
36	Figueroa St. and Third St., L.A.	Compacted Fill over Old Alluvium over Fernando Fm.	Holocene over Pleistocene over Pliocene	Silt, Sand & Clay over Siltstone	(5'-10') of Fill; 20'-30' (20'-45') to Fernando Fm.
37	Olympic Blvd. and Valencia St., L.A.	Fill over Old Alluvium	Holocene over Pleistocene	Sand and Clay w/ Gravel	(5') to Old Alluvium
38	750 S. Garland, L.A.	Old Alluvium over Fernando Fm.	Pleistocene over Pliocene	Sand and Gravelly Sand over Siltstone	15'-35' (15') to Gravelly Sand Layer; 55' to Fernando Fm.

[1] Note: Values represent thickness of fill or depth to specified layer. Numbers in parentheses are taken from geophysical surveys; others are taken from soil logs.

TABLE 2 (Cont'd)

LOCAL GEOLOGY

SITE NO.	LOCATION	GEOLOGY	AGE	LITHOLOGY	DEPTH
39	Von Kleinsmid Center, U.S.C., L.A.	Recent over Old Alluvium	Holocene over Pleistocene	Silt & Sand w/ Gravel over Gravelly Sand	10'-15' (15') to Gravelly Sand
40	Loma Vista Ave. and 49th St., Vernon	Recent Alluvium	Holocene	Sand w/Gravel	NA[2]
41	3710 Wilshire Blvd., L.A.	Old Alluvium	Pleistocene	Silt, Sand & Clay	NA
42	Wilshire Blvd. and Spaulding, L.A.	Compacted Fill over Old Alluvium	Holocene over Pleistocene	Silt, Clay & Sand over Asphaltic Sands	(8') of Fill; 25' to Asphaltic Sands
43	Wilshire Blvd. and McCarthy Vista, L.A.	Old Alluvium	Pleistocene	Silt, Clay & Sand over Asphaltic Sands	45'-50' to Asphaltic Sands
44	Wilshire Blvd. and Palm Dr., Beverly Hills	Recent over Old Alluvium	Holocene over Pleistocene	Clay over Gravelly Sand	15' (10') to Gravelly Sand (Very Dense-Old Alluvium?)
45	435 Oakhurst Dr., Beverly Hills	Recent over Old Alluvium	Holocene over Pleistocene	Silt, Clay & Sand over Gravelly Sand	10'-20' (20') to Gravelly Sand
46	Santa Monica Blvd. and Linden, Beverly Hills	Recent	Holocene	Silt, Clay & Sand	NA
47	Beverly Dr. and Sutton Way, Beverly Hills	Old Alluvium over Santa Monica Slate	Pleistocene over Triassic	NA	(3'-11') to Slate

NA[2]: Not available.

TABLE 2 (Cont'd)

LOCAL GEOLOGY

SITE NO.	LOCATION	GEOLOGY	AGE	LITHOLOGY	DEPTH
48	U.C.L.A., Westwood	Fill over Recent Alluvium	Holocene	Silt and Sand	(10') of Fill
49	Zonal St. and San Pablo St., L.A.	Diluvial Soil over Puente Fm.	Holocene over U. Miocene	Clay over Silt-stone	5'-15' (9'-16') to Puente Fm.
50	Pomeroy St. and Mark St., L.A.	Old Alluvium	Pleistocene	NA	(10' to Puente Fm.?)
51	Cal Tech Athenaeum, Pasadena	Old Alluvium	Pleistocene	NA	NA
52	Cal Tech Millikan Library, Pasadena	Old Alluvium	Pleistocene	NA	NA
53	Cal Tech Seismological Laboratory, Pasadena	Basement Complex	Mesozoic	Granite	NA
54	Flintridge Riding Club, Pasadena	Old Alluvium	Pleistocene	Silt & Sand over Gravelly Sand	(14') to Gravelly Sand
55	900 S. Fremont, Alhambra	Old Alluvium	Pleistocene	Silt & Sand over Gravelly Sand	5'-7' (10'-15') to Gravelly Sand
56	Westchester Rec. Center, Westchester	Older Dune Sand	Pleistocene	Fine to Medium Sand	(Partially Cemented Zone Near Surface)
57	Malaga Lane, Palos Verdes Estates	Old Alluvium over Monterey Fm.	Pleistocene over Miocene	Sand over Shale	(14') to Shale
58	Whittier Narrows Dam	Recent Alluvium	Holocene	Gravelly Sand	(Shallow Water Table)

TABLE 2 (Cont'd)

LOCAL GEOLOGY

SITE NO.	LOCATION	GEOLOGY	AGE	LITHOLOGY	DEPTH
59	Legg Lake Rec. Center	Recent Alluvium	Holocene	Silt and Sand	(Loose Sands)
60	OSO Pump Plant, Gorman	Recent Alluvium	Holocene	NA	NA
61	Pearblossom Pump Plant, Pearblossom	Basement Complex	Mesozoic	Granite	NA
62	Ocean Blvd. and Cedar Ave., Long Beach	Old Alluvium	Pleistocene	NA	NA
63	Long Beach State Univ., Long Beach	Fill over Old Alluvium	Holocene over Pleistocene	Silt and Sand	(3') of Fill

TABLE 3

LAYER PROPERTIES

SITE NO.	LOCATION	FIRST LAYER		SECOND LAYER		THIRD LAYER		FOURTH LAYER
		V_s	H	V_s	H	V_s	H	V_s
31	MacArthur Park, L.A.	410	3	740	9	1280	24	2640
32	Ambassador Hotel, L.A.	990	16	2500				
33	Normandie Ave. and Sixth St., L.A.	620	9	1160	18	2790		
34	Grand Ave. and Third Place, L.A.	880	2	1110	13	1370		
35	First St. and Hope, L.A.	720	8	1260				
36	Figueroa St. and Third St., L.A.	590	8	870	26	1420		
37	Olympic Blvd. and Valencia St., L.A.	510	5	1020	12	1530	13	1980
38	750 S. Garland, L.A,	1000	15	1980				
39	Von Kleinsmid Center, U.S.C., L.A.	790	15	1710	24	2310		
40	Loma Vista Ave. and 49th St., Vernon	870	16	1390	32	2000		
41	3710 Wilshire Blvd., L.A.	1040	12	1250				
42	Wilshire Blvd. and Spaulding, L.A.	630	8	1030				
43	Wilshire Blvd. and McCarthy Vista, L.A.	820	9	1480				

TABLE 3 (Cont'd)

LAYER PROPERTIES

SITE NO.	LOCATION	FIRST LAYER		SECOND LAYER		THIRD LAYER		FOURTH LAYER
		V_s	H	V_s	H	V_s	H	V_s
44	Wilshire Blvd. and Palm Dr., Beverly Hills	1000	10	1610				
45	435 Oakhurst Dr., Beverly Hills	600	8	780	15	1600		
46	Santa Monica Blvd. and Linden Dr., Beverly Hills	560	13	830	21	1470		
47	Beverly Dr. and Sutton Way, Beverly Hills	960	7	2860				
48	U.C.L.A., Westwood	440	10	880	22	1170	44	1700
49	Zonal St. and San Pablo St., L.A.	590	13	1690				
50	Pomeroy St. and Mark St., L.A.	890	9	2860				
51	Cal Tech Athenaeum, Pasadena	860	9	1200	11	1380		
52	Cal Tech Millikan Library, Pasadena	980	17	1270				
53	Cal Tech Seismological Laboratory, Pasadena	2670	34	4210				
54	Flintridge Riding Club, Pasadena	850	14	1900				
55	900 S. Fremont, Alhambra	840	11	1670				

TABLE 3 (Cont'd)

LAYER PROPERTIES

SITE NO.	LOCATION	FIRST LAYER		SECOND LAYER		THIRD LAYER		FOURTH LAYER
		V_s	H	V_s	H	V_s	H	V_s
56	Westchester Rec. Center, Westchester	890	21	2000				
57	Malaga Lane, Palos Verdes Estates	1000	14	1850				
58	Whittier Narrows Dam	1050	17	1840				
59	Legg Lake Rec. Center	520	8	670	18	820		
60	OSO Pump Plant, Gorman	560	12	740	34	1190		
61	Pearblossom Pump Plant, Pearblossom	1380	9	3930				
62	Ocean Blvd. and Cedar Ave., Long Beach	1000	7	1310				
63	Long Beach State Univ., Long Beach	500	3	1000	12	1980		

Site Sheets

The results of the analysis of each site are displayed on site sheets found in Appendix A. A master sheet is presented at the beginning of the Appendix which graphically describes and explains the information contained on each sheet.

Each site sheet contains both a map and a section. The map positions the shot line with respect to major streets and landmarks in the area. The section displays the subsurface stratification along the shot line (A-B) as determined from the surveys. The layer depths at both ends of the section were determined from the analysis previously described, which assumes straight line boundaries between layers. The shear-wave velocities are inserted in the corresponding layers.

There were some sites where the velocity boundary of the next layer was detected on only one end of the survey line. It was thought that this information, although partial, would provide useful data and therefore it was included. From this limited data a horizontal layer boundary could be estimated. This boundary is represented on the site sheets by dotted line interfaces.

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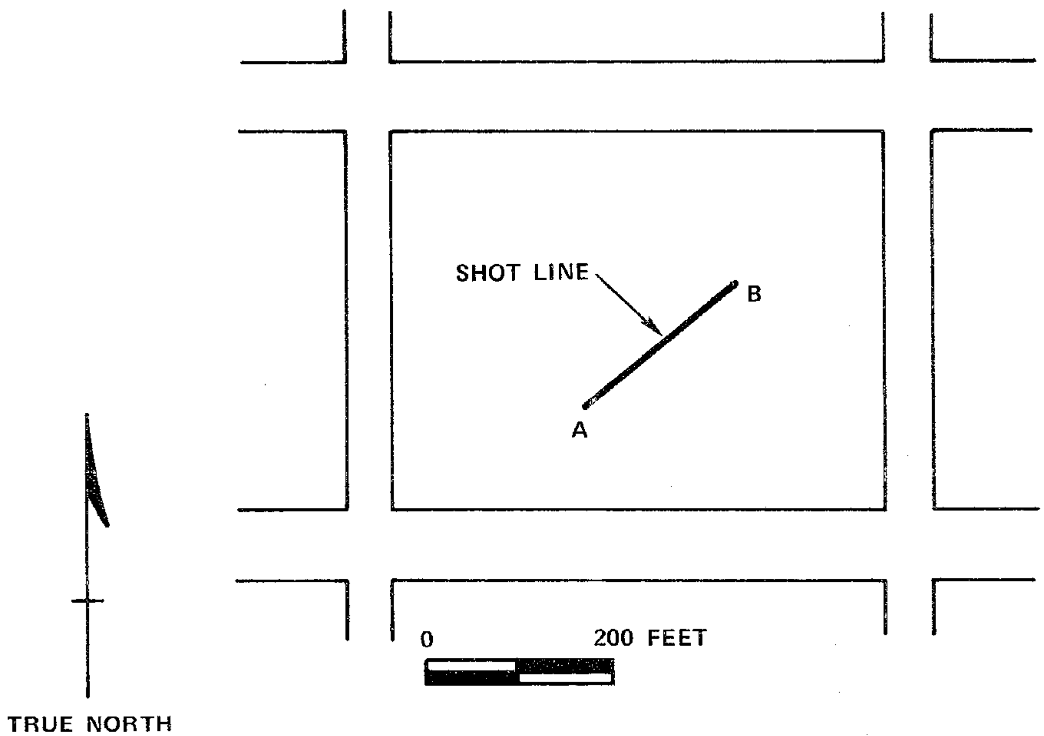
APPENDIX A

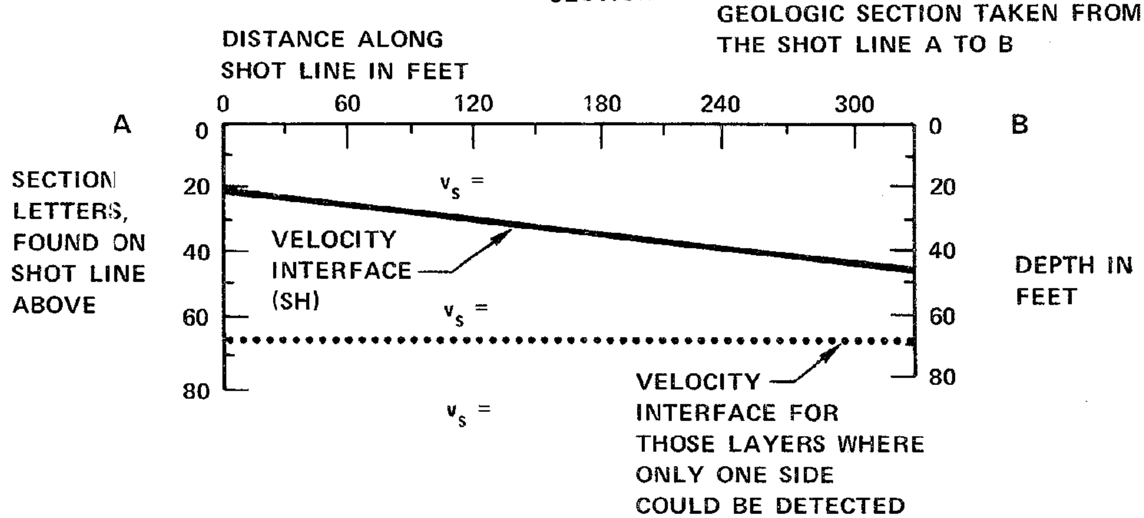
MASTER SITE SHEET

SITE: NAME AND GENERAL LOCATION OF SITE



SECTION

GEOLOGIC SECTION TAKEN FROM THE SHOT LINE A TO B



* SITE NUMBER CORRESPONDS TO NUMBERS FOUND IN TABLE 1 AND ON SITE LOCATION MAPS

DATE: DATE OF FIELD WORK

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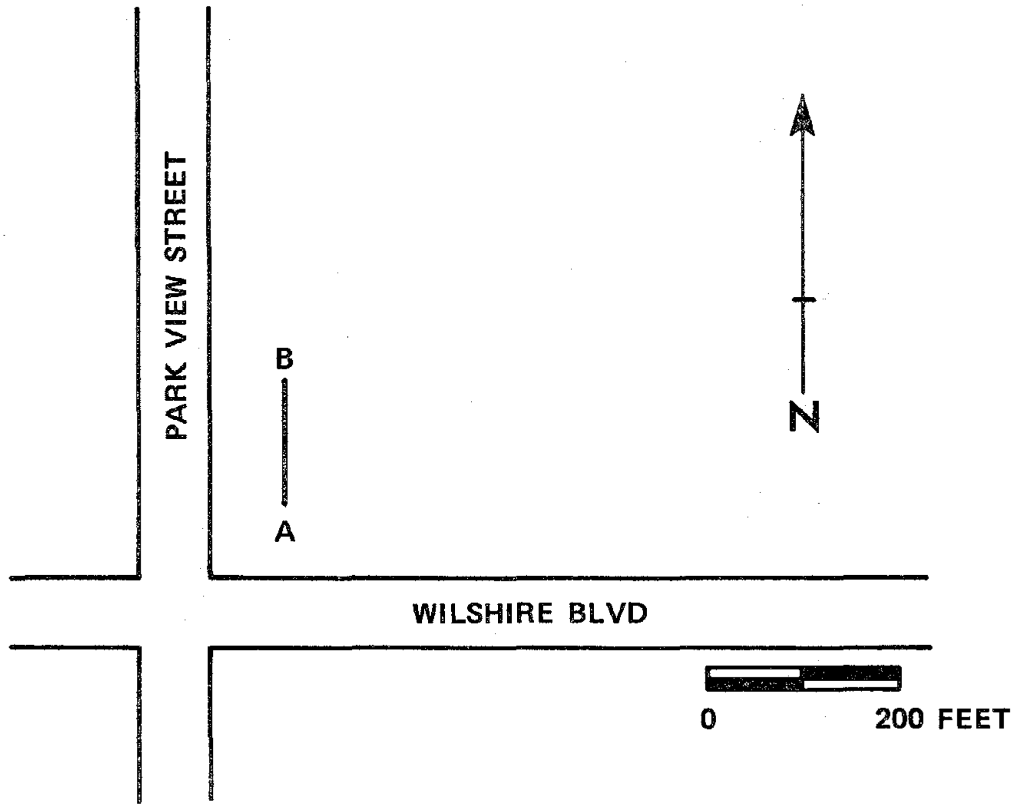
NO. 31

SITE: MAC ARTHUR PARK, L.A.



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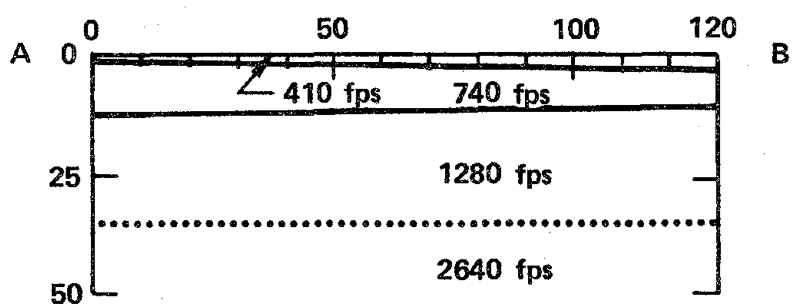
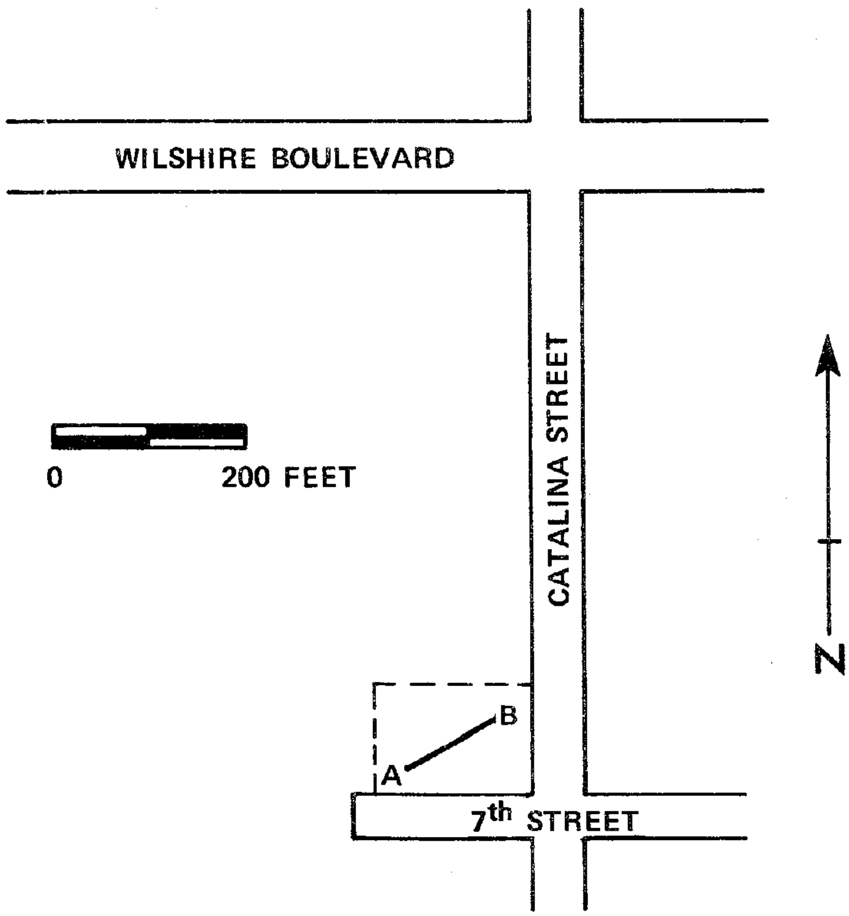


DATE – JULY 1975

NO. 32

SITE: AMBASSADOR HOTEL, L.A.



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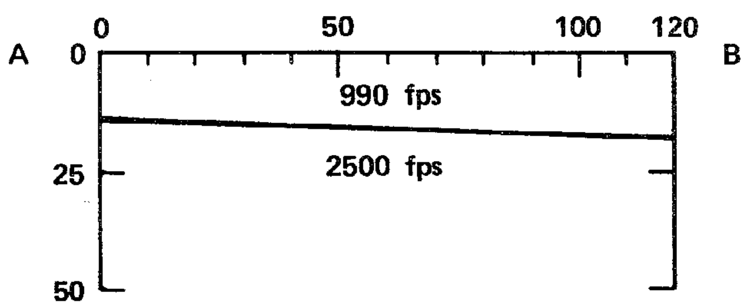
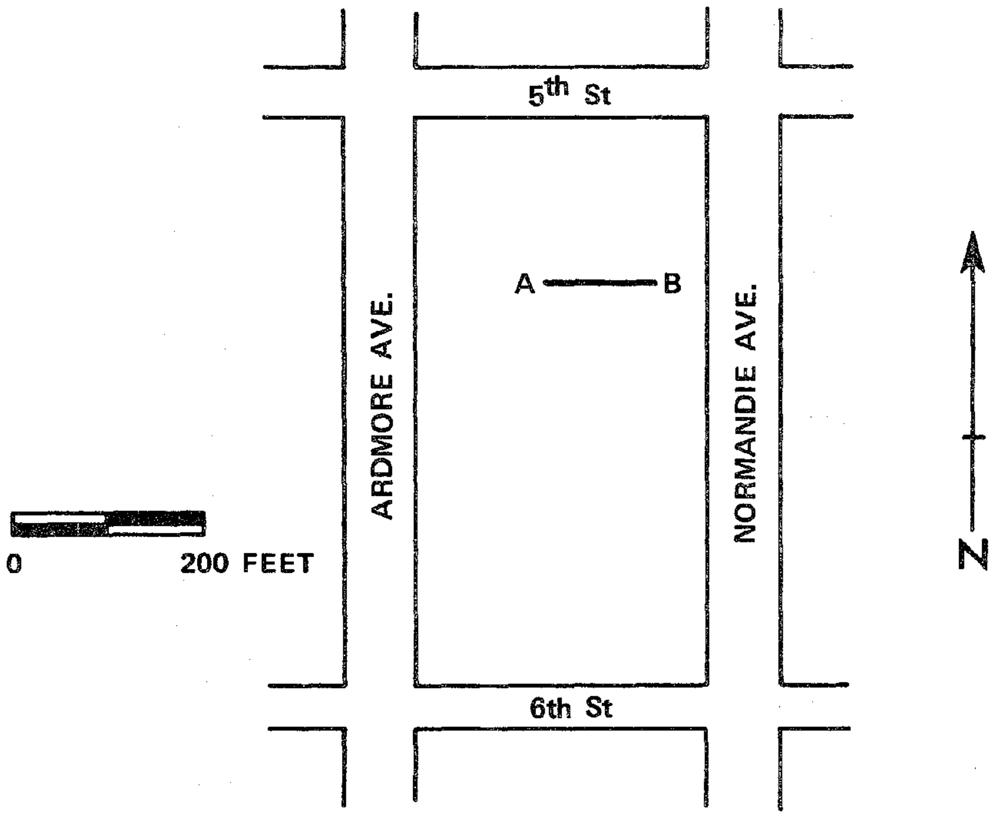


DATE – AUG. 1975

NO. 33

SITE: NORMANDIE AVE. AND SIXTH ST., L.A.



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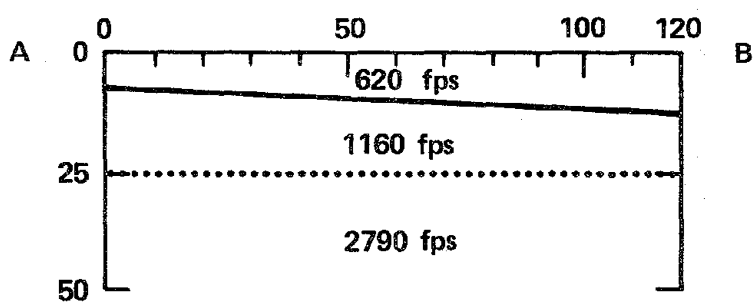
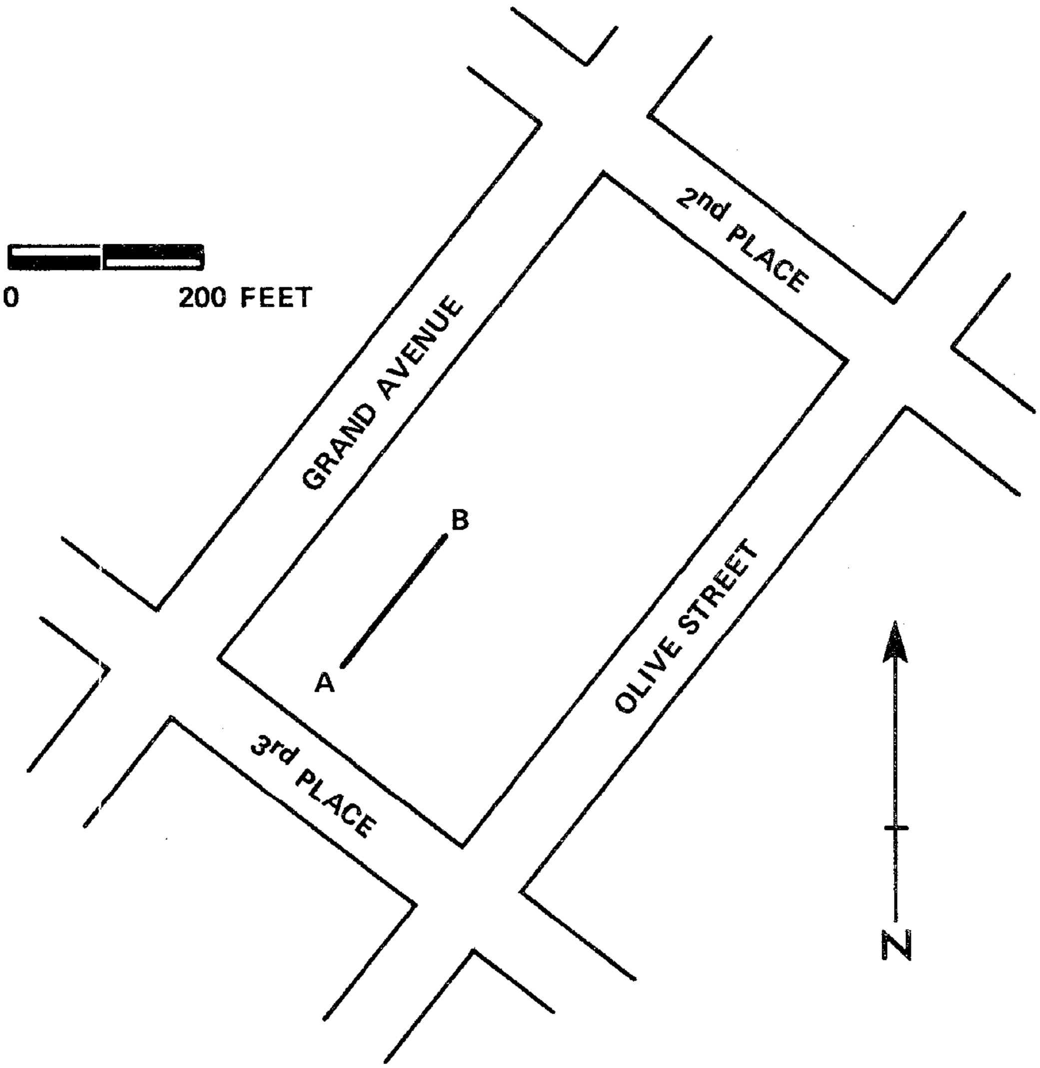


DATE – AUG. 1975

NO. 34

SITE: GRAND AVE. AND 3RD PL., L.A.



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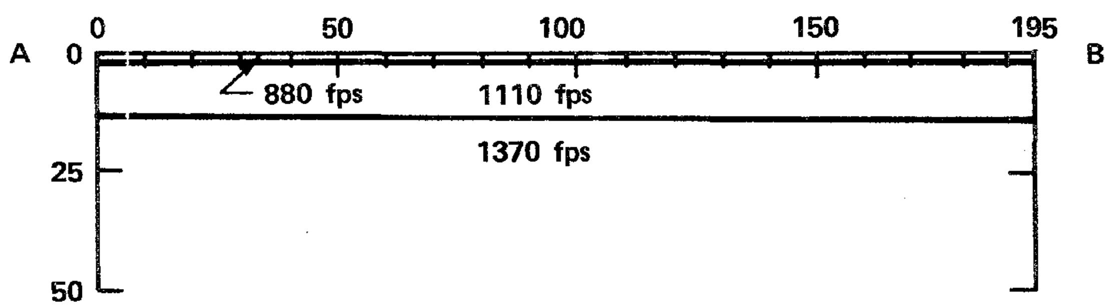
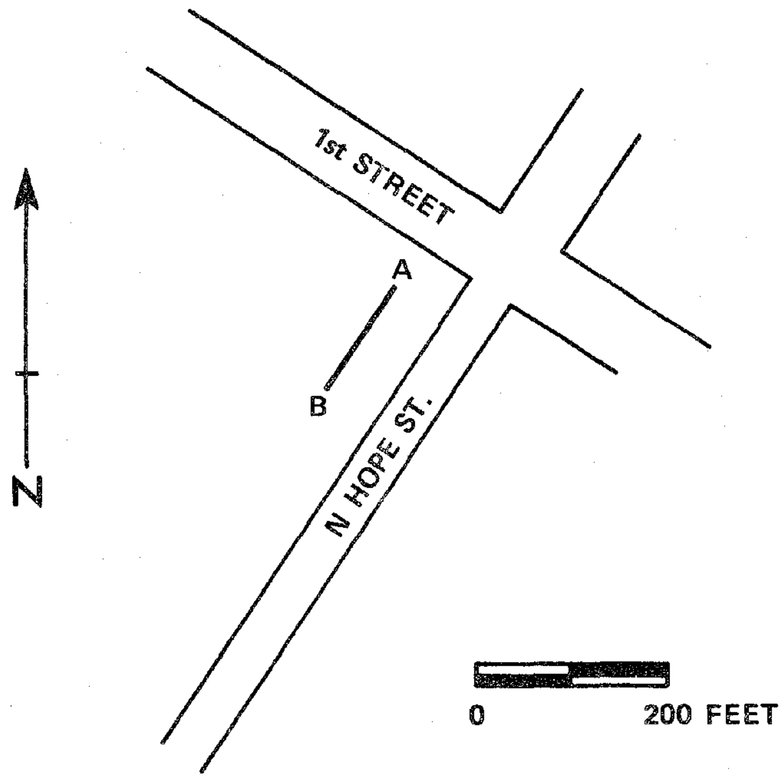


DATE – JULY 1975

NO. 35

SITE : 1st. ST. AND HOPE ST., L.A.



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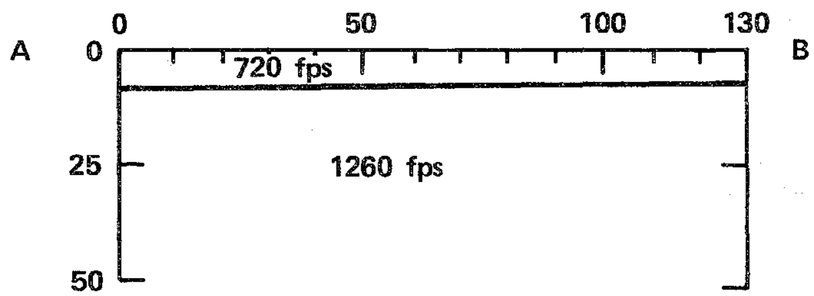
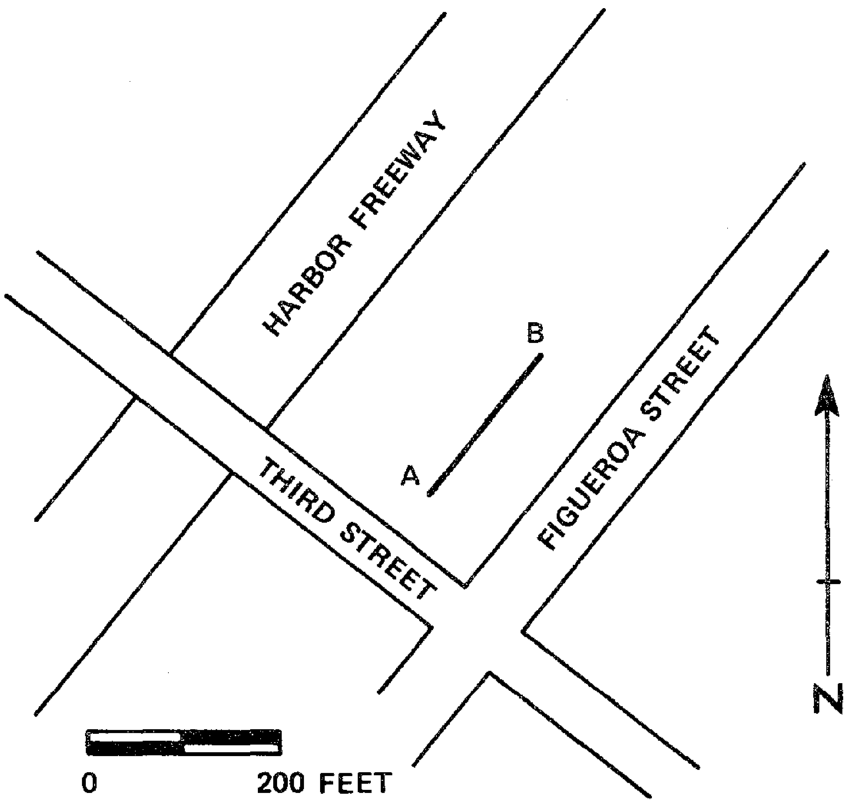


DATE – JULY 1975

NO. 36

SITE : FIGUEROA ST. AND 3RD St., L.A.



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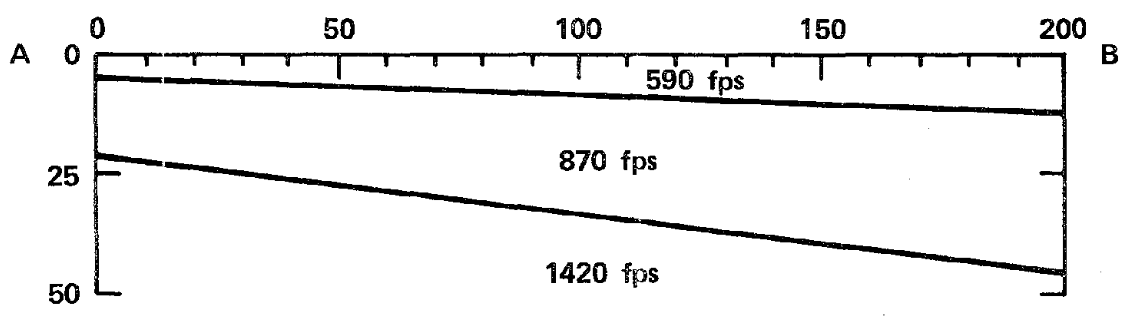
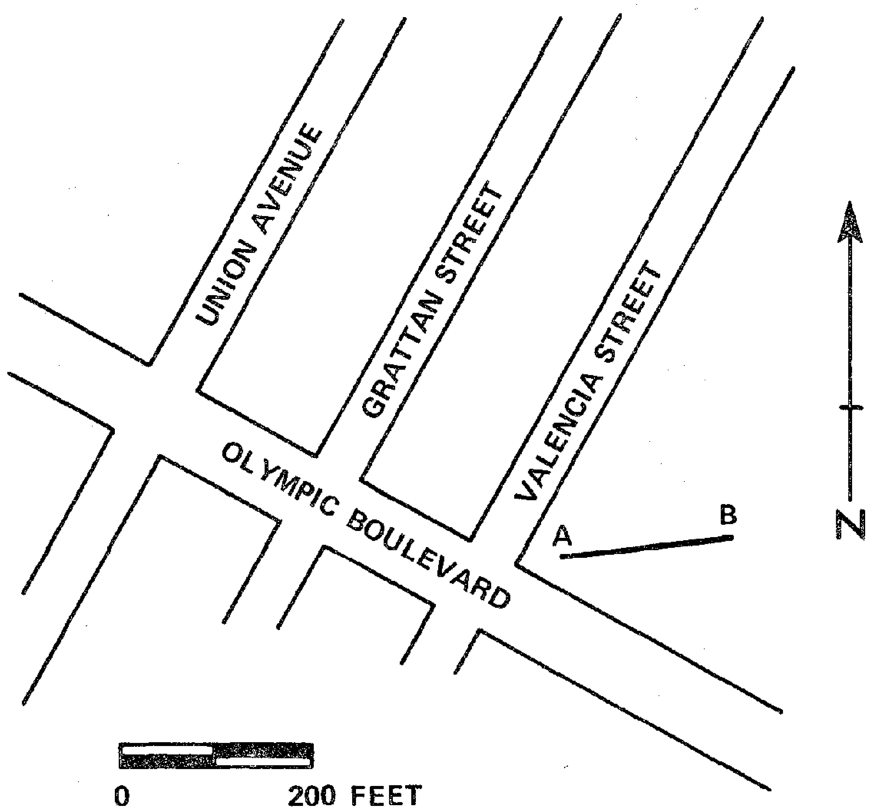


DATE — FEB. 1975

SITE : OLYMPIC BLVD. AND VALENCIA ST., L.A.



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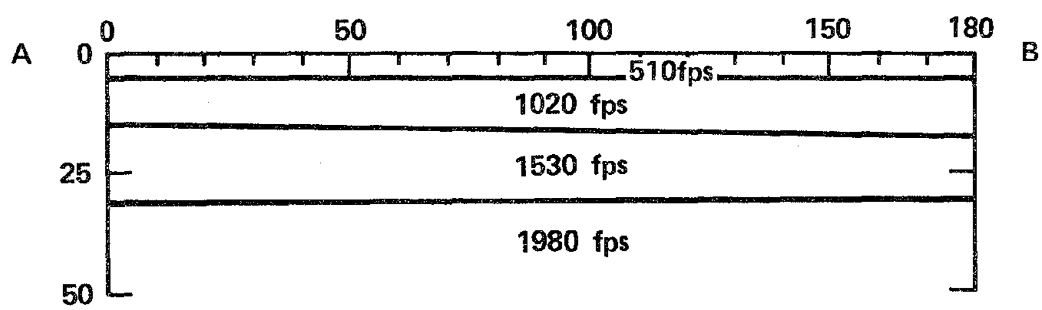
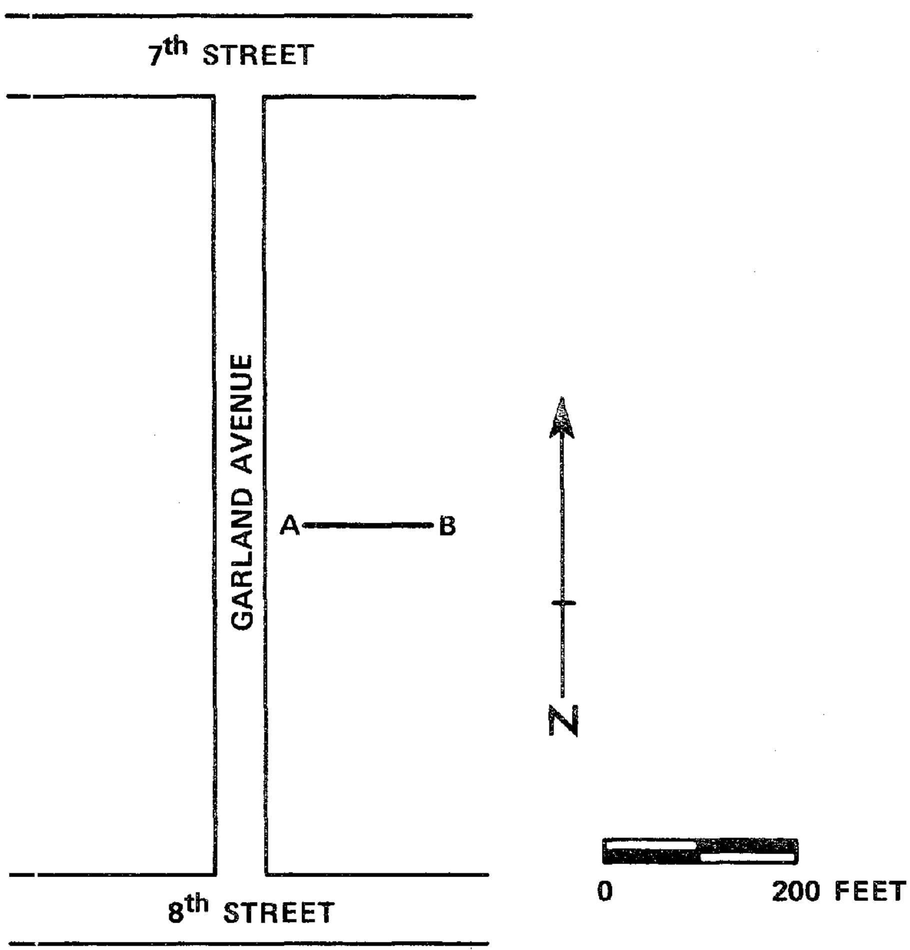


DATE — FEB. 1975

NO. 38

SITE: 750 S. GARLAND AVE., L.A.



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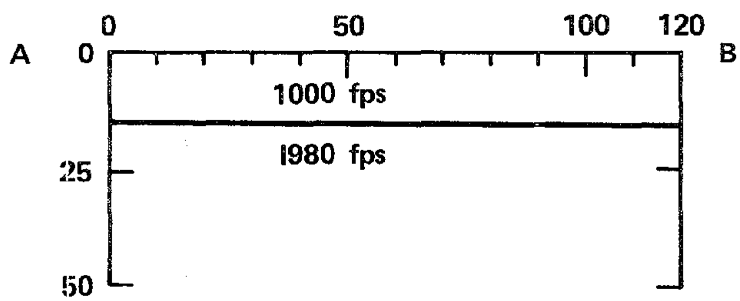
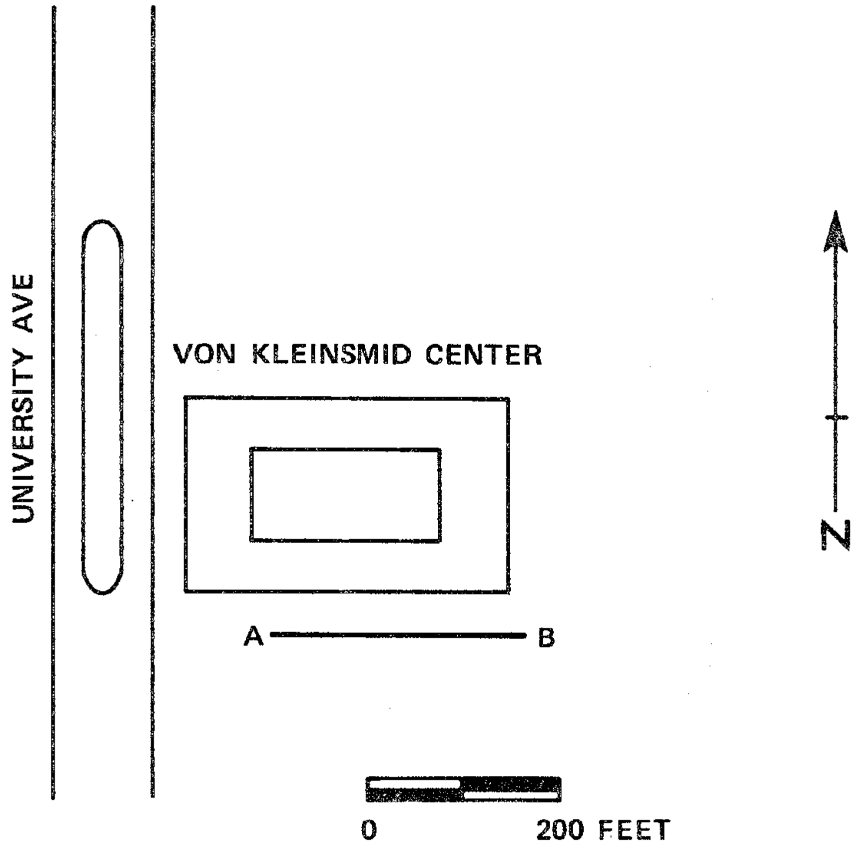
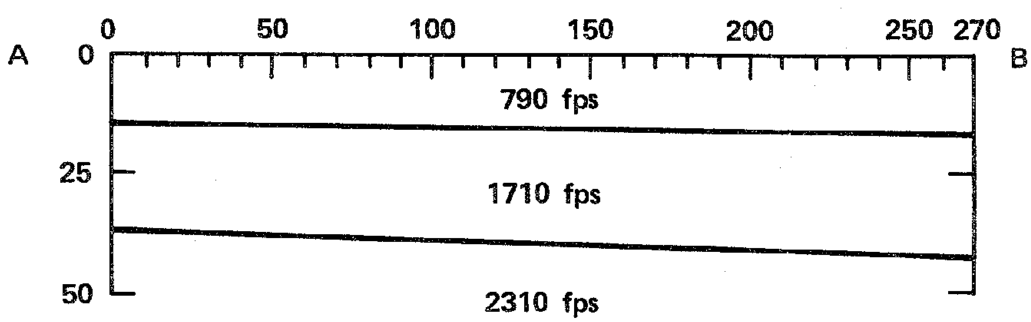


DATE — AUG. 1975

NO. 39

SITE : VON KLEINSMID CENTER, U.S.C., L.A.

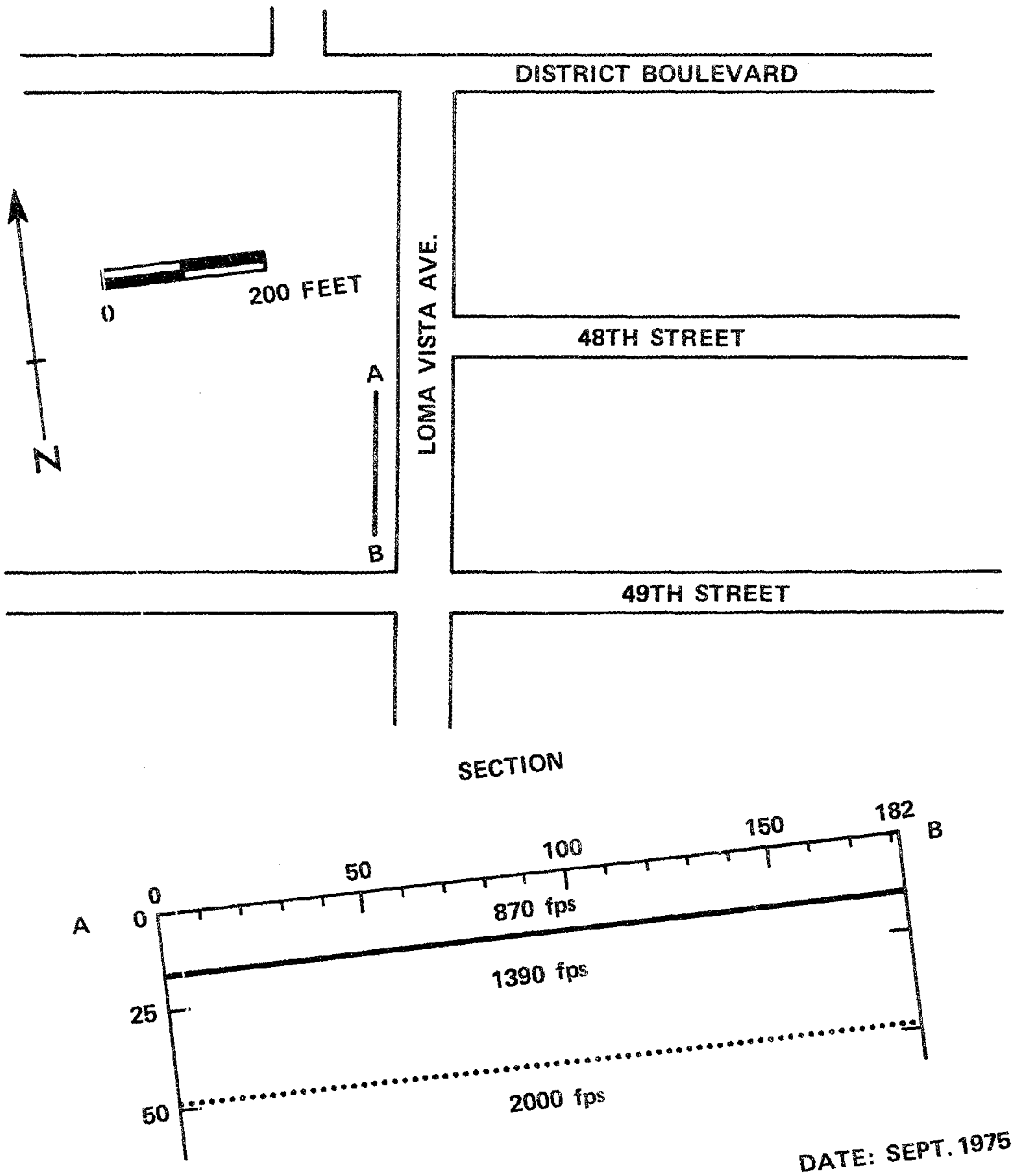




DATE – SEPT. 1975

NO. 40

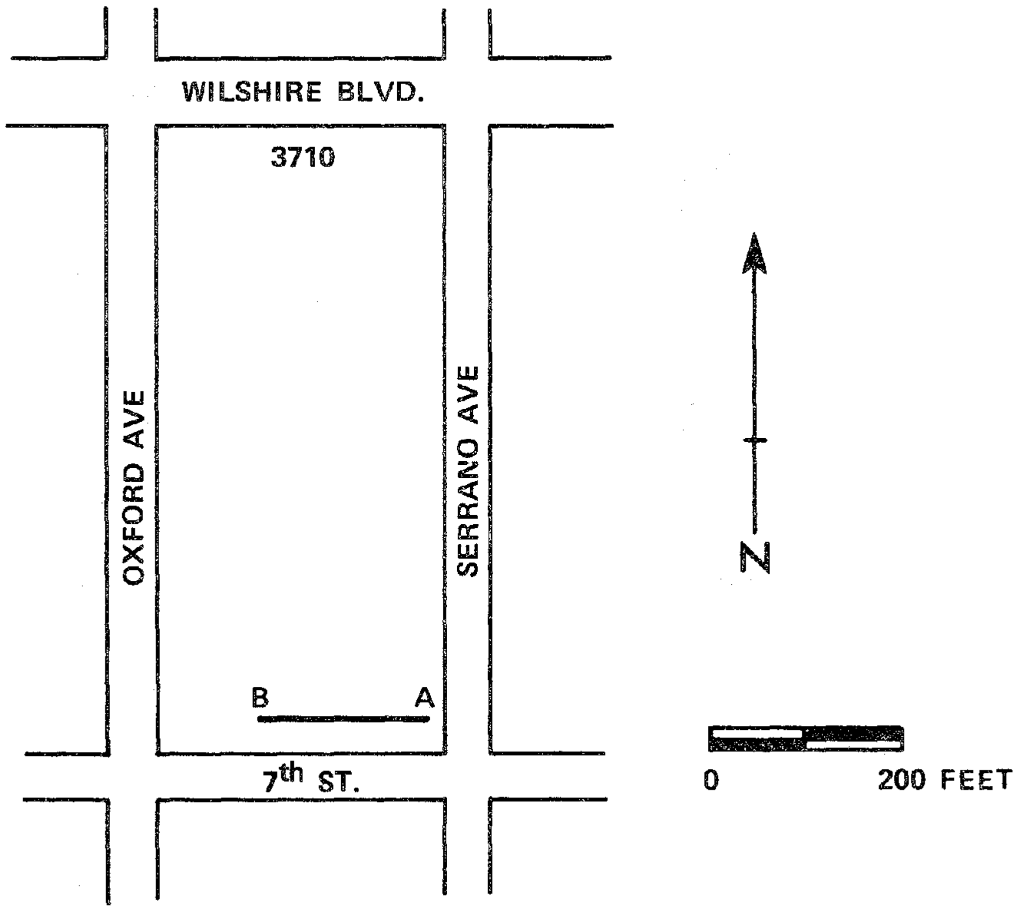
SITE: LOMA VISTA AVE. AND 49TH ST., VERNON



DATE: SEPT. 1975

NO. 41

SITE : 3710 WILSHIRE BLVD., L.A.



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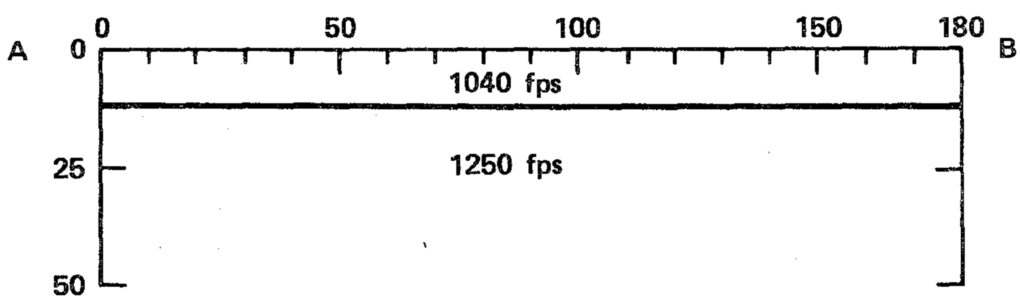
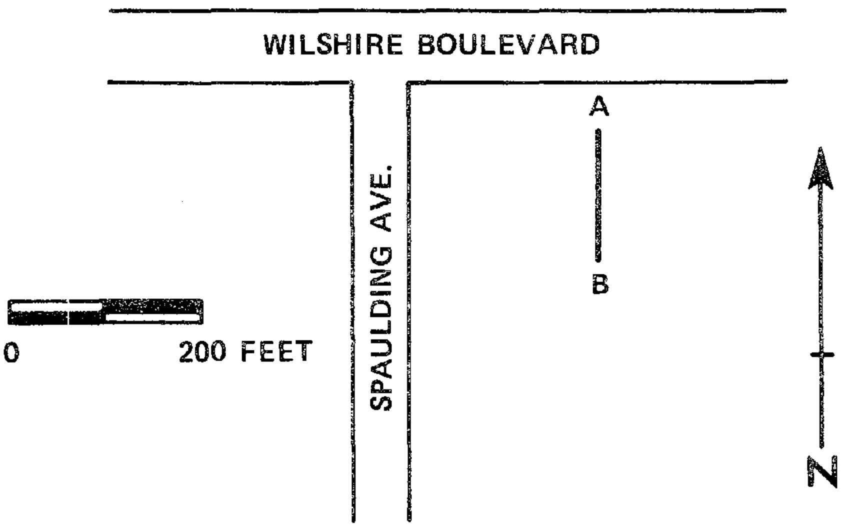


DATE – AUG. 1975

NO. 42

SITE : WILSHIRE BLVD. AND SPAULDING AVE., L.A.



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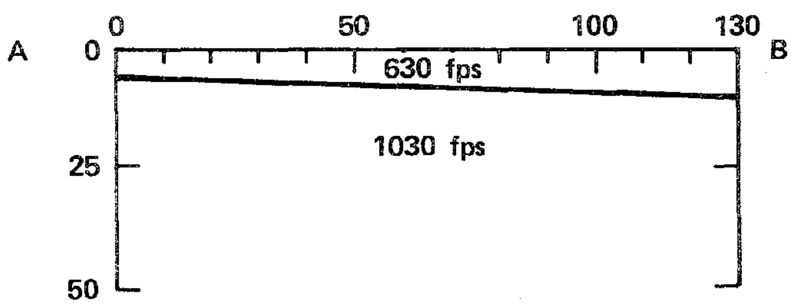
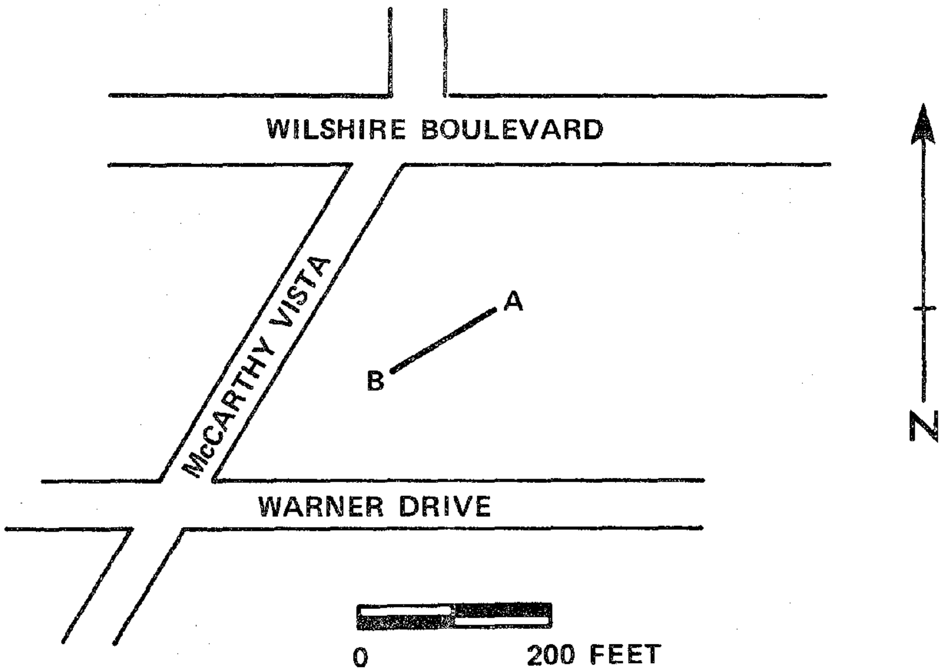


DATE — AUG. 1975

NO. 43

SITE : WILSHIRE BLVD. AND McCARTHY VISTA, L.A.



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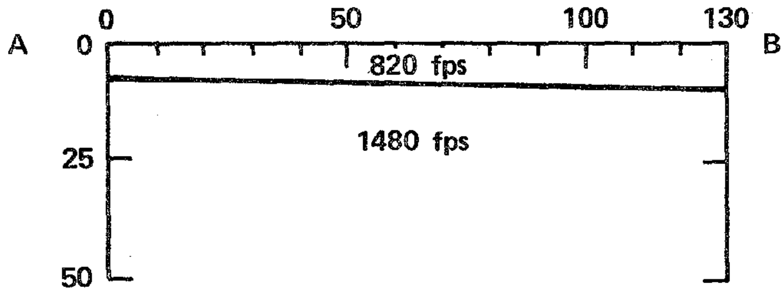
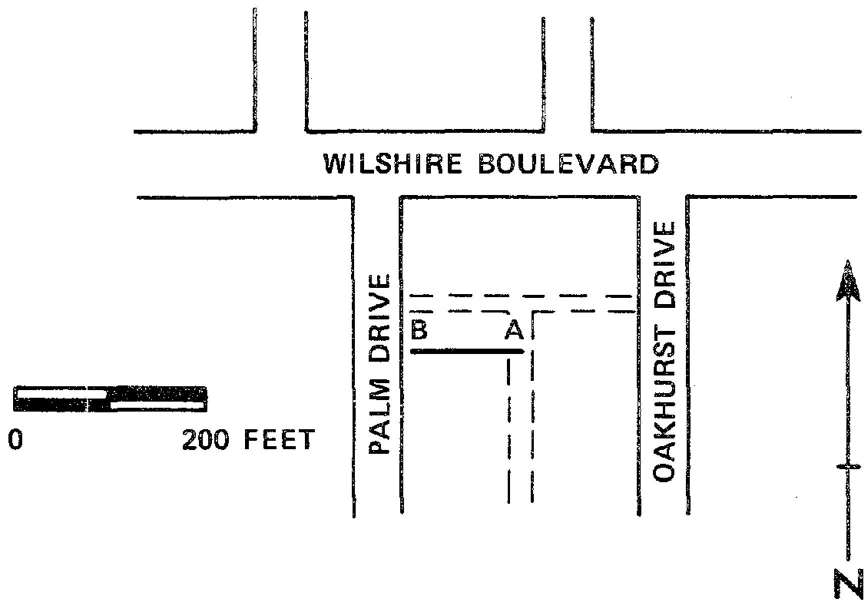


DATE – AUG. 1975

NO. 44

SITE : WILSHIRE BLVD. AND PALM DR., L.A.



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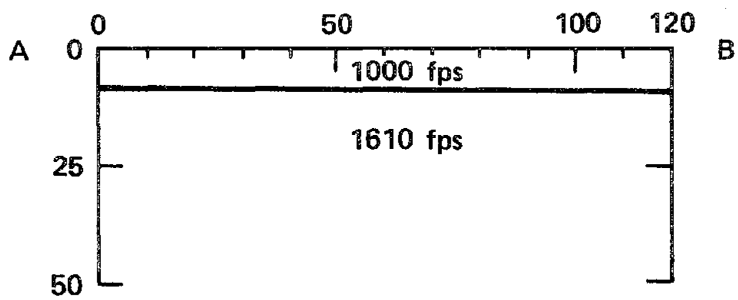
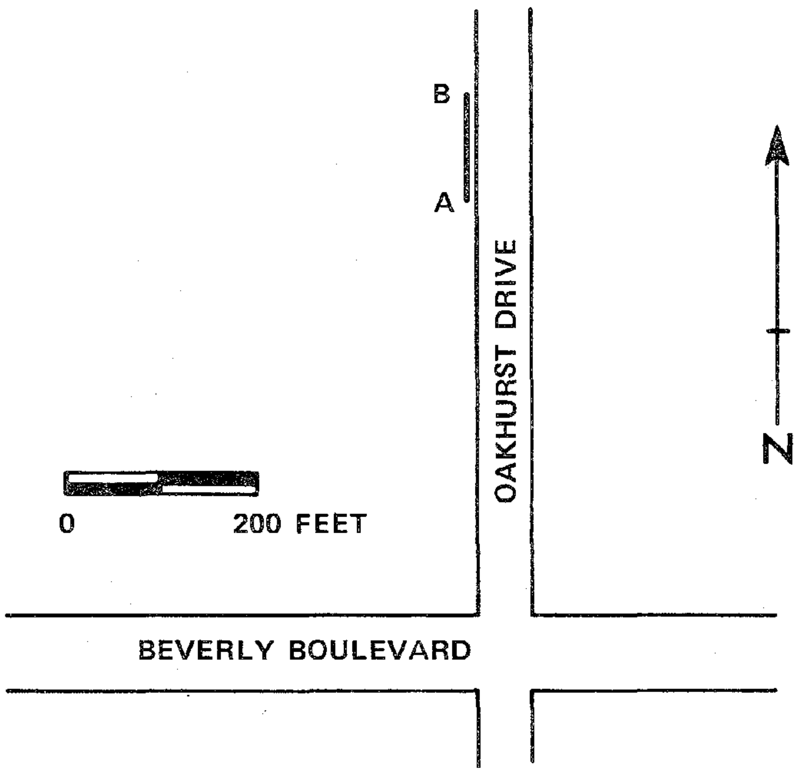


DATE — AUG. 1975

NO. 45

SITE: 435 OAKHURST DR., BEVERLY HILLS



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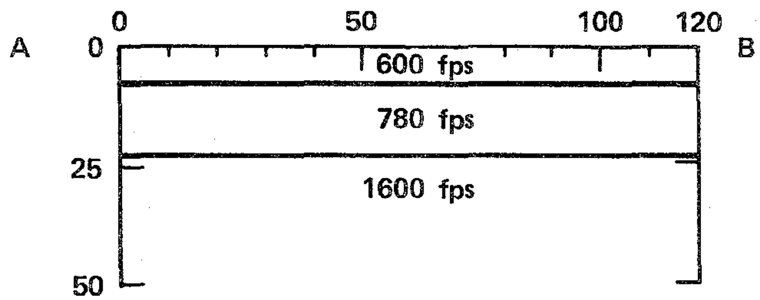
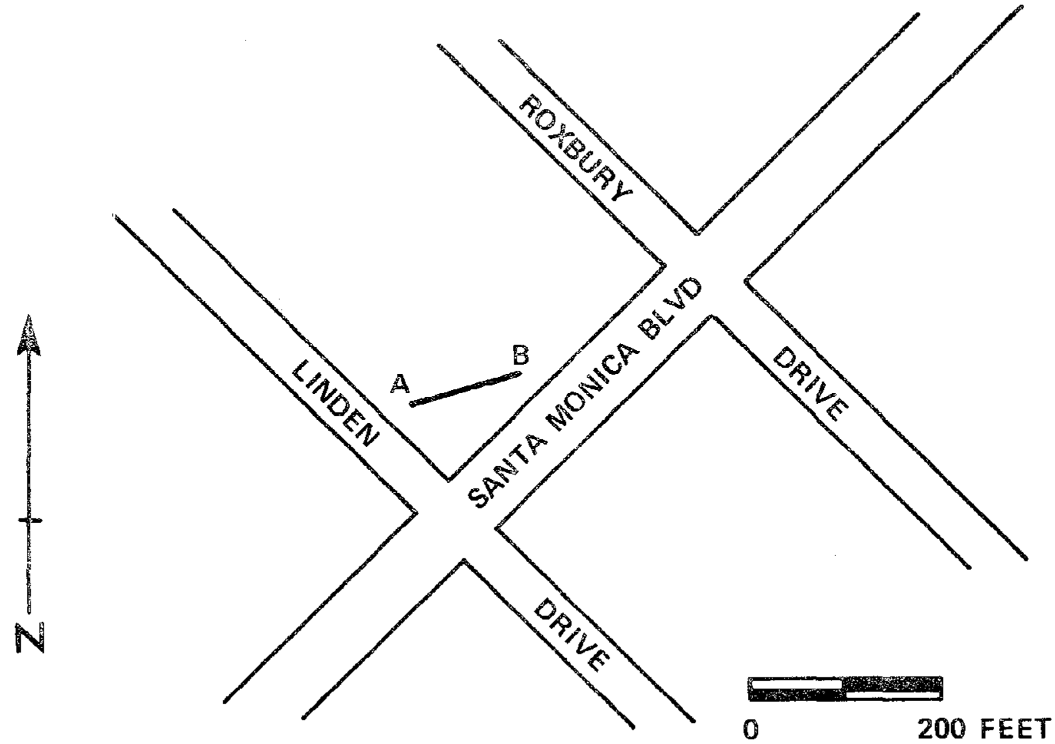


DATE – FEB. 1975

NO. 46

SITE : SANTA MONICA BLVD AND LINDEN DR., BEVERLY HILLS



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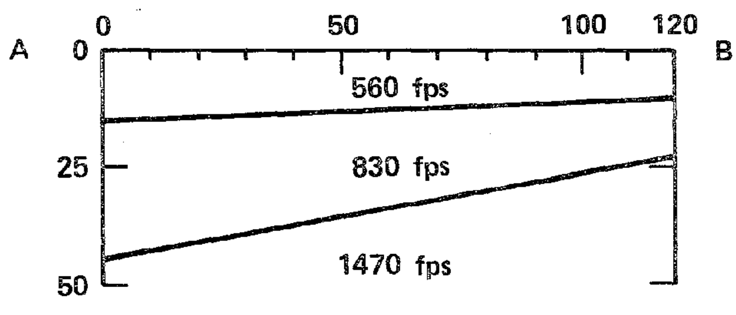
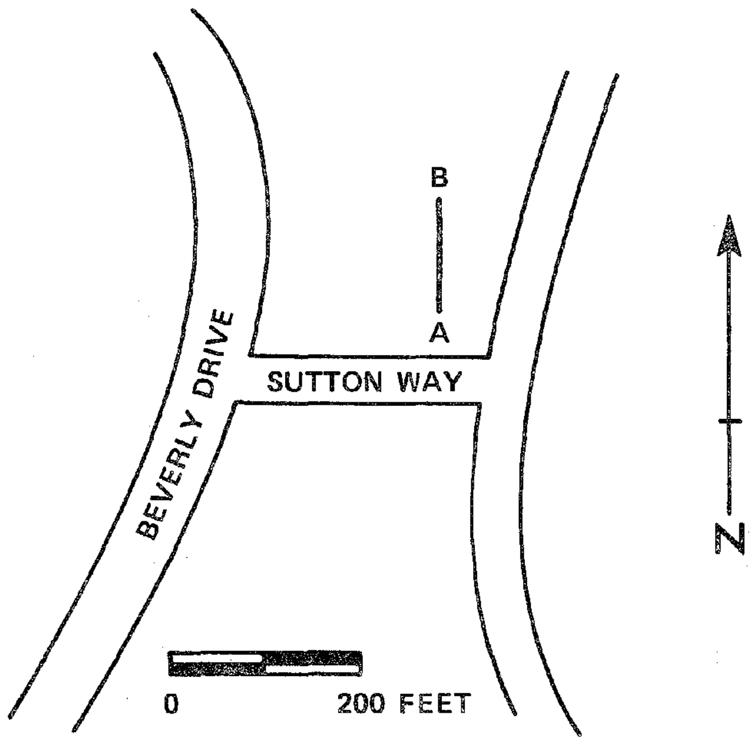


DATE – AUG. 1975

NO. 47

SITE: BEVERLY DR. AND SUTTON WAY, BEVERLY HILLS



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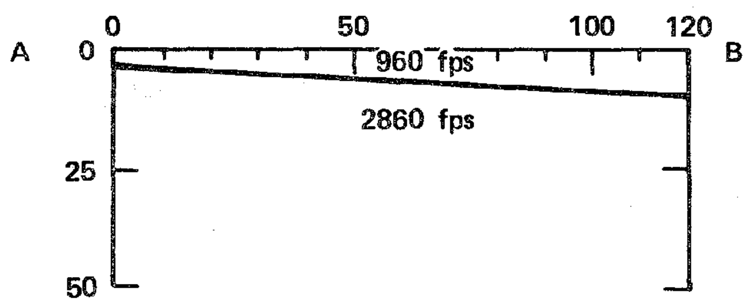
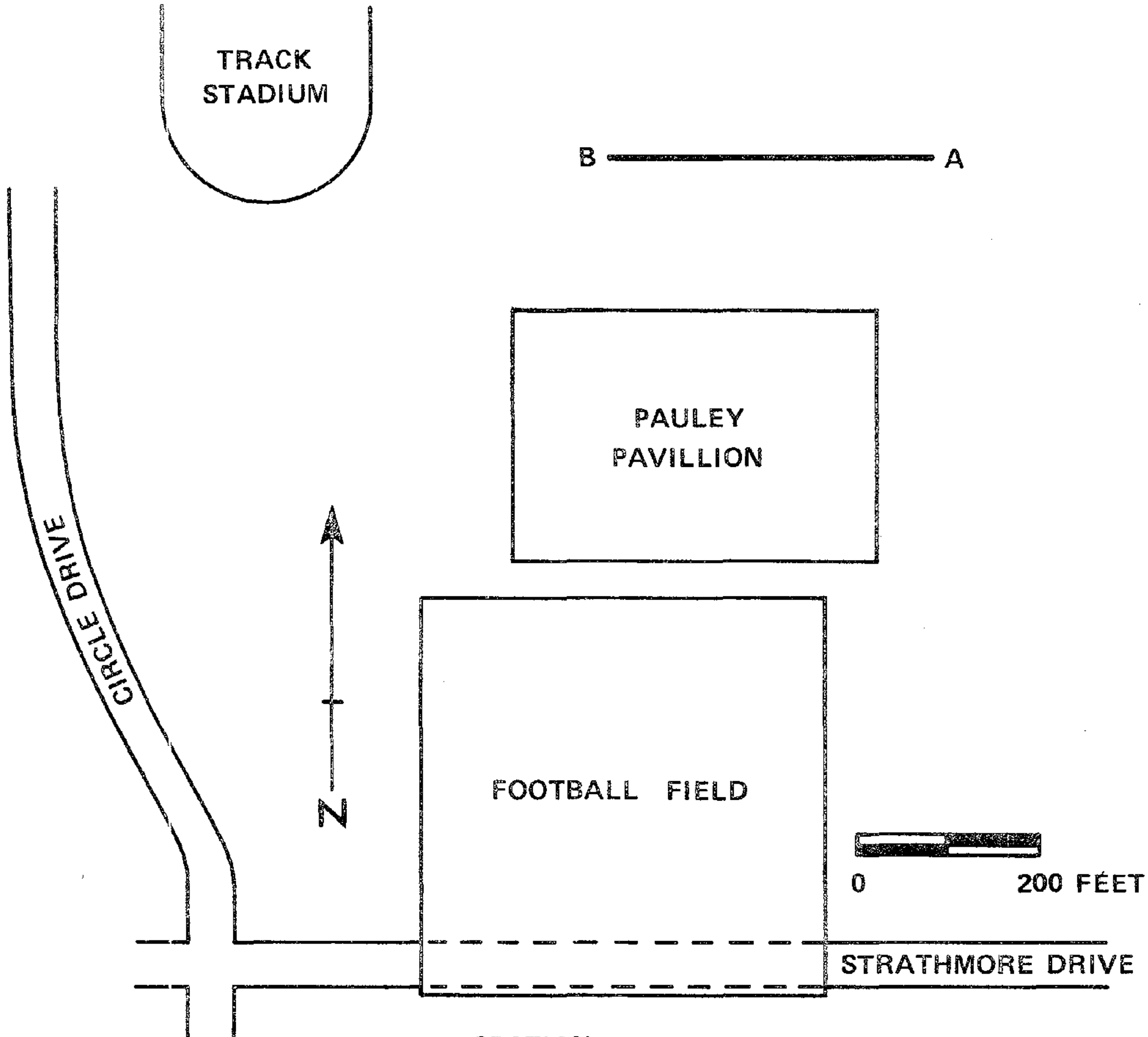


DATE — AUG. 1975

NO. 48

SITE: U.C.L.A. ATHLETIC FIELD, WESTWOOD



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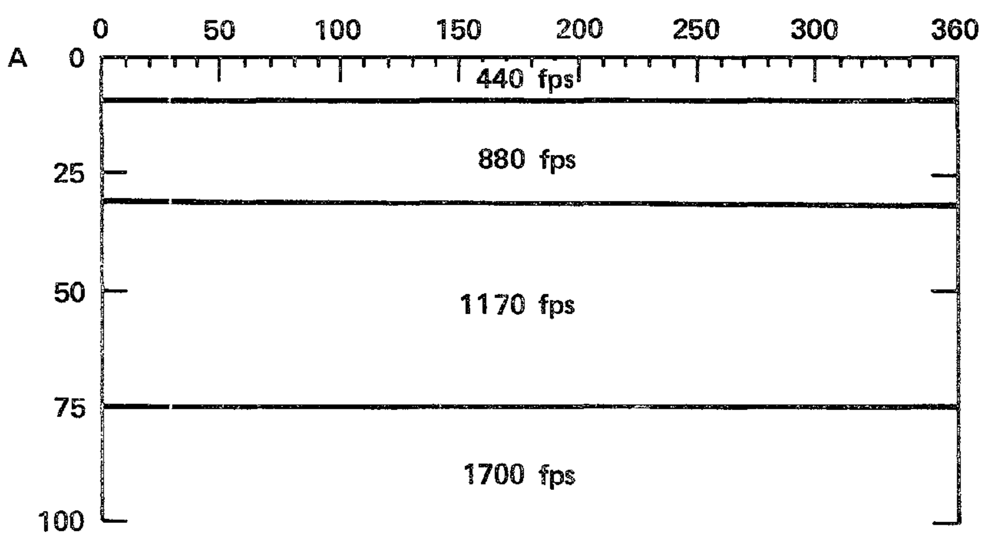
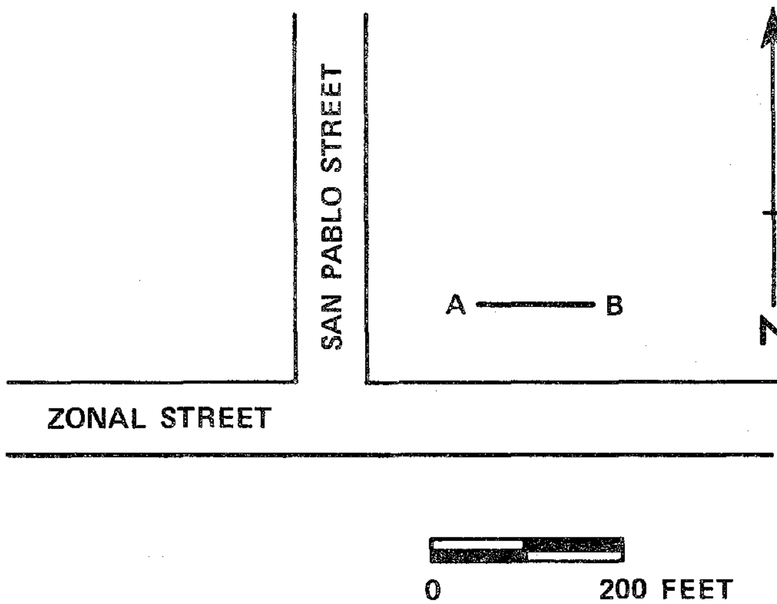


DATE – SEPT. 1975

NO. 49

SITE: ZONAL ST. AND SAN PABLO ST., L.A.



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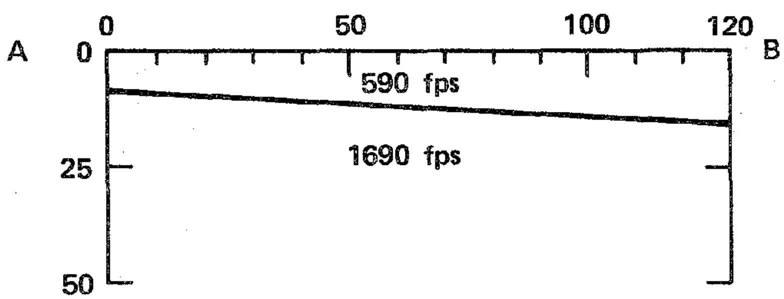
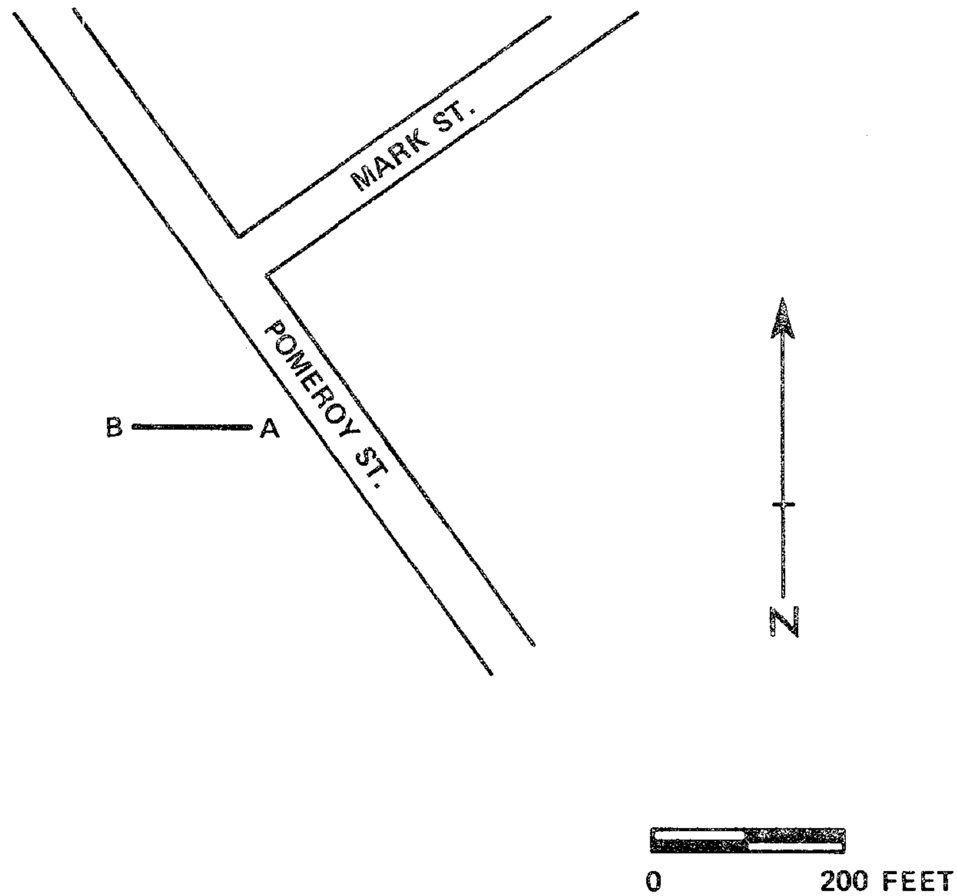


DATE – AUG. 1975

NO. 50

SITE: POMEROY ST. AND MARK ST., L.A.



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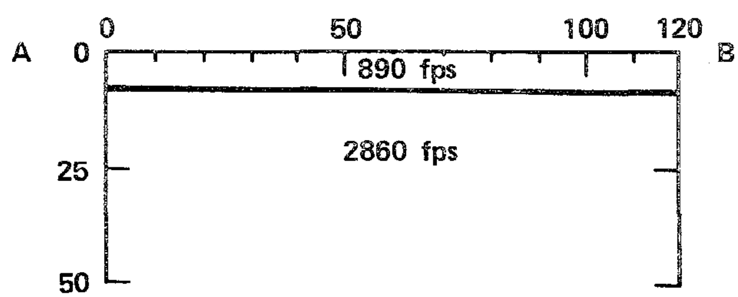
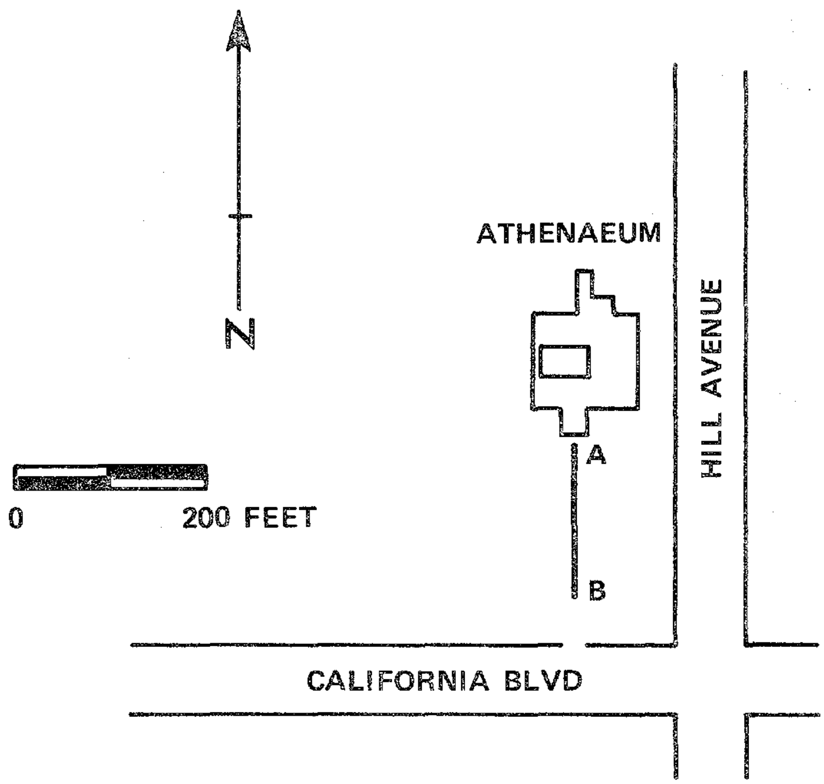


DATE – AUG. 1975

NO. 51

SITE: CALTECH ATHENAEUM, PASADENA



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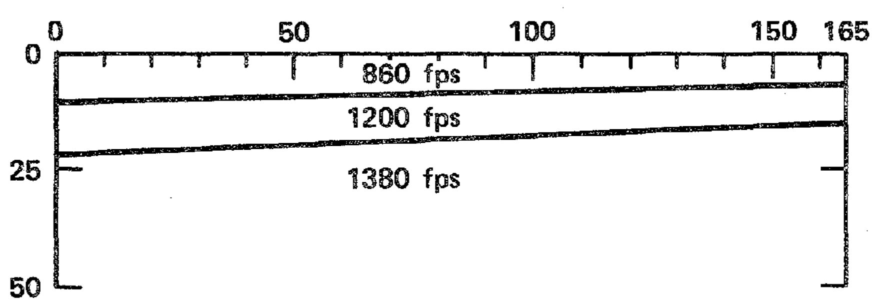
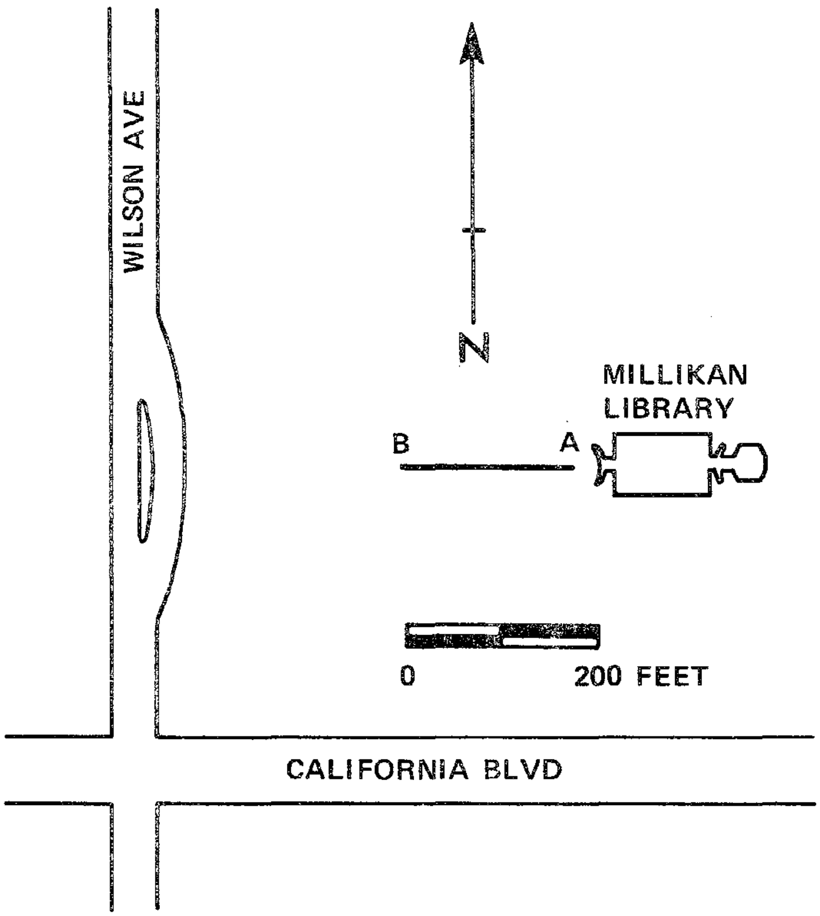


DATE – AUG. 1975

NO. 52

SITE: CALTECH MILLIKAN LIBRARY, PASADENA



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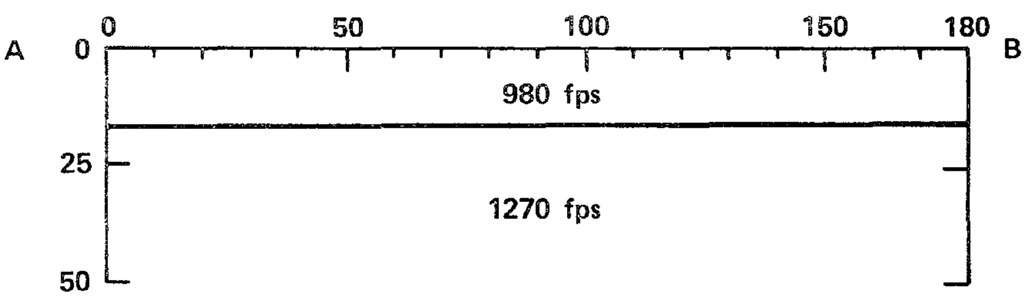
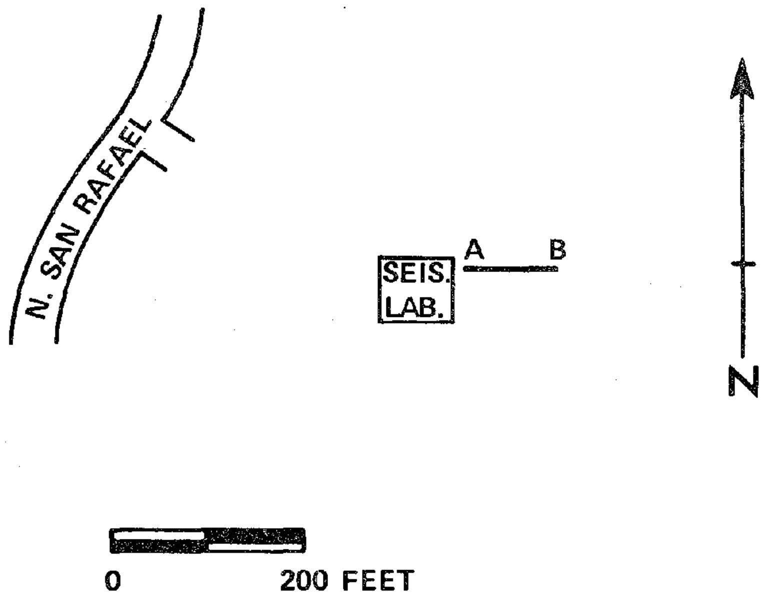


DATE — AUG. 1975

NO. 53

SITE: CALTECH SEISMOLOGICAL LABORATORY, PASADENA



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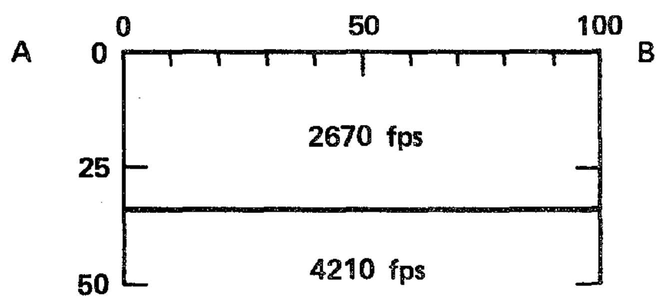
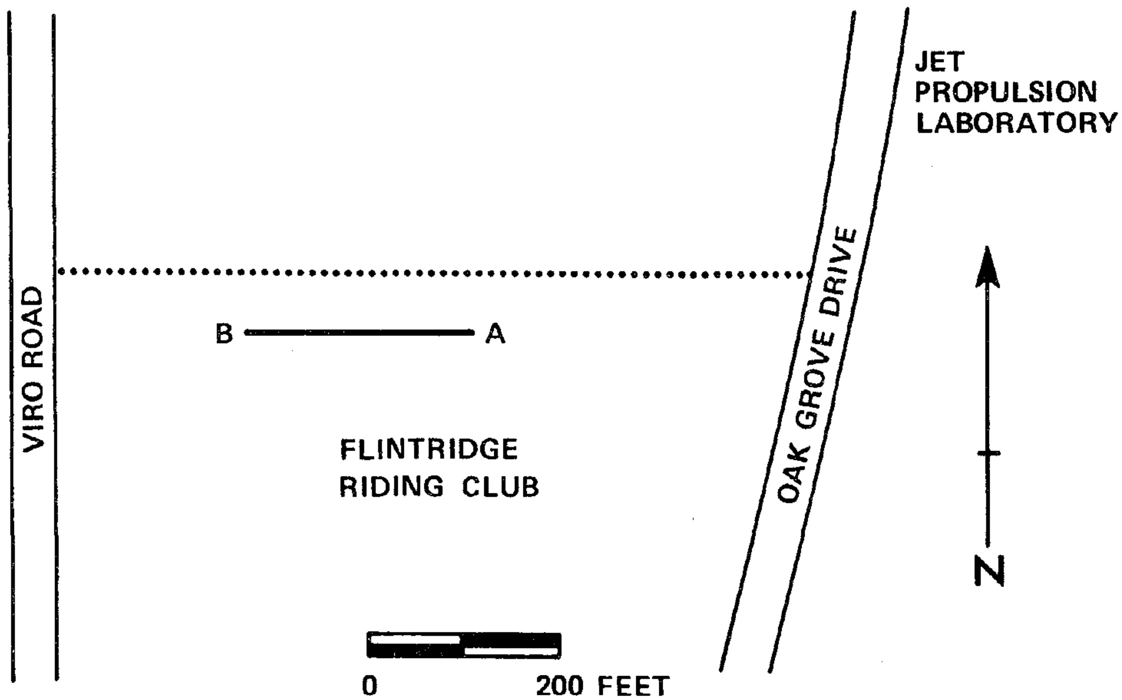


DATE – AUG. 1975

NO. 54

SITE: FLINTRIDGE RIDING CLUB, PASADENA



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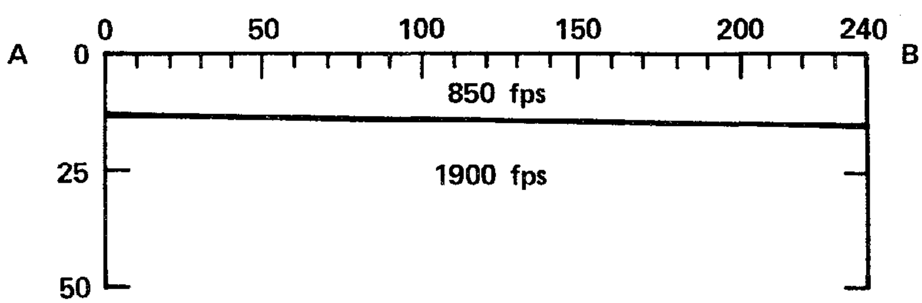
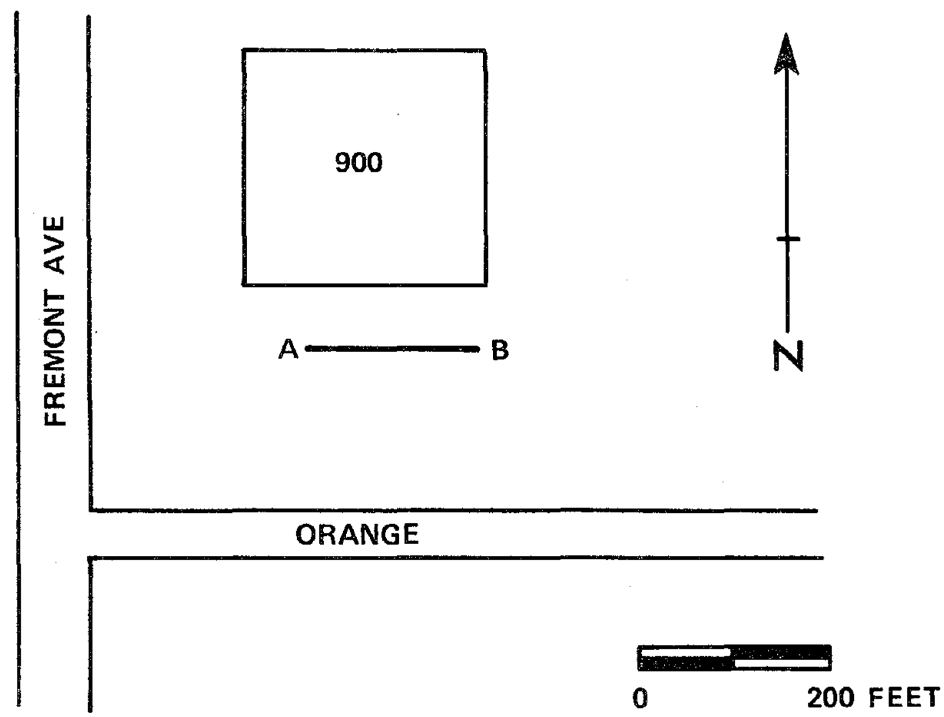


DATE – AUG. 1975

NO. 55

SITE : 900 S. FREMONT AVE., ALHAMBRA



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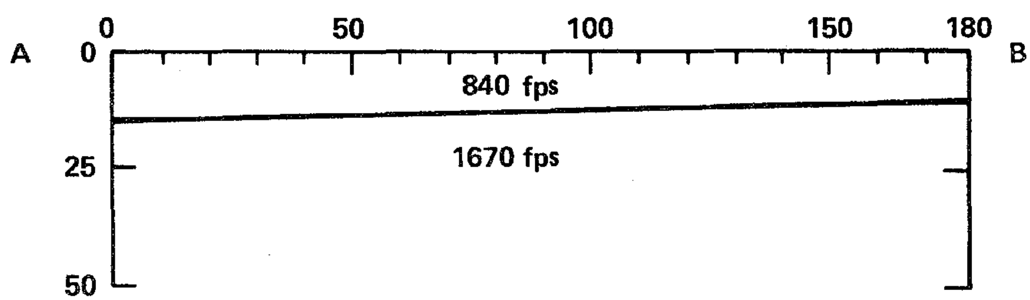
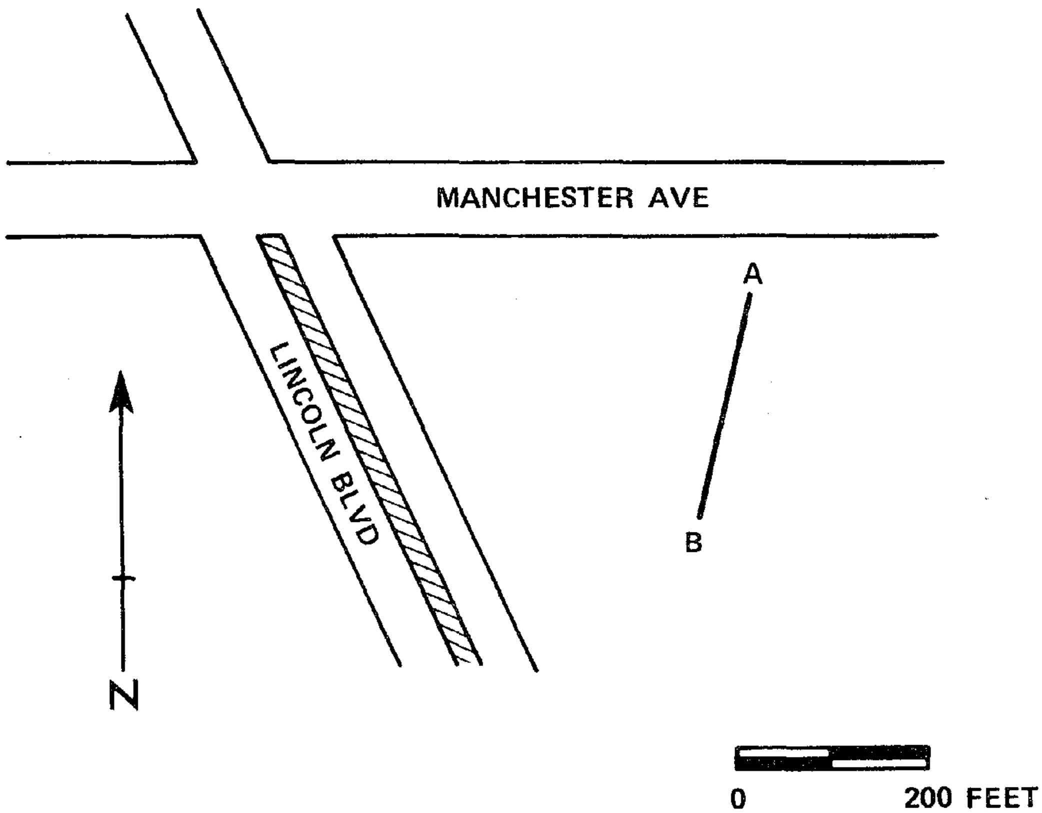


DATE – AUG. 1975

NO. 56

SITE: WESTCHESTER RECREATION CENTER, WESTCHESTER



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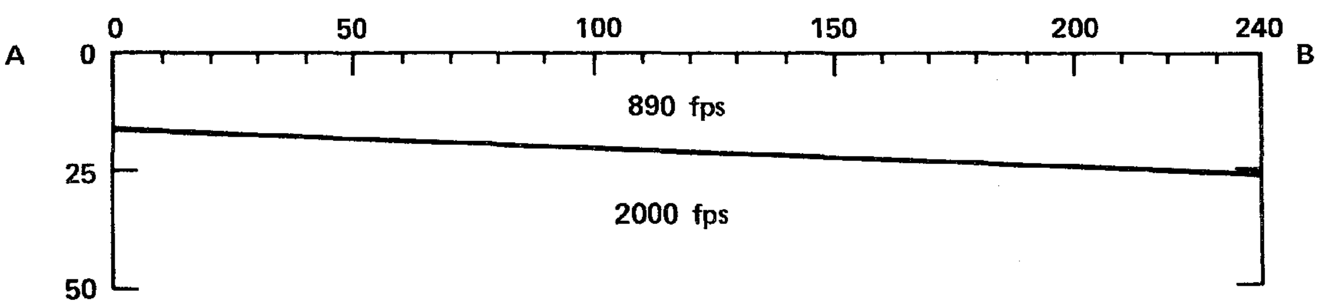
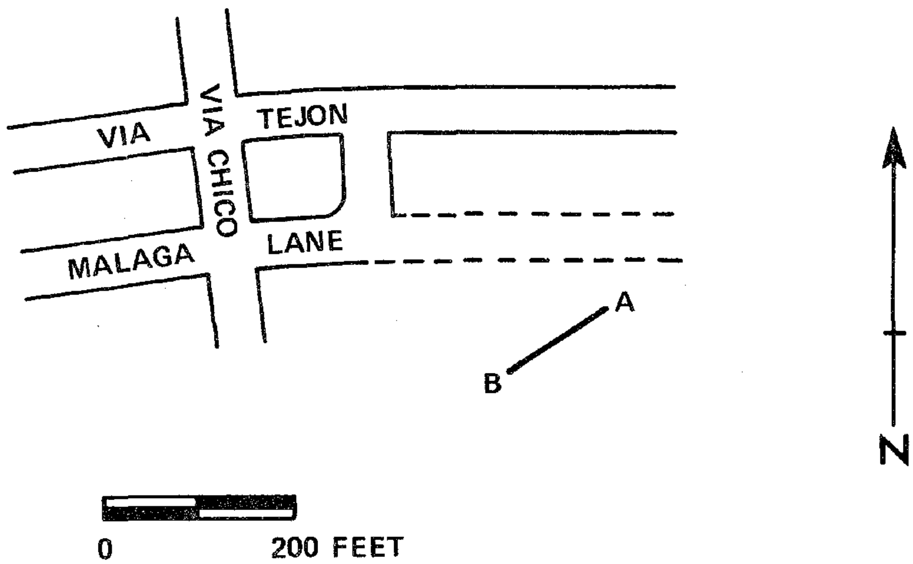


DATE – AUG. 1975

NO. 57

SITE: MALAGA LANE, PALOS VERDES ESTATES



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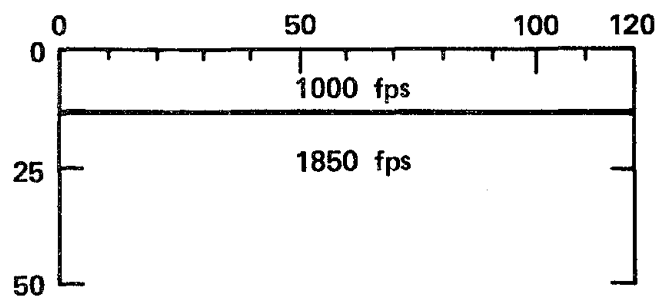
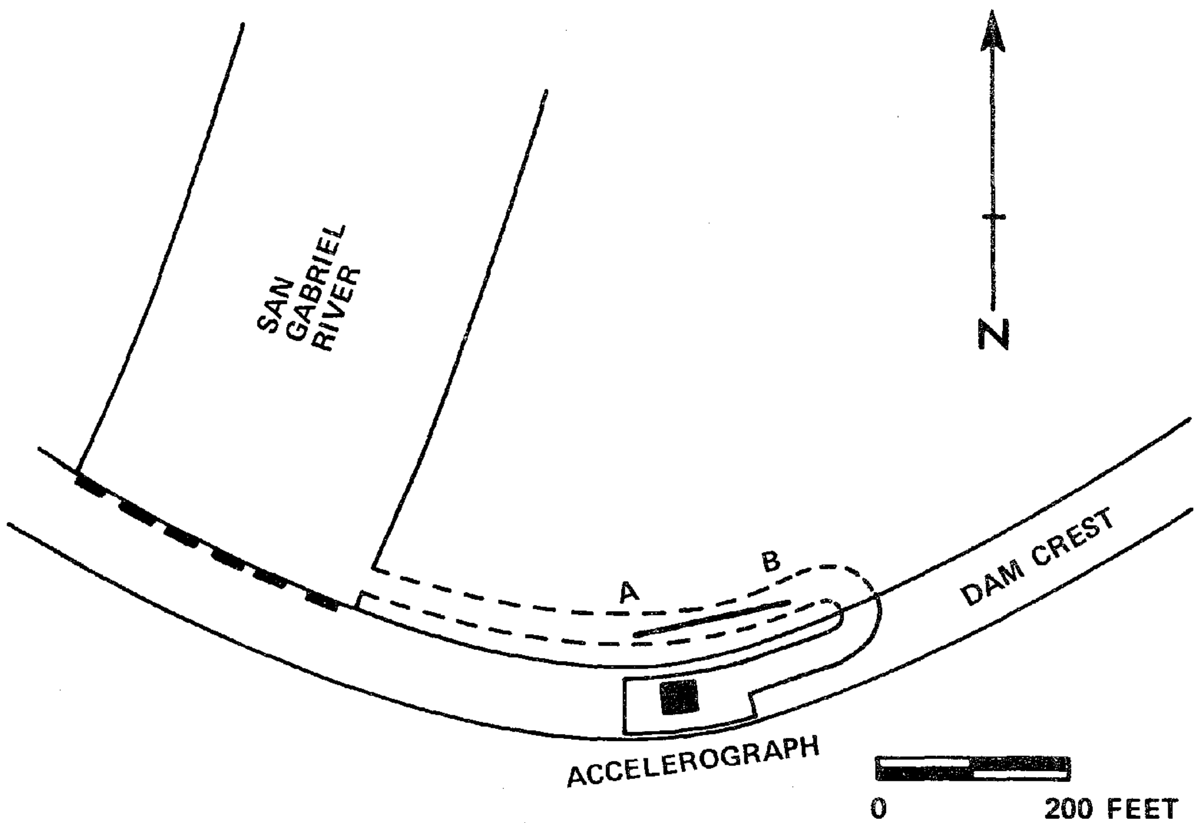


DATE – SEPT. 1975

NO. 58

SITE: WHITTIER NARROWS DAM



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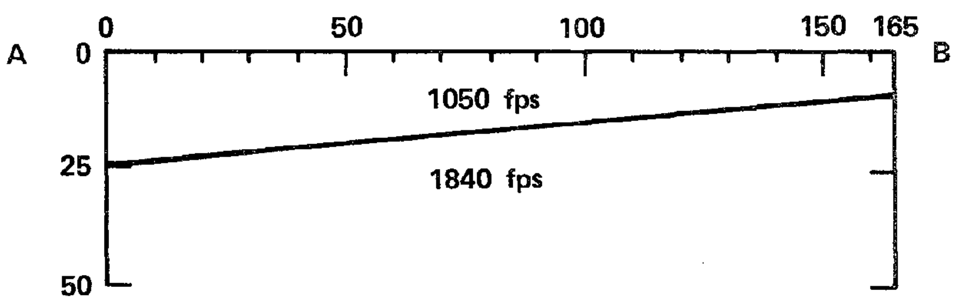
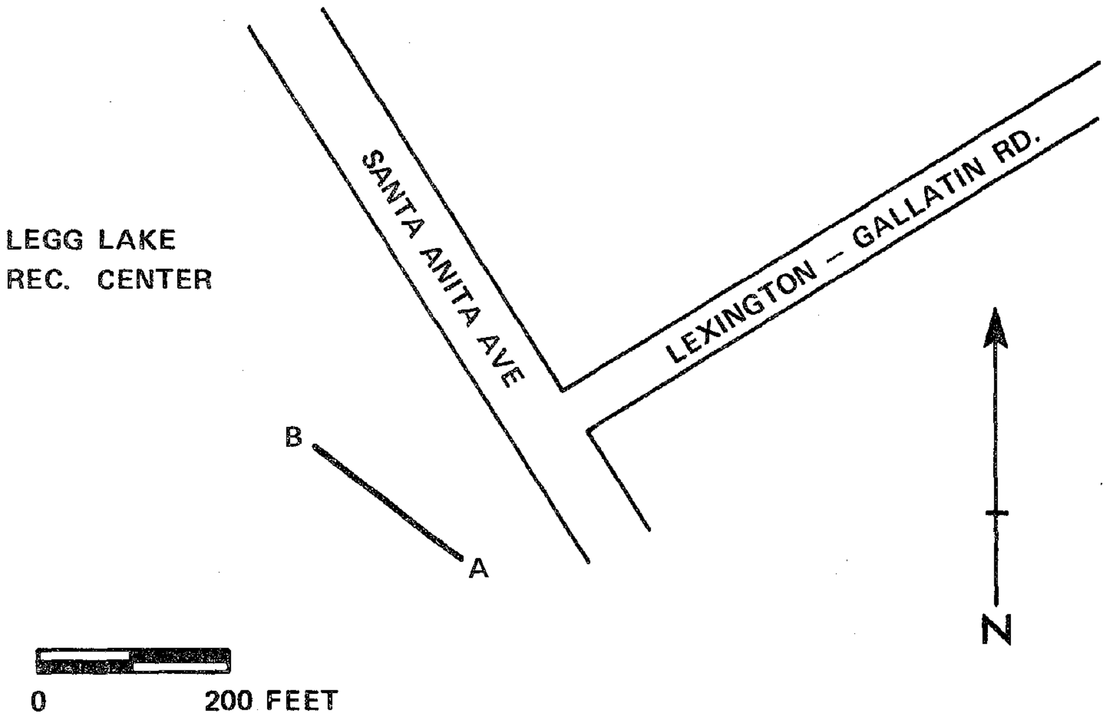


DATE – SEPT. 1975

NO. 59

SITE : LEGG LAKE REC. CENTER



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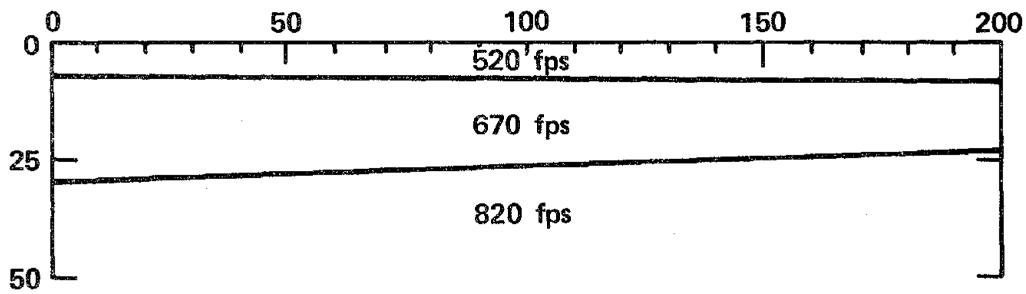
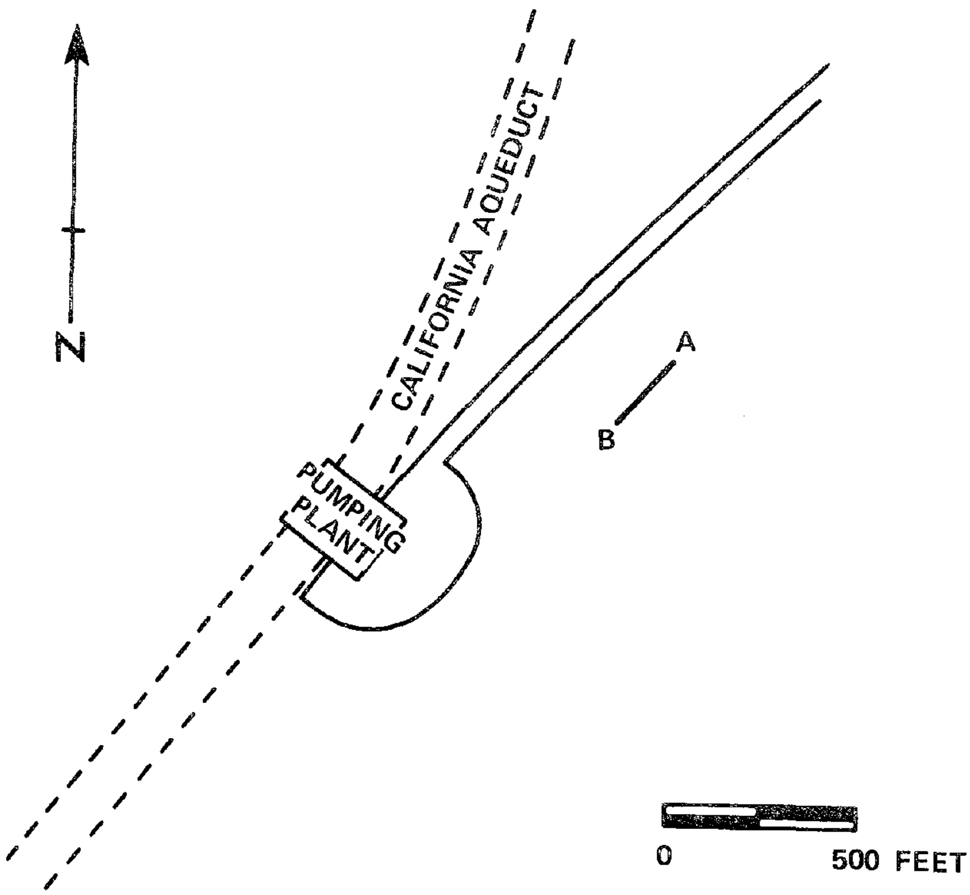


DATE – SEPT. 1975

NO. 60

SITE : OSO PUMPING PLANT, GORMAN



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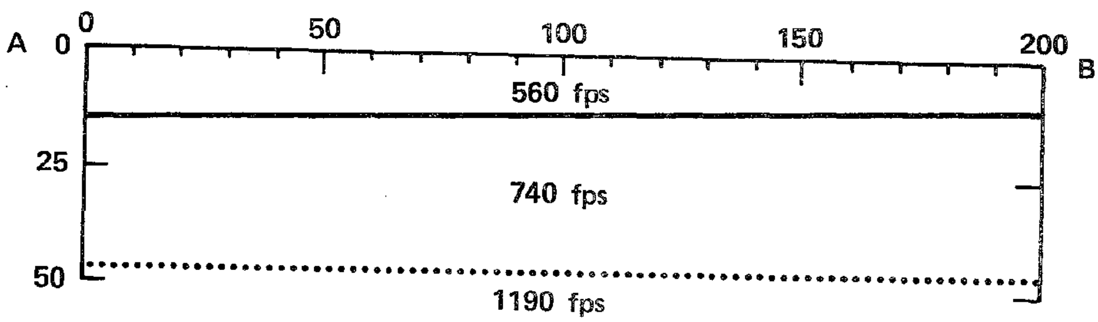
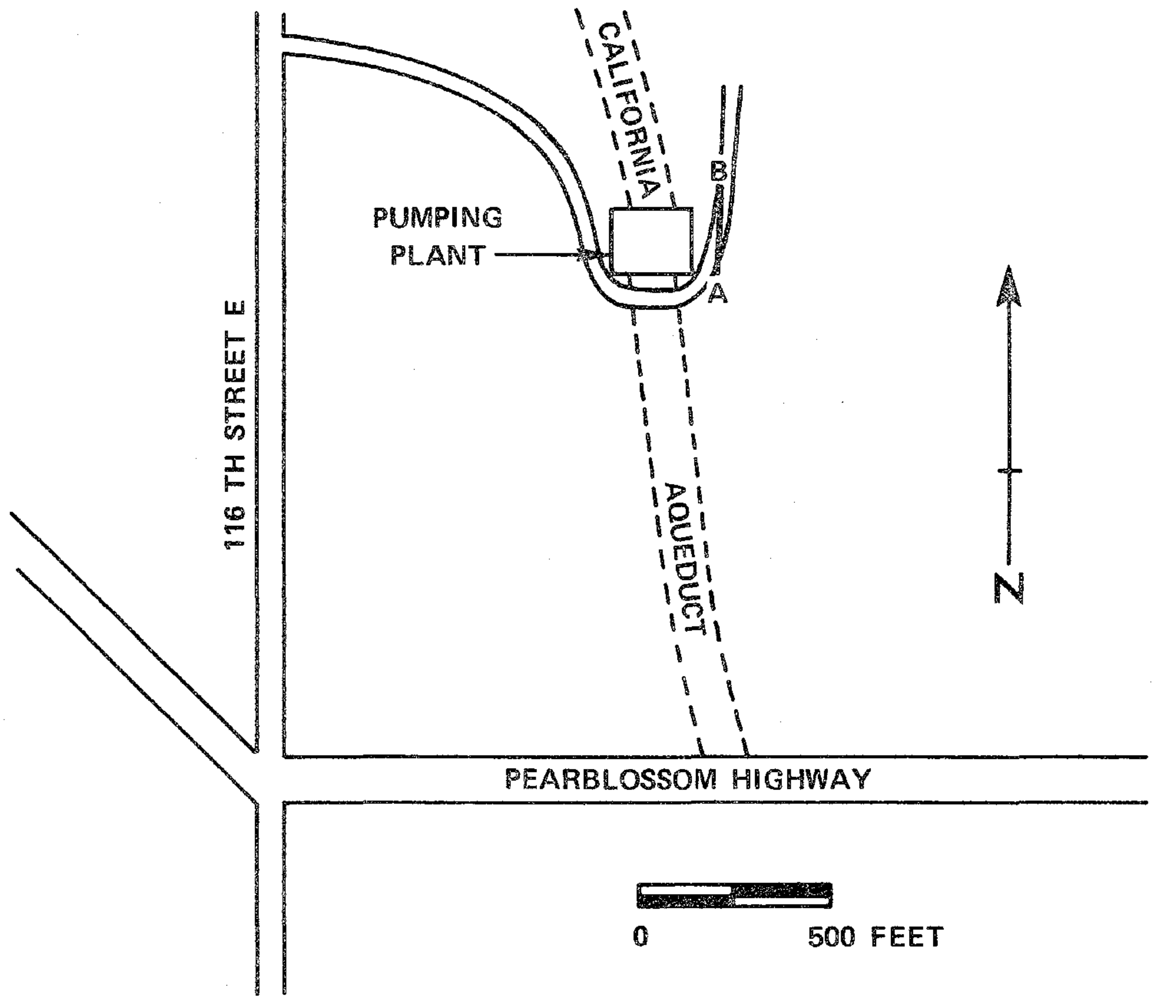


DATE – SEPT. 1975

NO. 61

SITE: PEARBLOSSOM PUMPING PLANT, PEARBLOSSOM



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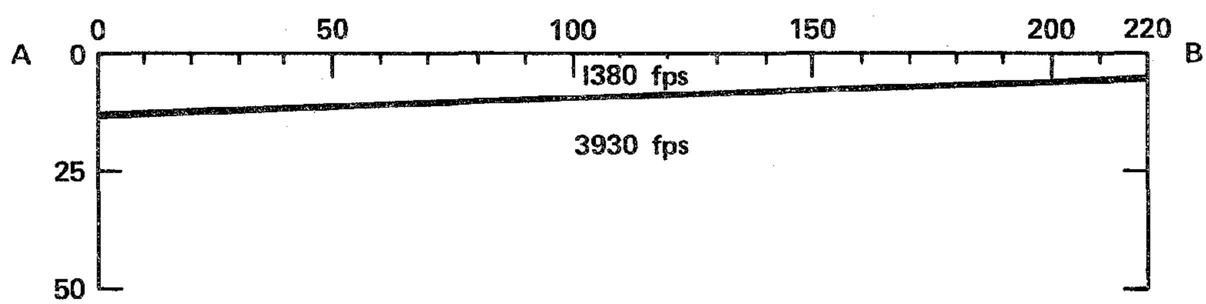
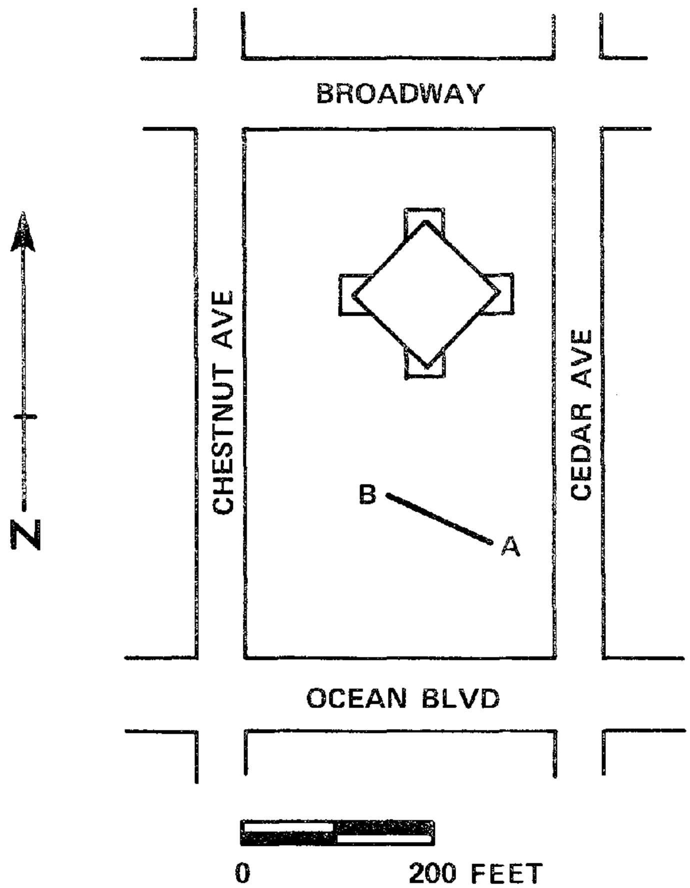


DATE — SEPT. 1975

NO. 62

SITE : OCEAN BLVD. AND CEDAR AVE., LONG BEACH



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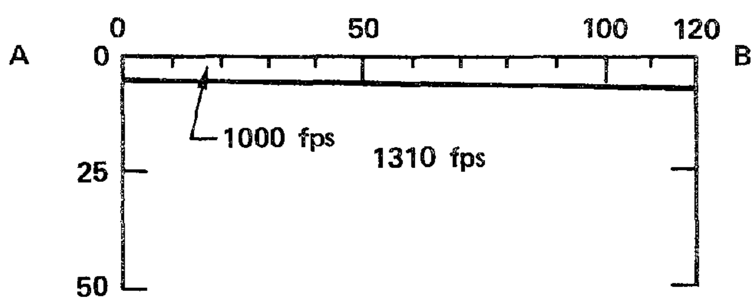
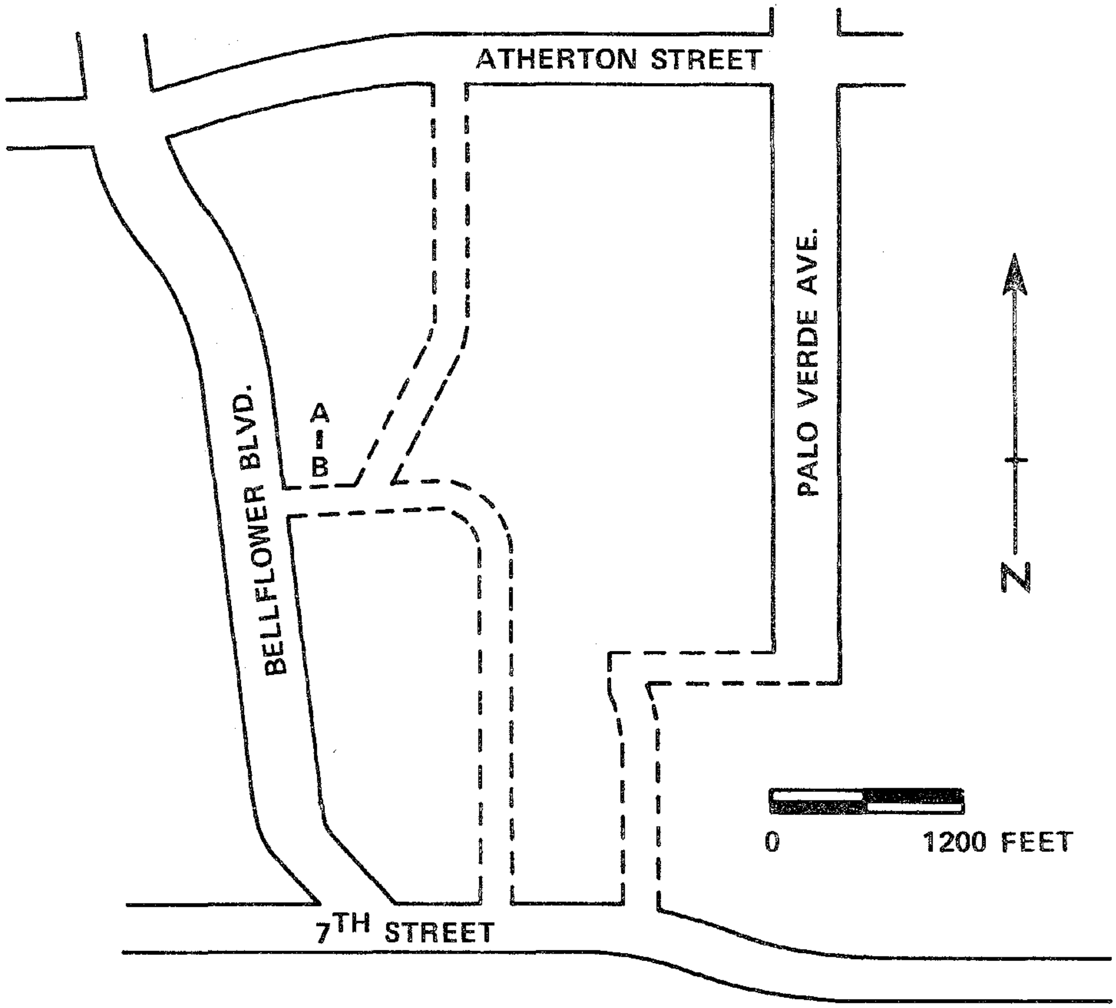


DATE – AUG. 1975

NO. 63

SITE : LONG BEACH STATE UNIV.



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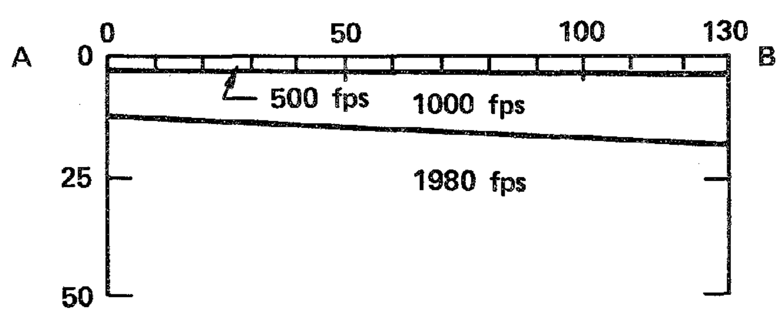

DATE — AUG. 1975

APPENDIX B

NEW TECHNIQUES IN FIELD MEASUREMENT

The conducting of refraction surveys has been largely restricted to those sites where ample space and bare ground were available. However, many sites exist where the space is available, but where a survey could not be conducted due to the existence of some type of asphaltic surface. To determine the feasibility of performing a refraction survey on a paved site, a comparative study was performed on the U.C.L.A. campus. Two sets of geophone lines were set up, one on asphalt and the other on soil. These lines were parallel to each other and had a separation of fifty feet between them. For the paved site, the geophones were simply placed on the pavement. For the soil site, the geophones were spiked into the ground.

Two sets of records were then obtained and time-distance curves plotted to represent them, Figure B-1. The arrival times were identical beyond the first three geophones. However, there existed some difficulty in interpreting the first three arrivals for the paved site. This was apparently due to the occurrence of two direct waves. The first direct wave, possessed a velocity much too high for the underlying soil (the soil logs were examined). It is believed that this first velocity was the shear-wave traveling through asphalt. This is conceivable since the shear wave velocity is larger for asphalt than for soil. The second direct wave for the first 3 geophones on the paved site, however, had a slope equal to that of the adjacent soil site and consequently had the same shear-wave velocity. This can be seen in Figure B-1.

Therefore, with careful interpretation, supplemented with available geotechnical data, surveys at six other sites were conducted on asphalt: Sites 41, 51, 53, 55, 57, and 61.

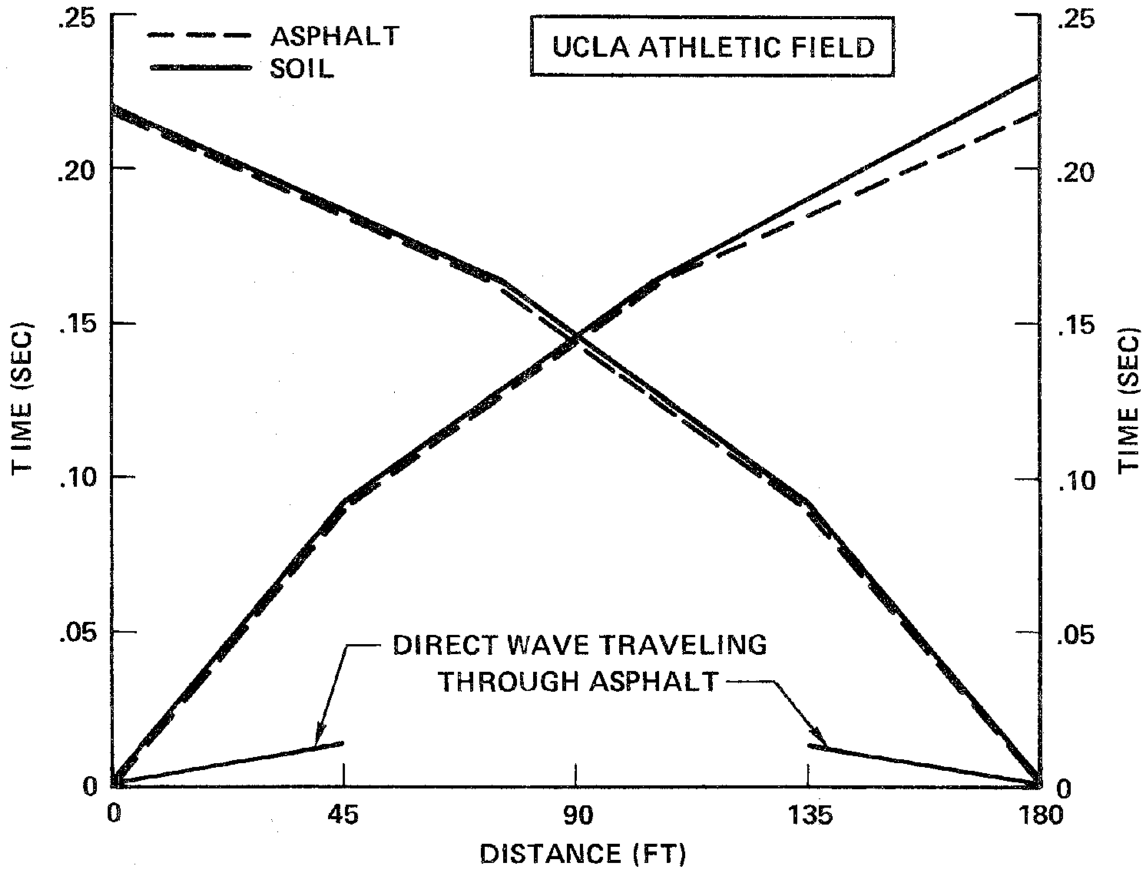

Figure B-1. Time-Distance Curves (Asphalt – Soil).

To examine the effect of impact intensity on the shape and amplitude of a record, a series of hits was made with the 25 lb. hammer using varying intensities. These intensities ranged from soft golf type putts to hard baseball type swings. Although the study was not conducted quantitatively, the results generally showed that beyond a certain threshold intensity, a harder hit provided no increase in amplitude, Figure B-2. A possible reason for this is that the additional energy produced by a harder hit was lost in the slippage of the plank. Experience showed that a hard hit displaced the plank by as much as an inch. Although this is not a desirable quality in general, in many cases it is not a hindrance. One such case would be a site where the rock is encountered at a relatively shallow depth. Here, a larger energy source will not, in general, provide any additional information beyond the direct wave velocity.

However, for most sites, the loss in energy will often hinder the acquisition of much needed information. By devising a method to eliminate this loss, one could obtain records with clearer onsets resulting in less ambiguity in interpretation. A possible procedure to eliminate this loss would be to line the bottom of the plank with a corrugated surface. This would provide additional friction to resist board movement while assuring that the amplification of P-waves remains minimal. A heavier weight on the plank might also help. More study is needed, however, before this procedure can be implemented.

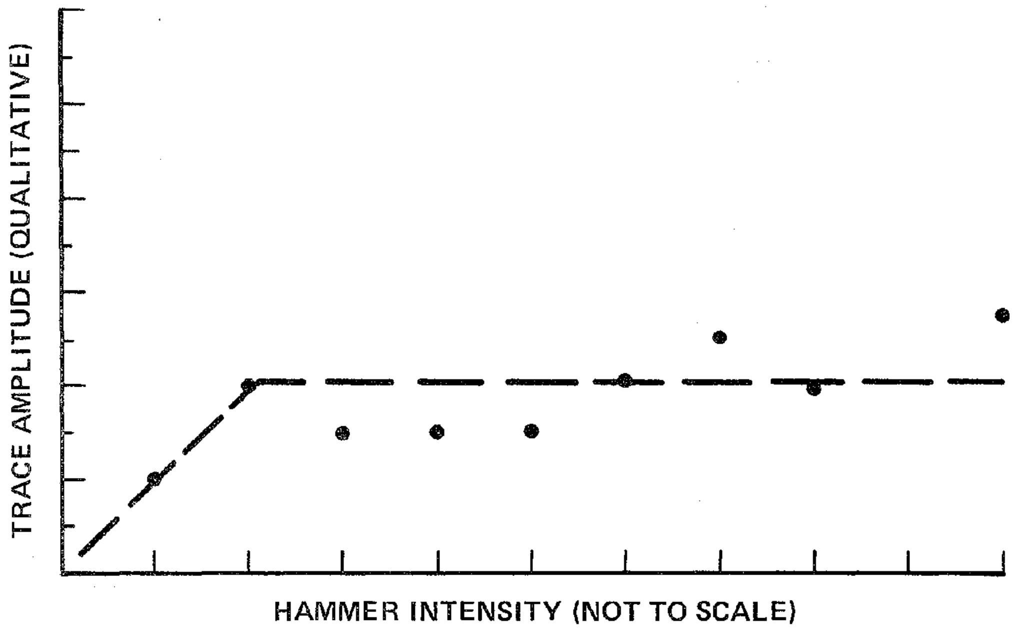

Figure B-2. The Effect of Impact Intensity on Wave Amplitude.

APPENDIX C

Era	Period	Epock	Approximate Duration in Millions of Years	Millions of Years Ago
Cenozoic	Quaternary	Holocene	0.01	9
		Pleistocene	2.5	2.5
	Tertiary	Pliocene	4.5	7
		Miocene	19.0	26
		Oligocene	12.0	38
		Eocene	16.0	54
		Paleocene	11.0	65

Abridged Geologic Time Scale (Bolt et. al., 1975).