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Geotechnical Data from Accelerograph Stations Investigated During the Period 1975-1979

Summary Report

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ABSTRACT

This report summarizes geotechnical data that was obtained in the investigation of 83 accelerograph stations located in the United States. These stations were studied during the period from 1975 to 1979 and the detailed findings are contained in nine data reports. Summary logs indicating subsurface soil conditions and material properties have been prepared for each of the accelerograph stations. A classification system was devised for grouping the stations as either rock sites, stiff soil sites or deep soil sites. Using this classification system, simple ground motion plots have been prepared which qualitatively indicate the dependency of earthquake motions on local site conditions. This classification system may be used in more elaborate and quantitative studies of the influence of local site conditions upon earthquake ground response. On a practical engineering level, the site classification system and the results of the individual site investigations may be used in selecting earthquake records to establish seismic design criteria. Further research of the subsurface conditions at additional accelerograph stations is needed to increase the data base of earthquake records and recording stations.

SUMMARY

One of the major objectives of this report was to provide a compilation of the subsurface data for each of the accelerograph stations discussed in the individual data reports. This information is presented in the summary logs of Appendix A which contain available data for each site, including a generalized soil log, tables and plots of the static engineering properties of the soil, and values of subsurface shear wave velocities.

A classification system was developed which permits the stations to be grouped on the basis of the depth to bedrock or "rock-like" material. The three categories within this scheme are: 1) Rock Sites - rock within about 30 feet of the ground surface; 2) Stiff Soil Sites - rock at a depth of 50 to 200 feet; and 3) Deep Soil Sites - rock at a depth greater than 250 feet. It was attempted to classify each of the 83 accelerograph stations according to this scheme. However, only 48 sites clearly fell within any one of the groupings, providing a total of 18 rock sites, 26 stiff soil sites, and 4 deep soil sites.

The subsurface conditions at the individual accelerograph stations and the recommended site classification scheme may be used in both research and engineering applications. In research applications, the subsurface information and classification system may be used to study the influence that local site conditions have upon recorded earthquake ground motions. For example, simple plots indicating the attenuation of peak ground motion with distance were prepared for both rock sites and deep soil sites. These plots qualitatively indicate that different attenuation rates apply to each site condition, with ground motion attenuating more rapidly for rock sites. In engineering applications, the site data and classification system may be used to select earthquake records for site matching studies, and thus provide a more consistent basis upon which seismic design criteria may be formulated.

It is concluded that while the accelerograph station studies have significantly increased the information on the earthquake data base, still more research is needed in this area. Future studies should be made at accelerograph stations in seismically active areas in the world for the dual purpose of increasing the number of sites as well as the number of records in the earthquake data base.

SUMMARY REPORT

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1.0 INTRODUCTION

1.1 Purpose and Scope

Although many theoretical and analytical advancements have been made in the seismic design of major structures, they have far outstripped our understanding of the basic earthquake data base. This data base consists of earthquake ground motions that have been recorded at accelerograph stations located in various parts of the United States as well as other countries. Together, these earthquake records constitute a set of maximum ground motion values, time histories of acceleration, and response spectra, upon which seismic design recommendations are formulated. Effective use of this data, however, has been clouded by incomplete information and by inconsistencies in reported subsurface conditions at many of the earthquake recording stations (Duke and Leeds, 1972; EERI and NOAA, 1971; Mohraz, 1976; Seed, et al., 1974 and 1975; Trifunac and Brady, 1975; USGS, 1976; etc.). Thus, to make better use of the earthquake data base, it is necessary to have a more clear and consistent understanding of the subsurface characteristics at the various accelerograph stations.

Accordingly, studies were performed to provide subsurface information for a total of 83 accelerograph stations in the United States. These studies were conducted during the period 1975-1979 and the findings are presented in nine individual data reports. These data reports include information about each accelerograph station and its earthquake recordings, the geology and seismicity of the site area, and local subsurface conditions. By providing this geotechnical information for the more significant accelerograph stations in the United States, the earthquake data base may be used more effectively and should lead to more realistic seismic design practices.

The purpose of this report is to summarize the information contained in the individual data reports. This included a review of the individual data reports and updating this information with the findings from available new studies. Additionally, a classification system was devised and used to group the accelerograph stations on the basis of similar subsurface conditions for use in research studies of the effects of local site conditions upon earthquake ground response. The data contained in this report also may be used to develop earthquake design criteria.

1.2 Organization

This report is organized in six sections, with the first section presenting introductory information. The second section of the report identifies all of the accelerograph stations that were studied and discusses the general nature of the data reports, including the different report series, the methods used in site explorations, and the format of the reports. Summary findings are presented in section three, which includes a brief discussion of the summary logs that contain subsurface information for each of the sites. Additionally, subsurface conditions at the sites studied in the Los Angeles area are summarized in this section and compared with the findings of other investigators. The site classification system is discussed in section four and the potential use of the system is mentioned in section five. Finally, the conclusions of the study are presented in section six.

1.3 Authorization

This study was performed under contract NRC: 04-76-200 between the U.S. Nuclear Regulatory Commission and the joint venture of Shannon & Wilson, Inc., and Agbabian Associates (SW-AA). The study is part of an overall research program to evaluate soil behavior under earthquake loading conditions.

1.4 Acknowledgements and Contributors

This study benefited from various individuals. We especially acknowledge and thank Dr. J. Harbour of the U.S. Nuclear Regulatory Commission for his recognition of the need for accurate geotechnical information at strong motion accelerograph station sites and for his support and contributions as technical project monitor.

The SW-AA joint venture efforts were directed by Dr. R. P. Miller, Project Manager. Principal Investigator and Project Engineer for the Summary Report was Mr. W. P. Grant. Professor H. Bolton Seed of the University of California, Berkeley, and Dr. I. Arango, formerly of Shannon & Wilson, Inc., were consulted on the site classification system and the grouping of the sites into the different categories.

2.0 ACCELEROGRAPH STATION STUDIES

2.1 Sites

Sites of both existing and discontinued accelerograph stations were selected for study based on several factors. The most important factor was the number of significant events recorded at a station and the use of these records in specifying seismic design criteria for major structures. Also considered was the estimated potential of a station for recording future earthquakes. Finally, it was desired to include stations that would provide diversity to the group in terms of subsurface soil conditions, and of geologic and tectonic setting.

The locations of the accelerograph stations selected for study are indicated in Figs. 1-5. All of the stations that were studied are associated with the Strong Motion Instrument Network of the U.S. Geological Survey (USGS). Each station within this system has a unique identification number (USGS, 1976), which is also used to identify the stations in this report. An alphabetical listing of the stations by state and city is presented in Table I, and a cross-index of station numbers and sites is presented in Table A-1 in Appendix A.

As indicated in Fig. 1, the accelerograph stations studied are located in seven states. Seventy-one of the sites (85 percent of the group) are located in California. The reason that so many California sites were studied is that the vast majority of earthquake records in the United States come from accelerograph stations in California. Of the California sites, approximately 80 percent are located in the southern portion of the state and have recorded the San Fernando earthquake. Thus, sites in southern California account for most of the stations that were studied and provide the bulk of the earthquake data set.

2.2 Report Series

The results of the site studies are presented in nine individual data reports and one summary report, all of which are indicated in Table II. The individual sites discussed in each of these reports are listed in Table III.

The accelerograph station studies are generally categorized into two groups: studies of stations located on soil deposits and studies of stations located on rock. These two groupings are indicated as the "soil site" and "rock site" studies in Tables II and III. The results of the soil site studies are presented in five volumes, one for each year from 1975 to 1979 (SW-AA, 1975, 1976a, 1977a, 1978 and 1979a). The soil site studies are generally distinguished by the use of deep borings and in-situ geophysical testing to explore subsurface site conditions.

In contrast, the rock site series are studies of stations that are regarded by others as being founded on rock (Maley and Cloud, 1971; EERI-NOAA, 1971; Duke, et al., 1972; Seed, et al., 1974 and 1975; Trifunac and Brady, 1975; Mohraz, 1976; USGS, 1976). Differing from the soil site studies, borings were generally not advanced at the rock site stations. Instead, the subsurface conditions at these locations were evaluated from foundation reports in the area and from a geological reconnaissance of each site. The results from the rock site studies are primarily presented in two volumes (SW-AA, 1976b and 1977b), with an appendix of earthquake records (SW-AA, 1977c) for the Volume 2 report. The third volume in this series (SW-AA, 1979b) presents detailed information on the subsurface conditions at nine of the forty-nine accelerograph stations reported in the Volume 1 and 2 studies. The Volume 3 rock site studies were performed since existing data at selected stations in the Volume 1 and 2 studies was not adequate for defining the subsurface soil conditions. Consequently, the Volume 3 studies explored nine sites, which were discussed in earlier reports, with deep borings and geophysical testing.

Two other reports complete the accelerograph station studies. The first report is on selected sites in Los Angeles (SW-AA, 1976c); the second (this report), provides a summary of the information contained in the nine data reports.

2.3 Exploration Methods

2.3.1 General

Subsurface conditions at the sites were evaluated from the results of site explorations, including a surface reconnaissance, borings, geophysical testing and laboratory testing. All of these techniques, however, were not necessarily used at each site. The mix of exploration methods used at each site

and the source of the data, whether from the SW-AA joint venture or others, is indicated in Table IV. Each of these different methods of exploration is discussed below.

2.3.2 Surface Reconnaissance

A surface reconnaissance was conducted by the SW-AA joint venture at each accelerograph station. The purpose of this reconnaissance was to observe the materials in nearby road cuts and rock exposures and to correlate these findings with conditions indicated on geologic maps. This technique was successfully used in identifying the presence of rock at a number of accelerograph stations, which are identified in Table IV as "sites with no boring data".

2.3.3 Borings

Borings made by the SW-AA joint venture as well as data from others were used to evaluate the subsurface conditions at the accelerograph stations. The depths of the borings at each site and the source of the data are indicated in Table IV.

A total of 36 borings, both shallow and deep, were drilled in the SW-AA joint venture studies and used to evaluate the subsurface conditions at 53 accelerograph stations. Nine shallow borings were drilled at relatively isolated accelerograph stations and could only be used to evaluate subsurface conditions at the individual sites. On the other hand, several of the 27 deep borings were drilled in areas with a high density of accelerographs and one boring, in many cases, could be used to evaluate the conditions at several sites. Thus, because of the high density of stations, the findings of the 27 deep borings were used to evaluate subsurface conditions at 44 sites.

The shallow borings of the SW-AA joint venture were drilled primarily to determine the depth to rock for the rock site studies (SW-AA, 1976b and 1977b). Consequently, these borings had only limited sampling, and geophysical testing was not conducted. These holes averaged 45 feet in depth.

The deep borings of the SW-AA joint venture were generally drilled at locations other than rock sites (SW-AA, 1975, 1976a, 1976c, 1977a, 1978, 1979a, 1979b). These holes were drilled to an average depth of 300 feet, and included detailed sampling and geophysical testing. Most of the deep borings were drilled using rotary techniques, with a bentonite slurry used in the hole to stabilize the walls and return the cuttings to the surface. Soil samples were taken at selected intervals using Standard Penetration Test (SPT) or drive samplers, Shelby tubes, and Pitcher tubes. Samples were typically taken at 5-foot intervals in the first 100 feet of boring depth, 10-foot intervals between 100 and 200 feet, and at 20-foot intervals thereafter. Samples retrieved from the borings were sealed in containers and shipped to the Shannon & Wilson, Inc. laboratory for further examination and testing. Upon completion of drilling, the borings were cased for the geophysical testing.

Borings made by others also were used to evaluate the subsurface conditions at a majority of the rock site stations. This information was primarily obtained from foundation investigation reports for the site or nearby locations. Borings used from these reports were generally less than 100 feet deep.

Several sites are indicated in Table IV as having boring information from others as well as from the SW-AA joint venture. In such instances, shallow borings of others were available at the site, but an SW-AA boring was also made in the general vicinity. The depth indicated in the table represents that of the deeper, SW-AA hole.

2.3.4 Geophysical Testing

Shear wave velocity data at the sites were obtained from geophysical surveys performed in connection with the SW-AA joint venture studies and from the data of others. The measurement techniques used at each site and the source of the data are indicated in Table IV.

Geophysical testing techniques used in the SW-AA joint venture studies include the downhole method and a modified crosshole method. In the downhole method, a source at the ground surface is used to create shear waves which propagate downward and are detected by geophones lowered to different

depths in the boring. The incremental travel time of the waves between geophones and the separation distance of the geophones are used to compute the shear wave velocity. This testing technique is described in detail by Schwarz and Musser (1972).

The modified crosshole testing technique was used at eight of the soil sites. This method of exploration utilized special equipment and procedures developed by the SW-AA joint venture for the U.S. Nuclear Regulatory Commission (SW-AJA, 1974; SW-AA, 1977d). This test is conducted using four or more borings located along a line. Each of the borings is surveyed to determine the relative distance between the holes at each test depth. An energy source which creates shear waves is placed in one of the borings and geophones are lowered to the same elevation in the other holes. The shear wave velocity is computed from measurements of the shear wave arrival times at each hole and the horizontal distance of each hole from the energy source. The advantage of this testing technique over the downhole method is that it allows velocity measurements at both low and high strain levels, thus permitting determination of strain-dependent relationships of shear modulus for the soil. These relationships are used in ground response and soil/structure interaction studies.

Shear wave velocity measurements of other investigators were also used to evaluate the subsurface conditions at a number of stations. As indicated in Table IV, the methods that were used by others include conventional downhole and crosshole techniques (in-hole) and surface refraction techniques. The majority of this outside data comes from surface refraction measurements. In this method, both the energy source and the geophones are placed along a line on the ground surface. Shear waves created at the source travel downward and, upon encountering a strata with a different density (different material type), are refracted back to the ground surface where they are detected by the geophone sensors. The main advantage of the surface refraction technique is that it is inexpensive and does not require borings. However, this technique is the most difficult to reliably interpret of the various geophysical methods.

2.3.5 Laboratory Testing

Properties of the subsurface soils at the accelerograph stations were evaluated from laboratory tests performed in connection with the SW-AA joint venture studies and from data of others.

The most detailed testing programs in the SW-AA joint venture studies were associated with sites of deep borings. These programs typically included index tests and tests to determine the engineering properties of the soils. Index tests included visual classifications, water contents, density tests, Atterberg limits, and grain size analyses. Tests to determine the engineering properties of the soil included static strength tests, such as unconfined compression tests and unconsolidated-undrained triaxial compression tests, and dynamic tests, such as resonant column and cyclic triaxial tests.

Laboratory test data from others was generally from foundation investigations of nearby structures. These studies typically included index and static strength tests, but they did not include dynamic tests of the soil properties.

2.4 Format of Data Reports

2.4.1 General

The same basic report format has been used for all the data reports. This format presents information describing the station, geology and seismicity of the site area, and local subsurface conditions. This information is discussed with the aid of figures and tables. Appendices are included with details of the station records, site explorations and laboratory testing. Information typically contained in a soil site report is discussed below and illustrated in Figs. 6-11.

2.4.2 Station Description

The station description section of the data reports contains information on the location of the station, the building housing the

accelerograph, the instrumentation at the site, and the earthquakes recorded at the station. A topographic map, indicating the location of the station, is provided for each site (Fig. 6). Information describing the general size, configuration and construction of the building containing the accelerograph is supplemented with a photo and sketch of the building (Fig. 7). Finally, a brief history of the instrumentation at the site is given, along with a summary of the major earthquakes that have been recorded at the site. A photograph of the station instrumentation and a sketch of the instrument room accompanies this description (Fig. 8). Much of the information on the station instrumentation has been obtained from the files of the USGS Seismic Engineering Branch.

2.4.3 Geology and Seismicity

Information on the geology and seismicity of each site was compiled from a literature review. The geology of each station is discussed on a regional and local level. This discussion is accompanied by a map displaying the regional geology (Fig. 9) and a subsurface cross-section through or adjacent to the site (Fig. 10). The geologic structure and seismicity of the region are also discussed with the aid of the geologic map and section. Epicenters of the major earthquakes in the region are indicated on the geologic map and the text generally discusses the seismicity of the region as it may relate to known faults. Some reports also contain tabulations of significant historic earthquakes that have occurred within the region covered by the geologic map.

2.4.4 Site Conditions

The site conditions in the soil site reports are discussed in terms of surficial features, subsurface conditions and dynamic soil properties. This data is typically displayed in the format shown in Fig. 11. The extreme left portion of this figure contains a generalized log of the boring advanced at the site. Immediately to the right are summary tables and plots of the static engineering properties of the soil. The dynamic properties of the soil, as determined from field geophysical tests and laboratory resonant column and cyclic triaxial tests, are presented in the right hand portion of the figure.

As indicated in Fig. 11, both the downhole and modified crosshole (in-situ impulse) geophysical tests were performed at the Lincoln School accelerograph station in Taft, California. The shear wave velocities plotted in this figure show that there is excellent correlation in the results of these two different test methods. The non-linear behavior of the soil measured in the modified crosshole test is illustrated in the plot in the extreme right portion of Fig. 11.

2.4.5 Appendices

The data reports typically contain three appendices: Earthquake Records, Field Explorations, and Laboratory Testing. The Earthquake Records appendix presents a listing of the earthquakes that have been recorded at the station. This appendix also contains time history and ground response spectra plots for earthquake records which have been digitized. The Field Explorations appendix discusses general procedures and detailed findings of the drilling, sampling, and geophysical testing conducted at each site. Similarly, the Laboratory Testing appendix discusses general testing procedures and presents detailed results of the tests conducted on the site materials.

3.0 SUMMARY FINDINGS

3.1 Summary Logs

Subsurface information at the sites has been compiled and is presented as a summary log for each of the 83 accelerograph stations. These logs, presented in Appendix A, resemble an abbreviated version of the Boring Log and Summary of Test Results figures (Fig. 11) which appear in the data reports. The summary logs present available data for the site, including a generalized soil log, tables and plots of the static engineering properties of the soil, and values of subsurface shear wave velocities. Sources of information used in compiling the logs are indicated on the individual sheets. Additionally, the logs contain a brief description of the accelerograph station building and the location of the instrument within the building.

The summary logs were compiled, based on all original information used in preparing the individual data reports, and on new information that has become available since the data reports were written. Consequently, some differences exist in the information presented in the summary logs and that appearing in the individual data reports. These differences mostly occur for stations in the rock site studies where boring data of others was used to depict site conditions. If the review of the original data indicated that logs other than those appearing in the data reports provided a more complete representation of site conditions, this data was used in the summary logs. Additionally, information on the subsurface conditions at several sites in the San Francisco Bay region was updated by the findings of recent studies of the USGS (1977 and 1978).

3.2 Los Angeles Area Studies

Because the majority of sites investigated are located in southern California, an overview of the subsurface conditions of the Los Angeles area is in order. The following summarizes our findings of site conditions in this area.

A total of 34 sites were studied in the vicinity of Los Angeles (See Fig. 12). The SW-AA joint venture explored the subsurface conditions in this area

with a total of nine deep borings and associated geophysical testing. These borings, represented by triangles in Fig. 12, were used to evaluate the subsurface conditions at 25 accelerograph stations. Because the remaining nine sites were not located near one of the SW-AA joint venture borings, the subsurface conditions were evaluated based on a geologic reconnaissance and on available soils and foundation reports for the building and surrounding area.

A generalized geologic cross-section of the Los Angeles area, represented as line A-A' in Fig. 12, is presented in Fig. 13. This cross-section indicates that the downtown area is situated in a region of uplifted sedimentary rocks of Tertiary age, which dip southwest and are covered by a veneer of unconsolidated Quaternary sediments. At the base of the Tertiary sequence is the Topanga Formation, which includes middle Miocene shale, sandstone and conglomerate. Overlying the Topanga Formation is siliceous and diatomaceous shale, siltstone, sandstone and conglomerate of the upper Miocene Puente and Modelo Formations. At the top of the Tertiary section are the Repetto and Pico Formations, collectively known as the Fernando Formation. The Fernando Formation, which is early to late Pliocene in age, chiefly consists of marine siltstone, sandstone and conglomerate. Each of the different formations comprising the Tertiary section may crop out locally in various parts of the Los Angeles area.

Subsurface shear wave velocities obtained in the SW-AA joint venture studies of the Los Angeles area sites are summarized in Fig. 14. The shear wave velocities have been grouped in this figure for the following geologic conditions: Pleistocene Alluvium, Pliocene Sedimentary Rock, and Miocene Sedimentary Rock. Individual formations within these groups are indicated by different line segments.

Review of the data in Fig. 14 indicates a relatively good correlation of the shear wave velocities in each of the groups. Within the Miocene rock group, the Topanga Formation has higher near-surface velocities than either the Puente or Modelo Formations. The Modelo Formation has the lowest shear wave velocities in this group. Compared to velocities obtained in the Pliocene sediments, values for the Miocene rock are typically 300 to 500 fps higher. The Pliocene data actually agree quite well with the velocities obtained for the Modelo Formation.

3.3 Comparisons with Other Investigations

Shear wave velocities have also been obtained from other investigators who used surface refraction techniques at a number of locations in the Los Angeles area (Duke, et al., 1971; Eguchi, et al., 1976). Velocities obtained at locations near an accelerograph station of this study have been included on the summary logs (Appendix A). At a number of locations, the velocities from the surface refraction measurements are in quite good agreement with the downhole velocities determined in the SW-AA joint venture studies. However, at many sites the refraction velocities were significantly higher than the downhole velocities.

A comparison of velocity data from surface refraction and downhole measurements at sites in Los Angeles is presented in Fig. 15. The velocity data shown in Fig. 15 have been plotted for the three geologic conditions: Pleistocene Alluvium, Pliocene Sedimentary Rock and Miocene Sedimentary Rock. The surface refraction velocities were obtained from Campbell and Duke (1976), who have summarized the velocities measured by Duke, et al., (1971) and Eguchi, et al. (1976). Velocities indicated by line segments correspond to the downhole measurements from the SW-AA joint venture studies.

Review of the data in Fig. 15 indicates that there are several significant differences in the findings of the SW-AA joint venture studies and those of Campbell and Duke (1976). First, the velocities of Campbell and Duke are consistently higher than those of the SW-AA joint venture studies. The difference may range from several hundred fps in the Pleistocene alluvium and Pliocene rock, to over 1000 fps in the Miocene rock. Secondly, the Campbell and Duke data indicate a much more rapid increase of shear wave velocity with depth than the findings of the SW-AA joint venture. Finally, the Campbell and Duke data indicate a much greater difference in velocity between the Pliocene and Miocene rock than the findings of the SW-AA joint venture.

Several factors may contribute to these differences in the velocity data, such as the manner of data presentation, anisotropy in the subsurface materials, and the method of testing.

The manner of data presentation may represent an "apparent difference" versus an "actual difference" in the data. The Campbell and Duke data presented in Fig. 15 show the velocities plotted with respect to the depth to the top of the layer. Consequently, plotting the velocities at the center of the layer would shift the data points down and provide for a better agreement with the SW-AA joint venture data. This phenomena is apparent in some of the summary logs where there is good agreement between the refraction and downhole data.

Anisotropy may account for velocity differences at some sites; however, it does not satisfactorily explain the overall data trends. Because of anisotropic conditions, shear waves may propagate at different velocities in directions perpendicular and parallel to bedding planes of layered deposits. Thus, surface refraction measurements may yield higher shear wave velocities in a horizontally layered deposit than downhole velocity measurements (Schwarz and Musser, 1972). However, this factor does not completely account for all the velocity differences, as the Tertiary strata at many locations in Los Angeles are not horizontal, having been deformed by folding and faulting. Consequently, at sites with steeply inclined strata, higher velocities would be expected from downhole measurements, if anisotropic effects were significant. This condition of bedding planes at different inclinations would tend to average out the data with some sites having higher velocities from refraction measurements and others having higher velocities from downhole measurements. Thus, the consistently higher values for the data from the surface refraction measurements appear to be indicative of something other than anisotropy.

Differences in the velocity data may also be attributed to the inherent limitations of the surface refraction method. Of the geophysical techniques commonly used, the surface refraction method is the most difficult to interpret, and different assumptions of layer thicknesses or inconsistencies in record interpretation may significantly affect the computed velocity. Accordingly, it is our opinion that the downhole measurements represent a more reliable index of the true shear wave velocity.

This relative confidence in the downhole technique is illustrated in the following comparisons. First, the downhole technique was used by both Duke, et al. (1971) and the SW-AA joint venture near Bunker Hill in the downtown area of

Los Angeles. The sites of the two measurements are about 500 feet apart and the results are indicated on the summary log for the 222 Figueroa St. site in Appendix A (Fig. A-29). The results from both of these independent measurements are in excellent agreement. Secondly, crosshole and downhole measurements were both made at a number of sites studied by the SW-AA joint venture. At these locations, velocities from the downhole measurements were found to be in good agreement with values determined from the crosshole method. Differences in these wave velocities are typically about 5 percent (Wilson and others, 1978), further illustrating the relative reliability of the downhole method. Finally, other independent studies which have employed downhole geophysical measurements have also found the surface refraction velocities of Campbell and Duke to be relatively high. The USGS has obtained shear wave velocities at a number of accelerograph stations in the San Francisco Bay Area, and compared these findings with those of Campbell and Duke for similar geologic conditions (USGS, 1978). The results of this comparison indicated that surface refraction velocities of Campbell and Duke were relatively high, compared to similar materials in the Bay Area.

4.0 SITE CLASSIFICATIONS

A classification system was devised to group the sites studied by the SW-AA joint venture on the basis of similar subsurface conditions. Such a grouping is useful in studies of the effects of local soil conditions upon earthquake ground response. The classification system also forms the basis for selecting earthquake records in engineering design applications.

Three categories were used in the site classification system: Rock Sites, Stiff Soil Sites, and Deep Soil Sites. The common denominator in the classification system is the depth to rock or "rock-like" material beneath the site. This system is similar to that used by Seed, et al. (1975) in which "rock-like" material is considered to have a shear wave velocity greater than about 2500 fps. The groups of the classification system are defined below.

1. Rock Sites - Rock within about 30 feet of the ground surface.
2. Stiff Soil Sites - Rock overlain by 50 to 200 feet of stiff clay, dense sand or gravel.
3. Deep Soil Sites - Rock overlain by more than 250 feet of soil.

The site classification scheme was devised so that there would be a gap in the depth to rock between the rock sites and the stiff soil sites, and between the stiff soil sites and deep soil sites. The purpose of these gaps was to create a more homogeneous and distinct data set.

Information on the subsurface conditions at each of the 83 accelerograph stations was reviewed in an attempt to classify the sites. Table V presents the results of the site classifications, along with a brief description of the site geologic conditions, the basis for the site classification, and information on the site explorations. Of the 83 accelerograph stations, 48 clearly fell into one of the three groupings. Thirty-two of the remaining sites were deleted from the classifications. These sites either lacked data indicating the depth to rock, or the data was marginal and would not clearly allow classification of the site in just one category. Three sites were omitted from the classifications because of unusual conditions,

such as accelerographs located on dams or highly variable geologic conditions in the vicinity of the site.

The distribution of the stations classified include 18 rock sites, 26 stiff soil sites, and 4 deep soil sites. The rock sites were identified by encountering rock in shallow borings or by observing rock in nearby outcrops. Half of the rock sites are founded on granitic materials. Of the stiff soil sites, five were identified by competent rock encountered in the boring and another five by high shear wave velocities measured in the soil column. The majority of the stiff soil sites, however, are located on Tertiary sediments which have relatively low, near-surface shear wave velocities. These sites are primarily located in Los Angeles, where the near- surface Tertiary strata have engineering properties and shear wave velocities more similar to a hard soil than a soft rock. The shear wave velocities in these Tertiary strata, however, generally reach a value of about 2500 fps within a depth of 200 feet. The deep soil sites include deposits of both cohesive and cohesionless materials. These deposits generally had low shear wave velocities for at least a depth of 250 feet.

5.0 APPLICATIONS OF STUDY RESULTS

The data contained in the SW-AA joint venture reports may be useful for both research and engineering applications.

In research applications, data at the individual sites may be used in special studies, such as the soil/structure interaction studies that the SW-AA joint venture performed for the El Centro accelerograph station (SW-AA, 1979c). Collectively, the site classification scheme may be used in studies of the effects of local soil conditions on earthquake ground response. Parameters which may be studied in this way may include maximum ground motions, ground motion ratios, response spectra (shapes, ordinates, spectrum intensity and arias intensity), fourier spectra, durations, and significant cycles of shaking as dependent variables; and earthquake source, size, mechanism and location as independent variables.

In engineering applications, information from the individual stations would be useful in assembling records for site matching studies. Site matching studies are commonly used in empirical derivations of seismic design criteria. The criteria for a project site are based upon a review of actual ground motion records obtained at accelerograph stations having subsurface conditions similar to those of the project site. The subsurface conditions disclosed in the accelerograph station studies provide a consistent basis in which these site matching studies may be performed.

An example of the use of the site classification system is presented in Fig. 16, which shows how peak ground motions and ground motion ratios attenuate with distance from the earthquake epicenter for rock sites and deep soil sites. These plots include data from magnitude 6.0-7.0 earthquakes, with data from the San Fernando event being differentiated from non-San Fernando records. It is evident that the rock site data are dominated by the San Fernando earthquake, while the deep soil sites contain no data from this event. Ground accelerations plotted in Fig. 16 correspond to uncorrected records in Volume I of the California Institute of Technology earthquake record series (Hudson, et al., 1969-1975). Velocities and displacements are from the corrected accelerograms in the Caltech Volume II series (Hudson, et al., 1971-1975).

In a preliminary way, the dependency of earthquake ground motions on local site conditions is illustrated by the data in Fig. 16. The data in the peak ground motion plots indicate that ground motions for deep soil sites and rock sites may attenuate at different rates with distance, with the rock sites having a relatively higher attenuation rate. Site dependent effects, however, are more clearly indicated in the ground motion ratio plot (V/A). Here, the ground motion ratios for the deep soil sites are significantly higher than those for the rock sites. Also, the ground motion ratios for both the rock and deep soil sites appear to be relatively insensitive to distance. A constant V/A relationship indicates that peak ground velocities attenuate with distance at the same rate as peak accelerations. Thus, for a given site condition, one attenuation rate applies equally to both acceleration and velocity. The separation of the rock site data from the soil site data in the V/A plot indicates differing attenuation rates of peak ground motion for both rock sites and deep soil sites.

6.0 CONCLUSIONS

The goal of the SW-AA joint venture studies was to broaden and refine the data base of earthquake records by providing geotechnical and seismological data at selected accelerograph stations. As a result, 83 accelerograph stations were studied and the findings presented in nine data reports (Table II).

The five volumes of the soil site data reports contain information on 23 accelerograph stations. Except for two sites in Helena, Montana, which are founded on rock, the subsurface conditions at all stations in the soil site reports were evaluated based on the findings of a deep boring, geophysical measurements and laboratory tests. The deep borings at the soil sites had an average depth of 300 feet.

The three volumes of the rock site reports contain information on 49 accelerograph stations. Subsurface conditions at these stations were generally evaluated from existing boring data in the vicinity of the sites. The results of the rock site studies show that only 15 of the stations regarded by other investigators as being founded on rock were actually located on rock. In fact, 15 other sites were found to be located on alluvial deposits, where the depth to rock ranged from a minimum of 50 feet to a maximum of over 300 feet. The remaining 19 stations were founded on Tertiary sediments with less than 50 feet of overburden. These sites are primarily located in Los Angeles, where the near-surface Tertiary sediments were found to have engineering properties more similar to a hard soil than a soft rock.

The remaining data report discusses 11 sites in the Los Angeles area. These stations were located in three areas, where a deep boring in each area was adequate to evaluate subsurface conditions at several accelerograph stations. Each boring was advanced to depths in excess of 300 feet, in-situ geophysical testing was conducted in each to determine shear wave velocities, and laboratory tests were performed on samples retrieved from each of the borings.

To facilitate use of the findings of the data reports, a summary log was prepared for each of the stations, and a site classification scheme adopted to allow

grouping of the data. The summary logs and site classification system presented in this report are intended to provide a basis in which the relationship of recorded ground motions to local site conditions may be studied for both research and engineering applications. Simple plots of earthquake ground motion for rock sites and deep soil sites indicate the dependency of earthquake ground motions on local site conditions.

Although the accelerograph station studies have significantly increased the information on the earthquake data base, more studies are needed to broaden the earthquake data base. More stations in each grouping, particuarly the deep soil group, need to be studied and more earthquake data is needed for the sites in each of the groupings. Perhaps future studies may be extended to include accelerograph stations in other, more seismically active, areas of the world.

TABLE I

GEOGRAPHIC INDEX OF ACCELEROGRAPH STATIONS

Reference No.		Station		USGS Station No.	Map Fig.	SW-AA Report
		ALASKA				
1	Anchorage	AMU Gould Hall		2702	1	1978
2	Fairbanks	UA Duckering Hall		2721	1	1975a
		CALIFORNIA				
3	Carbon Canyon Dam			108	4	1977b
4	Castaic	Old Ridge Route		110*	4	1977b
5	Cedar Springs	Miller Canyon Guard Sta. (Formerly called Allen Ranch)		111	3	1977b
6	Cedar Springs	Pump House		112*	3	1977b
7	Cholame - Shandon Array	Station 2		1013	3	1975
8	Cholame - Shandon Array	Temblor		1438*	3	1977b
9	Cholame - Shandon Array	Temblor II		1097	3	1977b
10	Costa Mesa	666 W. 19th St.	Bethel Towers	114	4	1977b
11	Edmonston Pumping Plant			1027*,991*	3	1976b
12	El Centro	Terminal Substation	302 Commercial Ave.	117	3	1975
13	Eureka	Federal Bldg.	500 "H" St.	1022	1	1977b,1979b
14	Fairmont Reservoir			121	4	1976b
15	Ferndale	Fire Station (Former City Hall)	Brown St.	1023	1	1975
16	Fort Tejon			1096*,998*	3	1976b
17	Gilroy	Gavilan College	Physical Science Bldg.	1250	1	1977a
18	Glendale	633 E. Broadway	Municipal Services Bldg.	122	4	1977b,1979b
19	Goleta	UCSB Fluid Mech. Lab.		282*	3	1977b
20	Hollister	City Hall	375 Fifth St.	1028	1	1979a
21	Lake Hughes Array	Station 1 and 1A		125*,828	4	1976b
22	Lake Hughes Array	Station 4		126	4	1977b
23	Lake Hughes Array	Station 9		127	4	1976b
24	Lake Hughes Array	Station 12		128	4	1977b
25	Los Angeles	1900 Ave. of Stars	Union Bank Bldg.	184	5	1976c
26	"	1901 Ave. of Stars		187	5	1976c
27	"	1800 Century Park East	Northrup Bldg.	425	5	1976c

TABLE I

GEOGRAPHIC INDEX OF ACCELEROGRAPH STATIONS (Cont'd)

Reference No.	Station			USGS Station No.	Map Fig.	SW-AA Report
		CALIFORNIA (Cont'd)				
28	Los Angeles	1880 Century Park East	Property Research Bldg.	440	5	1976c
29	"	222 Figueroa	Bunker Hill Towers-West	145	5	1976b,1979b
30	"	234 Figueroa	Bunker Hill Towers-South	148	5	1976b,1979b
31	"	445 Figueroa	Union Bank	157	5	1976b,1979b
32	"	800 W. First	Bunker Hill Towers-Ctr.	172	5	1976b,1979b
33	"	420 S. Grand Ave.	Pacific Tel	154	5	1977b
34	"	Griffith Observatory		141	4	1977b
35	"	1025 N. Highland Av.	Hollywood Storage Bldg.	133	5	1979a
		"	"	135	5	"
36	"	111 N. Hope	Water & Power Bldg.	137	5	1976b,1979b
37	"	3838 Lankershim	Sheraton-Universal Hotel	220	4	1977b,1979b
38	"	616 S. Normandie Av.	Wilshire Christian Manor	431	5	1976b
39	"	3407 W. Sixth	Mutual Bldg.	199	5	1976c
40	"	4867 Sunset	Kaiser Hospital	226	5	1977b,1979b
41	"	14724 Ventura	Certified Life	253	4	1976c
42	"	15250 Ventura	Bank of California	466	4	1976c
43	"	15910 Ventura	KB Valley Center	461	4	1976c
44	"	2500 Wilshire	Wilshire-Coronado Bldg.	449	5	1976b
45	"	3345 Wilshire	Wilshire Square	196	5	1976c
46	"	3411 Wilshire	Equitable Life	202	5	1976b
47	"	3470 Wilshire	Pacific Tel.	208	5	1976c
48	"	3550 Wilshire	Tishman Bldg.	211	5	1976c
49	"	3710 Wilshire	Beneficial Plaza	217	5	1976b
50	"	4680 Wilshire	Farmers Insurance	223	5	1976b
51	"	5900 Wilshire	Mutual Benefit	428	5	1976b
52	"	6200 Wilshire	Wilshire Medical Bldg.	443	5	1976b
53	"	2011 Zonal	Hoffman Medical Res.	190	4	1976b
54	Melendy Ranch Barn			1211*	1	1976a
55	Oakland	City Hall	1421 Washington	1049	2	1977b

TABLE I

GEOGRAPHIC INDEX OF ACCELEROGRAPH STATIONS (Cont'd)

Reference No.	Station			USGS Station No.	Map Fig.	SW-AA Report
		CALIFORNIA (Cont'd)				
56	Oso Pumping Plant			1052*,993*	4	1976b
57	Pacoima Dam			279	4	1977b
58	Palos Verdes	2516 Via Tejon		411	4	1977b
59	Pasadena	CIT Millikan Library		264	4	1976a
60	•	CIT Old Seismic Lab.	295 N. San Rafael	266*	4	1977b
61	•	4800 Oak Grove (JPL)		267	4	1977b
62	Petrolia	General Store		1398	1	1979a
63	Puddingstone Reservoir			278	4	1977b
64	San Francisco	Alexander Bldg.	155 Montgomery	1065	2	1977b
65	•	Golden Gate Park	Prayerbook Cross	1117	2	1977b
66	•	State Bldg.	350 McAllister	1080	2	1977b
67	San Luis Obispo	City Rec. Bldg.	864 Santa Rosa	1083	3	1977b
68	San Onofre	Nuclear Power Plant		280	3	1977b
69	Santa Anita Dam			104	4	1977b
70	Santa Barbara	County Courthouse		283	3	1976a
71	Santa Felicia Dam	Outlet Works		284*	4	1977b
72	Taft	Lincoln School Tunnel		1094	3	1976a
73	Wrightwood	6074 Park Drive	United Ca. Bank	290*	4	1977b
		MISSOURI				
74	New Madrid	Noranda Aluminum Plant	Rectifier/Control Bldg.	2420	1	1979a
		MONTANA				
75	Bozeman	MSU Roberts Hall		2205		1977a
76	Helena	Carroll College		2202	1	1977a
77	•	Federal Bldg.		2229*	1	1977a
		OREGON				
78	Portland	PSU Cramer Hall		2172	1	1978
79	•	State Office Building	1400 S.W. Fifth Av.	2110*	1	1978

TABLE I

GEOGRAPHIC INDEX OF ACCELEROGRAPH STATIONS (Cont'd)

Reference No.	Station			USGS Station No.	Map Fig.	SW-AA Report
		UTAH				
80	Logan	USU Old Main Bldg.		2203	1	1977a
		WASHINGTON				
81	Olympia	Highway Test Lab.	318 State Av.	2101	1	1978
82	Seattle	Federal Office Bldg.	909 - First Av.	2102	1	1978
83	Tacoma	County-City Bldg.		2104	1	1977a

* Station discontinued

TABLE II

DATA REPORTS

	SOIL SITE SERIES	ROCK SITE SERIES	OTHER
1975	Vol. 1 3 Sites in California (SW-AA, 1975a)		
1976	Vol. 2 4 Sites in California (SW-AA, 1976a)	Vol. 1 19 Sites in California (SW-AA, 1976b)	Data for 11 sites in Los Angeles (SW-AA, 1976c)
1977	Vol. 3 6 Sites in the Western U.S. (SW-AA, 1977a)	Vol. 2 30 Sites in California (SW-AA, 1977b, and 1977c)	
1978	Vol. 4 5 Sites in the Western U.S. (SW-AA, 1978)		
1979	Vol. 5 5 Sites in the U.S. (SW-AA, 1979a)	Vol. 3 Subsurface conditions studied in greater detail at 9 sites in Vol. 1 and 2 reports (SW-AA, 1979b)	SUMMARY REPORT Summary data for stations studied from 1975-1979 (This report)

TABLE III

STATIONS IN THE DATA REPORTS

SOIL SITES

SW-AA, 1975
California

Ferndale, Fire Sta.
Cholame No. 2
El Centro, Terminal Substation

SW-AA, 1976a
California

Pasadena, CIT Millikan Library
Santa Barbara, County Courthouse
Taft, Lincoln School
Melendy Ranch Barn

SW-AA, 1977a

Gilroy, CA, Gavilan College
Logan, UT, USU Old Main Bldg.
Bozeman, MT, MSU Roberts Hall
Tacoma, WA , County-City Bldg.
Helena, MT , Federal Bldg. and
Carroll College

ROCK SITES

SW-AA, 1976b
California

* L.A.,	222 Figueroa	Edmonston Pumping Plant
*	234 Figueroa	Fairmont Reservoir
*	445 Figueroa	Fort Tejon
*	800 W. First	Lake Hughes No. 1
*	111 N. Hope	Lake Hughes No. 9
	616 S. Normandie	Oso Pumping Plant
	2500 Wilshire	
	3411 Wilshire	
	3710 Wilshire	
	4680 Wilshire	
	5900 Wilshire	
	6200 Wilshire	
	2011 Zonal	

SW-AA, 1976c
California

L.A.	3345 Wilshire
	3407 W. Sixth
	3470 Wilshire
	3550 Wilshire
	1900 Ave. of the Stars
	1901 Ave. of the Stars
	1800 Century Park East
	1880 Century Park East
	14724 Ventura
	15250 Ventura
	15910 Ventura

SW-AA, 1977b and 1977c
California

*	Eureka, Federal Bldg.	Cedar Spri
	San Francisco, Alexander Bldg.	Carbon Can
	Golden Gate Park	Puddingsto
	State Bldg.	L.A. 420
	Oakland, City Hall	* 486
	Cholame-Shandon Temblor	Gri
	Cholame-Shandon Temblor II	* 383
	San Luis Obispo, City Rec.	* Glendale,
	Goleta, UCSB Fluid Mech. Lab	Santa Anit
	Santa Felicia Dam	Pacoima Da
	Castaic, Old Ridge Route	Pasadena,
	Lake Hughes No. 4	
	Lake Hughes No. 12	Palos Verd
	Wrightwood, 6074 Park Dr.	Costa Mesa
	Cedar Springs, Pump House	San Onofre

OTHER

SW-AA, 1978

Anchorage, AK, AMU Gould Hall
Seattle, WA , Federal Office Bldg.
Olympia, WA , Highway Test Lab.
Portland, OR , State Office Bldg. and
PSU Cramer Hall

SW-AA, 1979a

Fairbanks, AK , UA Duckering Hall
Petrolia, CA , General Store
Hollister, CA , City Hall
Los Angeles, CA , Hollywood Storage Bldg.
New Madrid, MO , Noranda Aluminum Plant

SW-AA, 1979b
California

Eureka, Federal Bldg.
Glendale, 633 E. Broadway
L.A. 222 Figueroa
234 Figueroa
445 Figueroa
800 W. First
111 N. Hope
3838 Lankershim
4867 Sunset

...e, Miller Canyon Sta.
...n Dam
... Reservoir
... Grand
Sunset
...ith Observatory
Lankersnim
...33 E. Broadway
Dam

... Seismic Lab.
... 2516 Via Tejon
...66 W. 19th
...ower Plant

SW-AA, 1979
(This Report)
Summary Report
All Sites

* Stations whose subsurface conditions were studied in detail in SW-AA, 1979b

TABLE IV

SUMMARY OF SITE EXPLORATION METHODS

Reference No.	Station		Boring Data			Velocity Data					SW-AA Report
						SW-AA		Others			
			SW-AA	Others	Depth (ft.)	Downhole	Crosshole	In-hole	Refraction	Depth (ft.)	
	ALASKA										
1	Anch age	AMU Gould Hall	X		300	X				300	1978
2	Fairbanks	UA Duckering Hall	X		157	X				150	1979a
	CALIFORNIA										
3	Carbon Canyon Dam			X	33			NA			1977b
4	Castaic	Old Ridge Route		NA					X	90	1977b
5	Cedar Springs	Miller Canyon Guard Sta.		NA				NA			1977b
6	Cedar Springs	Pump House	X		63			NA			1977b
7	Cholame-Shandon Array, Station 2		X		221	X	X			210	1975
8	Cholame-Shandon Array, Temblor			NA				NA			1977b
9	Cholame-Shandon Array, Temblor II			NA				NA			1977b
10	Costa Mesa	666 W. 19th St.		X	65			NA			1977b
11	dmonston Pumping Plant		X		34			NA			1976b
12	El Centro	Terminal Substation	X		401	X	X			390	1975
13	Eureka	Federal Bldg.	X		348	X				340	1977b,1979b
14	Fairmont Reservoir		X		30			NA			1976b
15	Ferndale	Fire Station	X		263	X	X			180	1975
16	Fort Tejon		X		75			NA			1976b
17	Gilroy	Gavilan College	X		77		X			60	1977a
18	Glendale	633 E. Broadway	X		399	X				360	1977b,1979b
19	Goleta	UCSB Fluid Mech. Lab.		X	18				X	15	1977b
20	Hollister	City Hall	X		349	X				345	1979a
21	Lake Hughes Array	Station 1 and 1A	X		55			NA			1976b
22	Lake Hughes Array	Station 4		NA				NA			1977b
23	Lake Hughes Array	Station 9	X		9			NA			1976b
24	Lake Hughes Array	Station 12	X		3			NA			1977b
25	Los Angeles	1900 Ave. of Stars	X		401	X		X	X	400	1976c
26	•	1901 Ave. of Stars	X		401	X		X	X	400	1976c
27	•	1800 Century Park East	X		401	X		X	X	400	1976c
28	•	1880 Century Park East	X		401	X		X	X	400	1976c
29	•	222 Figueroa	X		405	X		X	X	395	1976b,1979b
30	•	234 Figueroa	X		405	X		X	X	395	1976b,1979b
31	•	445 Figueroa	X	X	405	X		X	X	395	1976b,1979b
32	•	800 W. First	X	X	405	X			X	395	1976b,1979b

TABLE IV

SUMMARY OF SITE EXPLORATION METHODS (Cont'd)

Reference No.	Station		Boring Data			Velocity Data					SW-AA Report
						SW-AA		Others			
			SW-AA	Others	Depth (ft.)	Downhole	Crosshole	In-hole	Refraction	Depth (ft.)	
	CALIFORNIA (cont'd)										
33	Los Angeles	420 S. Grand Ave.		X	75			X	X	150	1977b
34	"	Griffith Observatory		NA				NA			1977b
35	"	1025 N. Highland Ave	X		360	X			X	340	1979a
36	"	111 N. Hope	X	X	405	X			X	395	1976b,1979b
37	"	3838 Lankershim	X		349	X				345	1977b,1979b
38	"	616 S. Normandie Av.	X	X	401	X			X	235	1976b
39	"	3407 W. Sixth	X		401	X			X	235	1976c
40	"	4867 Sunset	X		302	X				300	1977b,1979b
41	"	14724 Ventura	X		321	X			X	320	1976c
42	"	15250 Ventura	X		321	X			X	320	1976c
43	"	15910 Ventura	X		321	X			X	320	1976c
44	"	2500 Wilshire	X	X	401	X			X	235	1976b
45	"	3345 Wilshire	X		401	X			X	235	1976c
46	"	3411 Wilshire	X		401	X				235	1976b
47	"	3470 Wilshire	X	X	401	X			X	235	1976c
48	"	3550 Wilshire	X	X	401	X			X	235	1976c
49	"	3710 Wilshire	X	X	40?	X			X	235	1976b
50	"	4680 Wilshire		X	62				X	25	1976b
51	"	5900 Wilshire		X	150				X	50	1976b
52	"	6200 Wilshire		X	130				X	50	1976b
53	"	2011 Zonal		X	60				X	50	1976b
54	Melendy Ranch Barn		X		340	X	X			340	1976a
55	Oakland	City Hall		X	92			X		85	1977b
56	Oso Pumping Plant			X	200				X	50	1976b
57	Pacoima Dam			NA				X	X	50?	1977b
58	Palos Verdes	2516 Via Tejon		X	25				X	50	1977b
59	Pasadena	CIT Millikan Library	X		401	X				400	1976a
60	"	CIT O'[illegible] Seismic Lab.		NA					X	50	1977b
61	"	4800 Oak Grove (JPL)		X	680	X		X		414	1977b
62	Petrolia	General Store	X		180	X				180	1979a
63	Puddingstone Reservoir			X	115			NA			1977b
64	San Francisco	Alexander Bldg.		X	140			X		90	1977b
65	"	Golden Gate Park		X	90			X		90	1977b
66	"	State Bldg.		X	217			X		90	1977b

TABLE IV

SUMMARY OF SITE EXPLORATION METHODS (Cont'd)

Reference No.	Station		Boring Data			Velocity Data					SW-AA Report
						SW-AA		Others			
			SW-AA	Others	Depth (ft.)	Downhole	Crosshole	In-hole	Refraction	Depth (ft.)	
		CALIFORNIA (cont'd)									
67	San Luis Obispo	City Rec. Bldg.	X		45				X	80	1977b
68	San Onofre	Nuclear Power Plant		X	987			X	X	?	1977b
69	Santa Anita Dam			NA			NA				1977b
70	Santa Barbara	County Courthouse	X		401	X			X	400	1976a
71	Santa Felicia Dam	Outlet Works		X	17		NA				1977b
72	Taft	Lincoln School Tunnel	X		321	X	X		X	321	1976a
73	Wrightwood	6074 Park Drive	X		89		NA				1977b
		MISSOURI									
74	New Madrid	Noranda Aluminum Plant	X		329	X				329	1979a
		MONTANA									
75	Bozeman	MSU Roberts Hall	X		99		X			80	1977a
76	Helena	Carroll College		NA				NA			1977a
77	"	Federal Bldg.		NA				NA			1977a
		OREGON									
78	Portland	PSU Cramer Hall	X	X	260	X				260	1978
79	"	State Office Building	X	X	260	X				260	1978
		UTAH									
80	Logan	USU Old Main Bldg.	X		287	X				250	1977a
		WASHINGTON									
81	Olympia	Highway Test Lab.		X	511			X		440	1978
82	Seattle	Federal Office Bldg.	X		400	X				400	1978
83	Tacoma	County-City Bldg.	X		398	X	X			310	1977a

NOTE:

Sites where either boring or velocity data is not available are indicated "NA".

TABLE V
SITE CLASSIFICATIONS

Reference No.	Station		Site Conditions	Classification[1]	Basis for Classification: Competent Rock - Outcrop -	Competent Rock - Boring -	Tertiary Rock - High V_s -	Soil - High V_s	>250' Soil - low V_s
	ALASKA								
1	Anchorage	AMU Gould Hall	>300' Glacial Till & Morraine	SS				X	
2	Fairbanks	UA Duckering Hall	5' Loess over Birch Creek Schist (Precambrian)	R		X			
	CALIFORNIA								
3	Carbon Canyon Dam		95' Fill (dam) over Fernando Fm.	Omit					
4	Castaic	Old Ridge Route	Castaic Fm SS/SH (Miocene)	SS			X		
5	Cedar Springs	Miller Canyon Guard Sta.	Granite	R	X				
6	Cedar Springs	Pump House	>63' Quat. Sediments Crowder Fm (Pleis.) @ 8', SS/congl.	Delete					
7	Cholame-Shandon Array, Station 2		>221' Alluvium	Delete					
8	Cholame-Shandon Array, Temblor		Serpentine & Shale	R	X				
9	Cholame-Shandon Array, Temblor II		Monterey Gp. SS/SH (Miocene)	R	X				
10	Costa Mesa	666 W. 19th St.	23' Alluvium over Fernando Fm.	Delete					
11	Edmonston Pumping Plant		13' Alluvium over Granite	R		X			
12	El Centro	Terminal Substation	>401' Quat. Sediments	DS					X
13	Eureka	Federal Bldg.	>3xx' Quat. Sediments Hookton Fm (Pleis) @ 87' unconsol. Sa.	Delete					
14	Fairmont Reservoir		17' Fill over Granite	R		X			
15	Ferndale	Fire Station	>263' Quat. Sediments Hookton Fm (Pleis.) @ 100' Sa./Gvl.	Delete					
16	Fort Tejon		70' Alluvium over Granite	SS		X			
17	Gilroy	Gavilan College	40' Alluvium over 20' Monterey Gp ? over Franciscan Assemblage	SS			X		
18	Glendale	633 E. Broadway	>399' Alluvium	SS				X	
19	Goleta	UCSB Fluid Mech. Lab.	14' Alluvium over Sisquoc Fm. SH. (Pliocene)	Delete					
20	Hollister	City Hall	>349' Alluvium	Delete					
21	Lake Hughes Array, Stations 1 and 1A		>55' Alluvium	Omit					
22	Lake Hughes Array, Station 4		Granite	R	X				
23	Lake Hughes Array, Station 9		Granite	R		X			
24	Lake Hughes Array, Station 12		5' Alluvium over Elizabeth Canyon Fm., SS/SH (Eocene)	R		X			
25	Los Angeles	1900 Ave. of Stars	>401' Pleistocene sediments, San Pedro Fm. (sand-silt) @ 77'	Delete					
26	"	1901 Ave. of Stars	>401' Pleistocene sediments, San Pedro Fm. (sand-silt) @ 77'	Delete					
27	"	1800 Century Park East	>401' Pleistocene sediments, San Pedro Fm. (sand-silt) @ 77'	Delete					
28	"	1880 Century Park East	>401' Pleistocene sediments, San Pedro Fm. (sand-silt) @ 77'	Delete					
29	"	222 Figueroa	19' Fill & Alluvium over Fernando Fm SH.	Delete					
30	"	234 Figueroa	19' Fill & Alluvium over Fernando Fm. SH.	Delete					
31	"	445 Figueroa	4' Fill over Fernando Fm. SH.	Delete					
32	"	800 W. First	Puente Fm. SH. (Miocene)	Delete					
33	"	420 S. Grand Ave.	10' Fill & Alluvium over Fernando Fm.	Delete					
34	"	Griffith Observatory	Granite	R	X				
35	"	1025 N. Highland Av.	146' Alluvium over Fernando Fm.	Delete					
36	"	111 N. Hope	Puente Fm. SS/SH	Delete					
37	"	3838 Lankershim	15' Fill over Topanga Fm. (Miocene)	SS			X		
38	"	616 S. Normandie Av.	32' Fill & Alluvium over Puente Fm.	SS			X		
39	"	3407 W. Sixth	28' Alluvium over Puente Fm.	SS			X		
40	"	4867 Sunset	xx' Alluvium over Puente Fm.	SS			X		
41	"	14724 Ventura	63' Alluvium over Modelo Fm.	Delete					
42	"	15250 Ventura	63' Alluvium over Modelo Fm.	Delete					
43	"	15910 Ventura	63' Alluvium over Modelo Fm.	Delete					
44	"	2500 Wilshire	32' Fill & Alluvium over Puente Fm.	SS			X		
45	"	3345 Wilshire	28' Alluvium over Puente Fm.	SS			X		
46	"	3411 Wilshire	28' Alluvium over Puente Fm.	SS			X		
47	"	3470 Wilshire	43' Alluvium over Puente Fm.	SS			X		

ion[2]

Exploration Information

Delete		Omit	Boring Data			Velocity Data				
						SW-AA		Others		
Marginal Data	Lack of Data	Unusual Conditions	SW-AA	Others	Depth (ft.)	Downhole	Crosshole	In-hole	Refraction	Depth (ft.)
			X		300	X				300
			X		157	X				150
		X		X	33		———			
			———						X	90
			———				———			
	X		X		63		———			
	X		X		221	X	X			210
			———				———			
			———				———			
	X			X	65		———			
			X		34		———			
			X		401	X	X			390
X			X		348	X				340
			X		30		———			
	X		X		263	X	X			180
			X		75		———			
			X		77		X			60
			X		399	X				360
	X			X	18				X	15
X			X		349	X				345
		X	X		55		———			
			———				———			
			X		9		———			
			X		3		———			
X			X		401	X		X	X	400
X			X		401	X		X	X	400
X			X		401	X		X	X	400
X			X		401	X		X	X	400
X			X		405	X		X	X	395
X			X		405	X		X	X	395
X			X	X	405	X		X	X	395
X			X	X	405	X			X	395
	X			X	75			X	X	150
			———				———			
X			X		360	X			X	340
X			X	X	405	X			X	395
			X		349	X				345
			X	X	401	X			X	235
			X		401	X			X	235
			X		302	X				300
			X		321	X			X	320
			X		321	X			X	320
			X		321	X			X	320
			X	X	401	X			X	235
			X		401	X			X	235
			X		401	X				235
			X	X	401	X			X	235

Reference No.	Station		Site Conditions
		CALIFORNIA (Cont'd)	
48	Los Angeles	3550 Wilshire	60' Alluvium over Fernando Fm.
49	"	3710 Wilshire	29' Alluvium over Fernando Fm.
50	"	4680 Wilshire	>62' Quat. sediments
51	"	5900 Wilshire	>150' Quat. sediments
52	"	6200 Wilshire	>130' Quat. sediments
53	"	2011 Zonal	2' Alluvium over Puente SS/SH
54	Melendy Ranch Barn		18' Alluvium over Etchegoin Gp. (Plio.) SS/SH
55	Oakland	City Hall	>92' Quat. sediments (probably >300')
56	Oso Pumping Plant		117' Alluvium over Menke Mine Fm. (Plio.)
57	Pacoima Dam		Granite
58	Palos Verdes	2516 Via Tejon	19' Quat. sediments over Monterey Sh. (Plio.)
59	Pasadena	CIT Millikan Library	>400' Alluvium (Pleistocene)
60	"	CIT Old Seismic Lab.	Granite
61	"	4800 Oak Grove (JPL)	635' Alluvium (Pleist.) over granite
62	Petrolia	General Store	56' Alluvium over Yager Fm. (Mes.) (SS/SH)
63	Pudding**stone Reservoir**		87' Breccia over basalt
64	San Francisco	Alexander Bldg.	140' Quat. sediments over Franciscan Assem. (Mes.)
65	"	Golden Gate Park	Franciscan Assem. (Mes.) SH/Chert
66	"	State Bldg.	211' Quat. sediments over Franciscan Assem.
67	San Luis Obispo	City Rec. Bldg.	17' Alluvium over Franciscan Assem., SH
68	San Onofre	Nuclear Power Plant	San Mateo Fm. (Poorly consol. SS)
69	Santa Anita Dam		Granite
70	Santa Barbara	County Courthouse	>401' Alluvium
71	Santa Felicia Dam,	Outlet Works	7' Alluvium over Modelo Fm. (Miocene)
72	Taft	Lincoln School Tunnel	301' Alluvium over Pleistocene S.
73	Wrightwood	6074 Park Drive	>89' Alluvium
		MISSOURI	
74	New Madrid	Noranda Aluminum Plant	190' Alluvium over Tert. unconsol. sand
		MONTANA	
75	Bozeman	MSU Roberts Hall	83' Alluvium over schist & gneiss
76	Helena	Carroll College	Limestone
77	"	Federal Bldg.	Limestone
		OREGON	
78	Portland	PSU Cramer Hall	92' Alluvium over 146' Troutdale Fm. gvl. (Plio.)
79	"	State Office Building	12' Alluvium over 140' Troutdale Fm. gvl. (Plio.)
		UTAH	
80	Logan	USU Old Main Bldg.	>287' Quaternary sediments
		WASHINGTON	
81	Olympia	Highway Test Lab.	>511'Glacial sediments
82	Seattle	Federal Office Bldg.	>400' Glacial sediments
83	Tacoma	County-City Bldg.	>398' Glacial sediments

NOTES:

1. Classifications

   R - **Rock Sites** (Rock $\leq$ 30 ft.)
   SS - **Stiff Soil Sites** (50 ft. $\leq$ Rock $\leq$ 200 ft.)
   DS - **Deep Soil Sites** (Rock > 250 ft.)

2.

TABLE V
TE CLASSIFICATIONS (Cont'd)

Classification[1]	Basis for Classification[2]								Exploration Information							
						Delete		Omit	Boring Data			Velocity Data				
												SW-AA		Others		
	Competent Rock - Outcrop -	Competent Rock - Boring -	Tertiary Rock - High V_s -	Soil - High V_s	>250' Soil - low V_s	Marginal Data	Lack of Data	Unusual Conditions	SW-AA	Others	Depth (ft.)	Downhole	Crosshole	In-hole	Refraction	Depth (ft.)
SS			X						X	X	401	X			X	235
SS			X						X	X	401	X			X	235
Delete							X			X	62				X	25
Delete							X			X	150				X	50
Delete							X			X	130				X	50
Delete							X			X	60				X	50
SS			X						X		340	X	X			340
Delete							X			X	92			X		85
Delete							X			X	200				X	50
R	X													X	X	507
Delete							X			X	25				X	50
Delete						X										
R	X								X		401	X				400
Delete						X									X	50
SS			X							X	680	X		X		414
SS		X							X		180	X				180
SS		X								X	115					
										X	140			X		90
R	X															
SS		X								X	90			X		90
										X	217			X		90
R		X														
Delete							X		X		45				X	80
R	X									X	987			X	X	?
DS					X				X		401	X			X	400
R		X								X	17					
SS				X					X		321	X	X		X	321
Delete							X		X		89					
DS					X				X		329	X				329
SS		X							X		99		X			80
R	X															
R	X															
SS			X						X	X	260	X				260
SS			X						X	X	260	X				260
SS				X					X		267	X				250
DS					X					X	511			X		440
SS				X					X		400	X				400
Omit								X	X		398	X	X			310

is for Classifications:

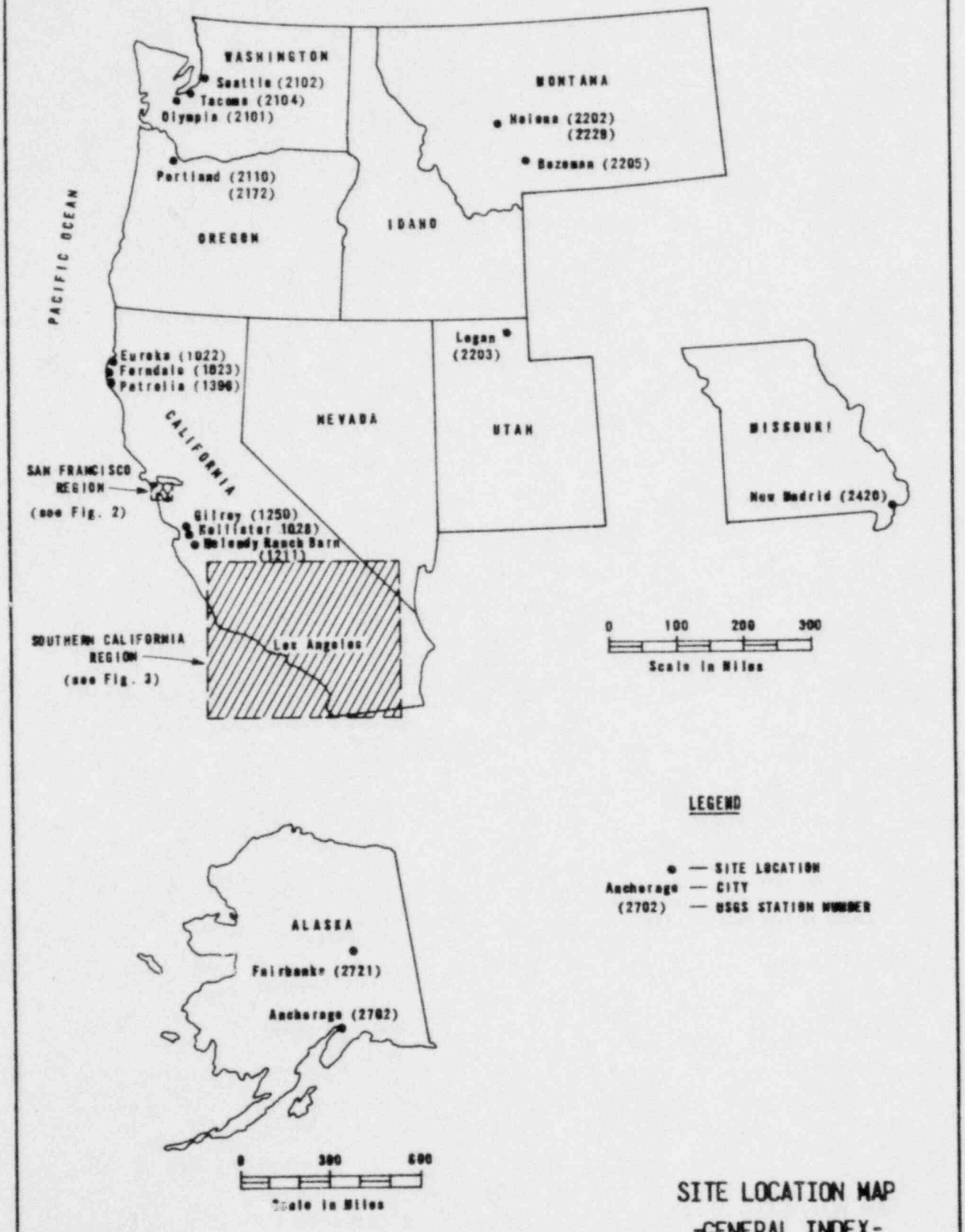
Deletions

Marginal Data - Shear wave velocities do not clearly fit into just one group.

Lack of data - No velocity data or data not sufficiently deep to identify "rock" like material.

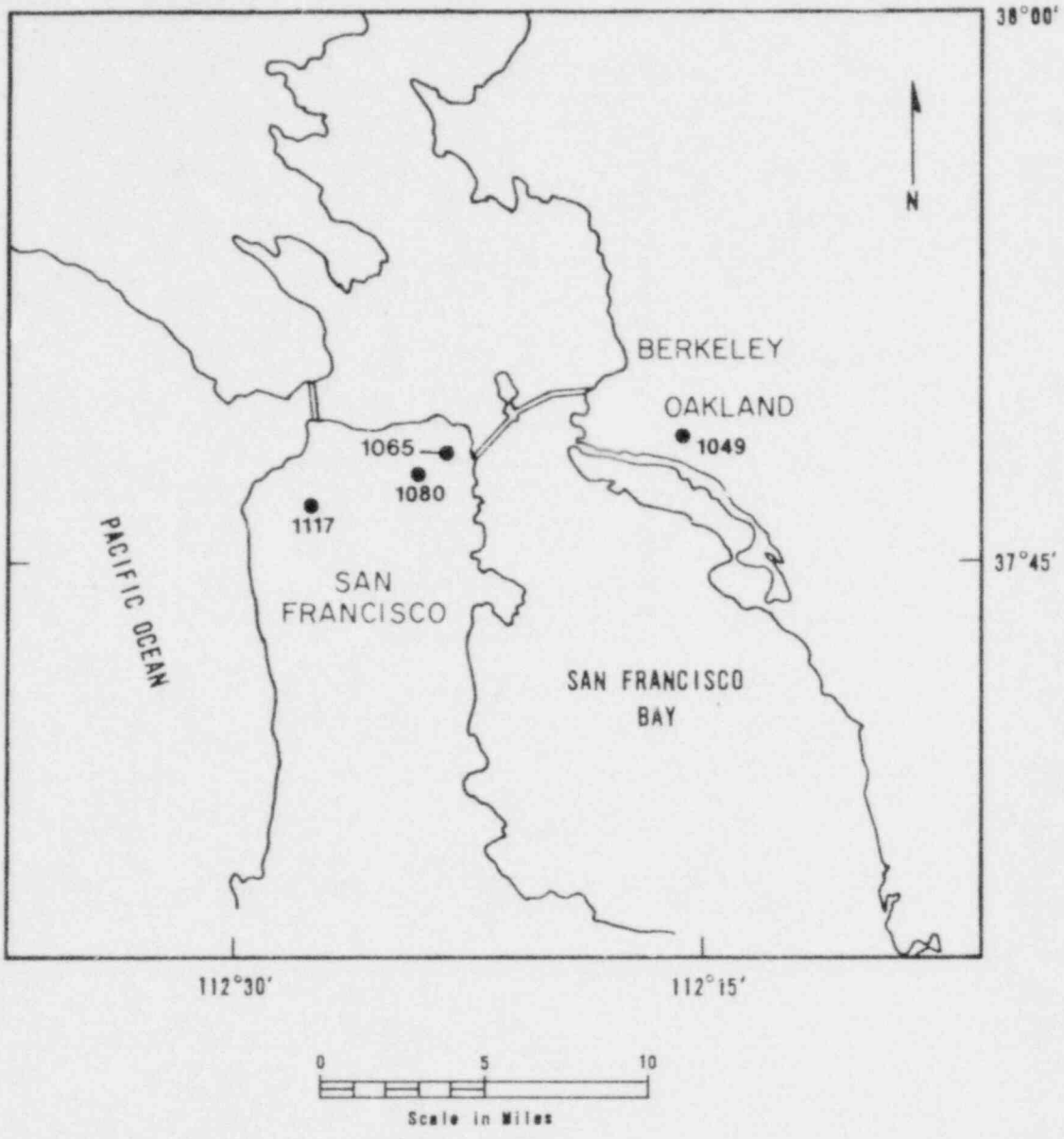
Omissions

Unusual Conditions - Locations on dams, depth to rock quite variable, velocity inversions.



SITE LOCATION MAP
-GENERAL INDEX-

FIG. 1

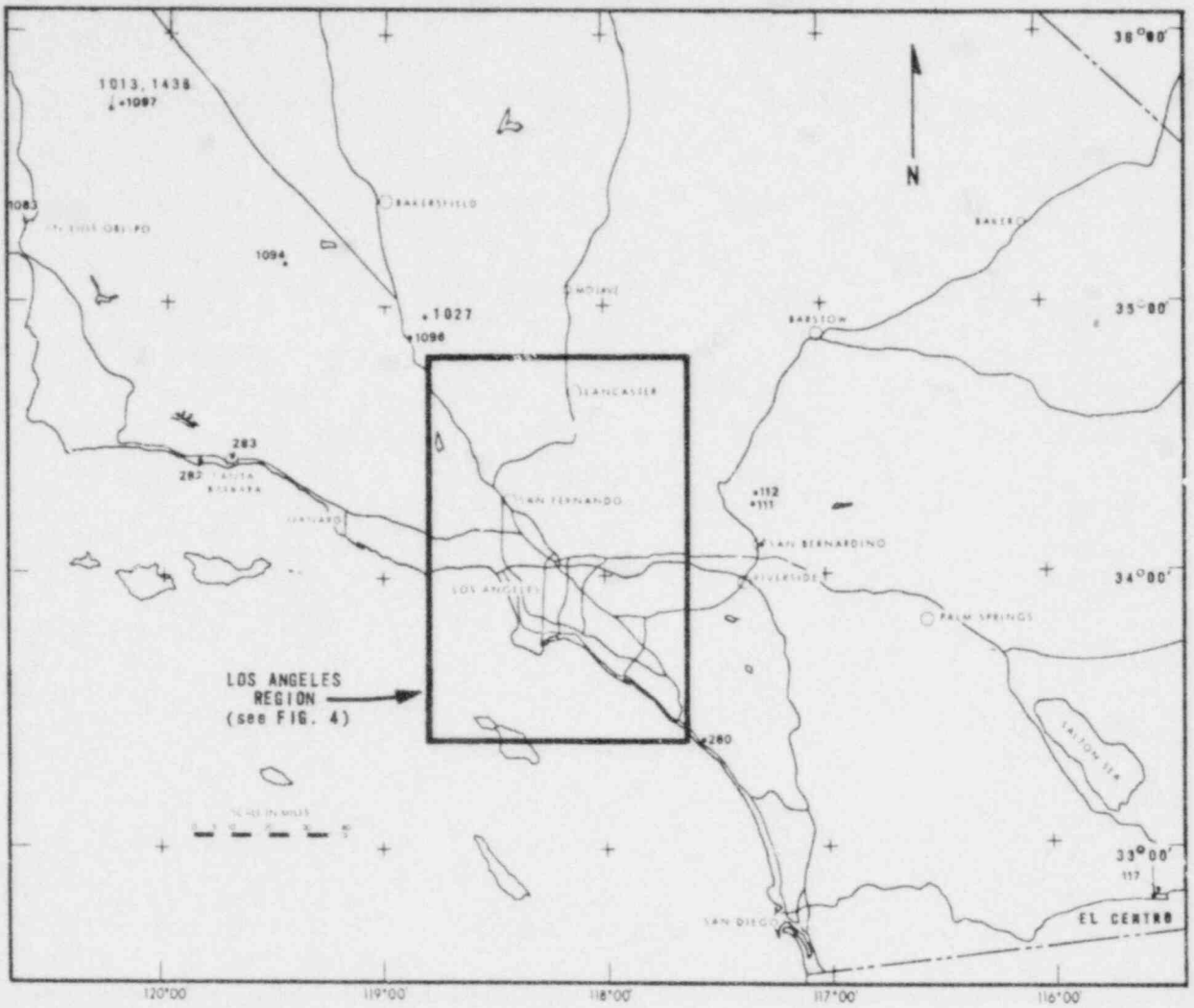


LEGEND

● 1117 Site Location and USGS Station Number

SITE LOCATION MAP
- SAN FRANCISCO REGION -

FIG. 2



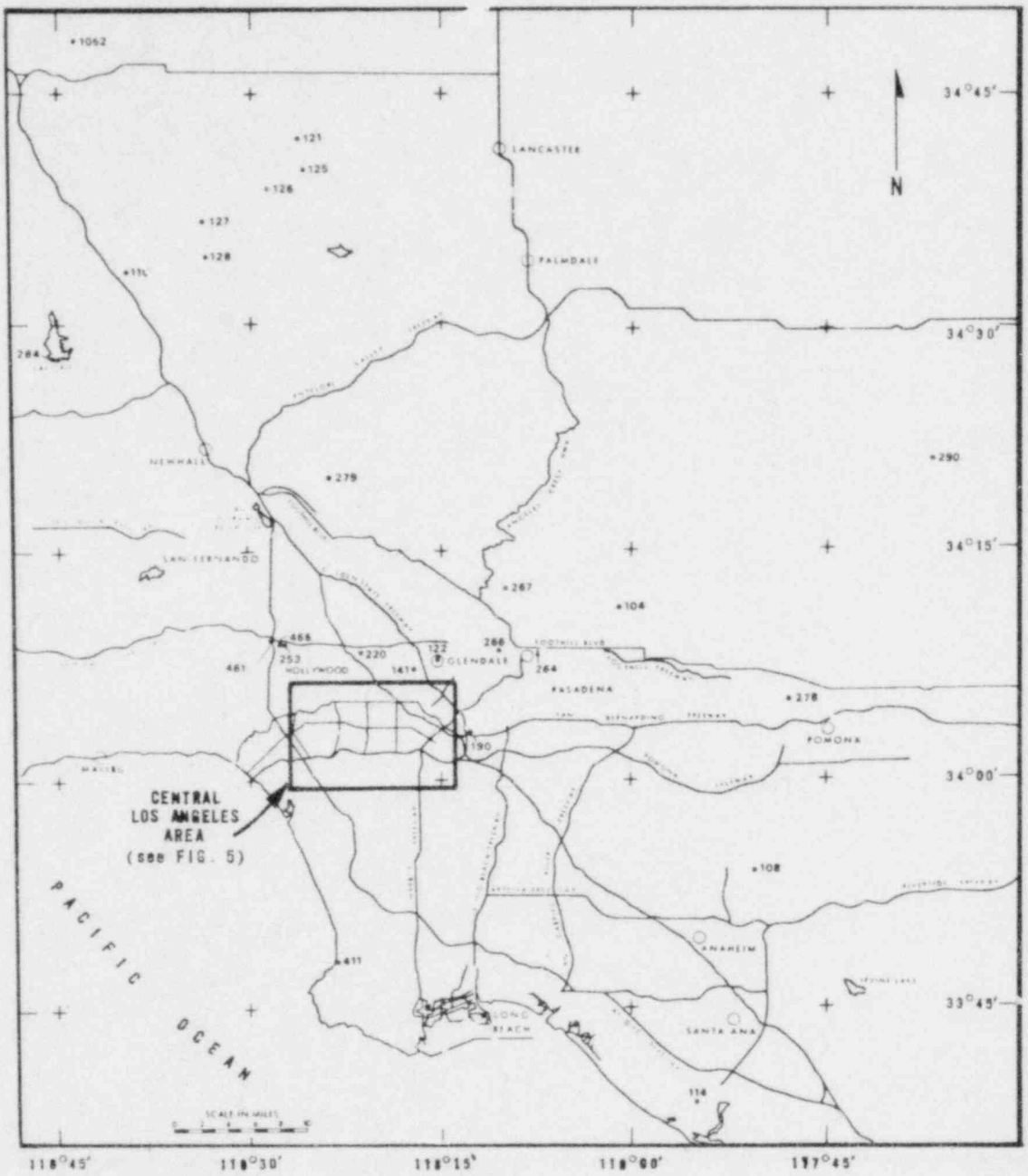
LEGEND

• 1013 Site Location and USGS Station Number

SITE LOCATION MAP

- SOUTHERN CALIFORNIA REGION -

FIG. 3



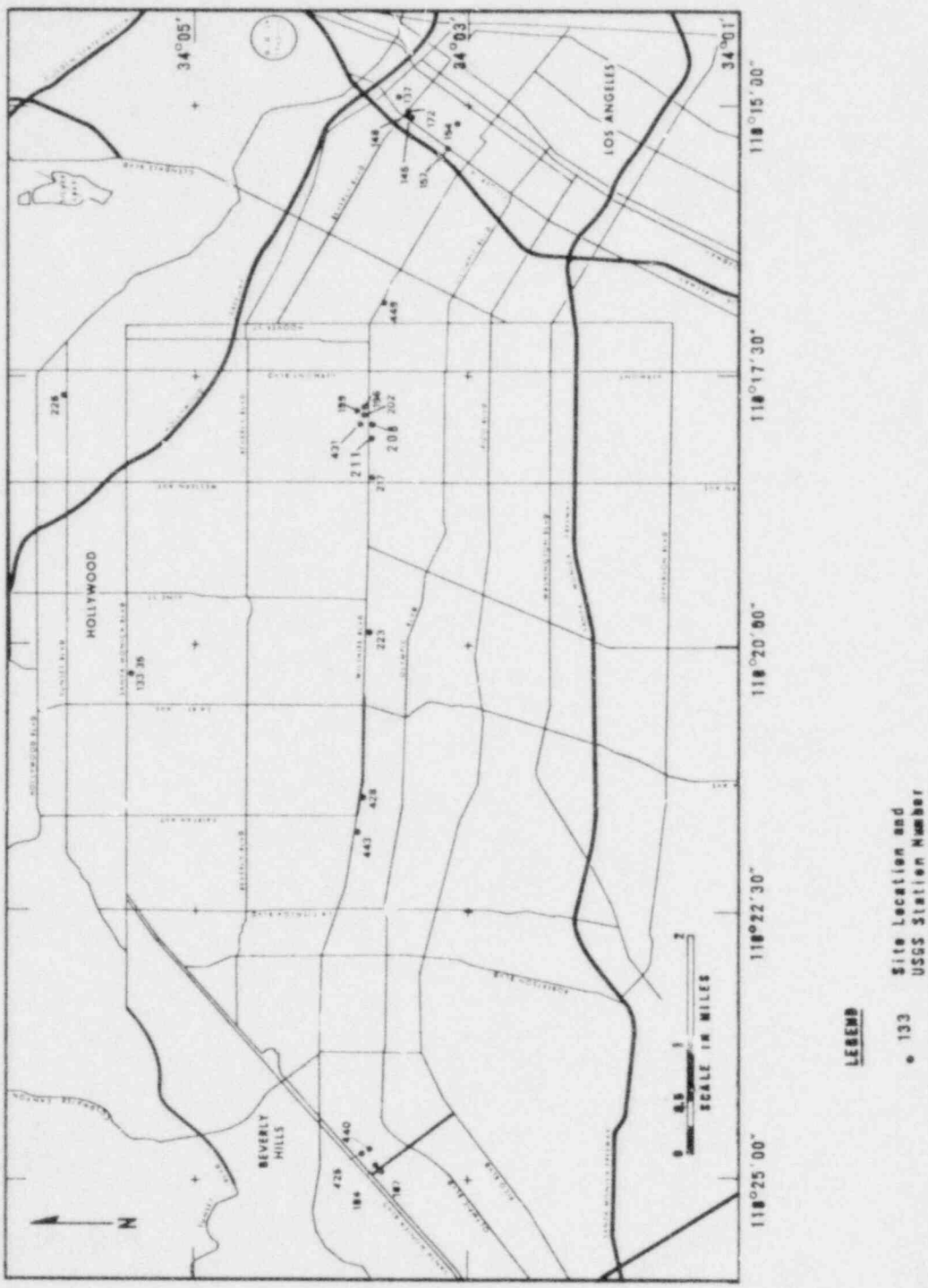
LEGEND

*1052 Site location and USGS Station Number

SITE LOCATION MAP

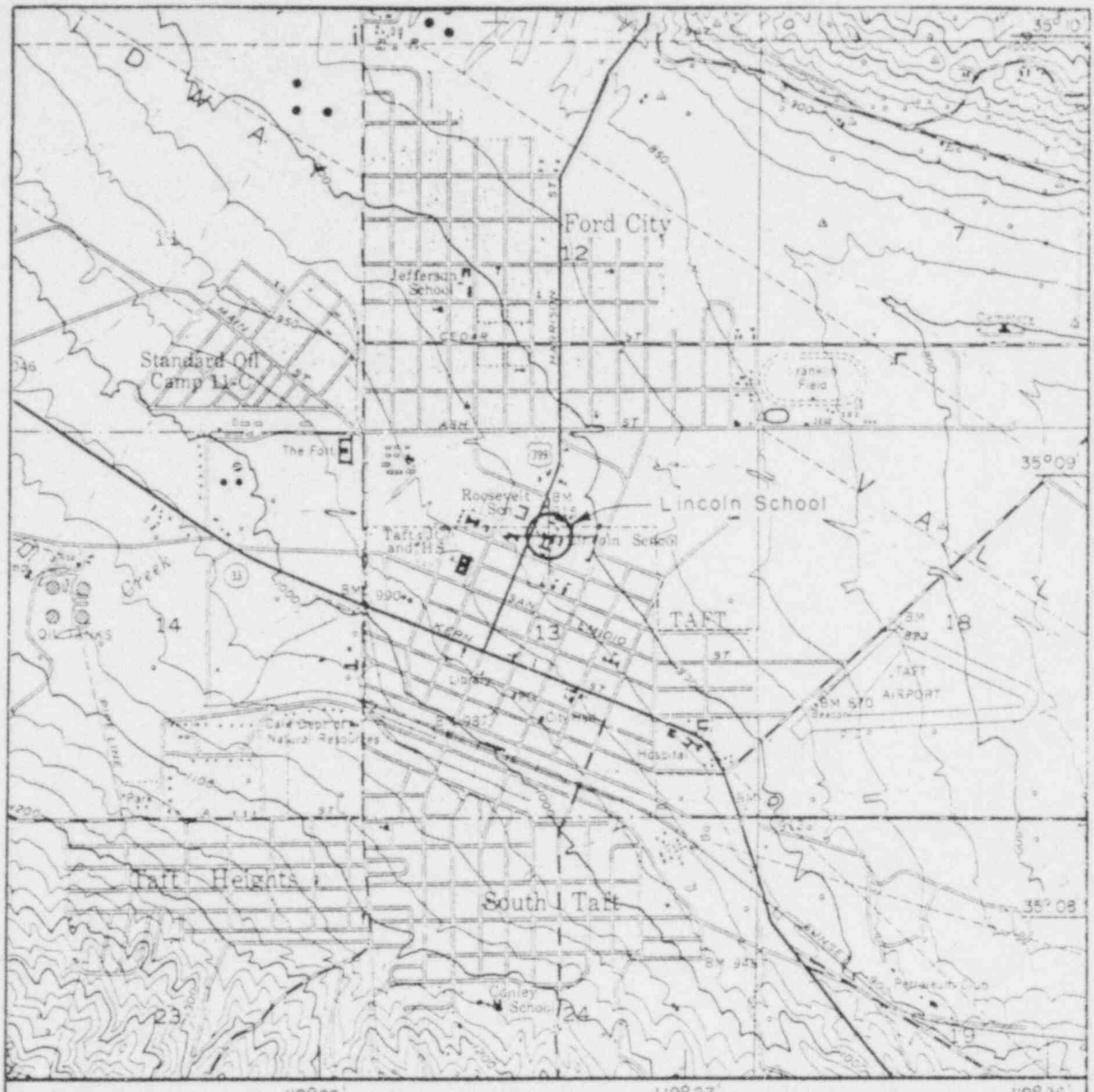
- LOS ANGELES REGION -

FIG. 4



SITE LOCATION MAP
- CENTRAL LOS ANGELES AREA -

FIG. 5



Lincoln School

USGS Topographic Quadrangle:
Taft, California

Coordinates: 35° 08' 52" N
119° 27' 22" W

Location: Sixth and Warren Streets.

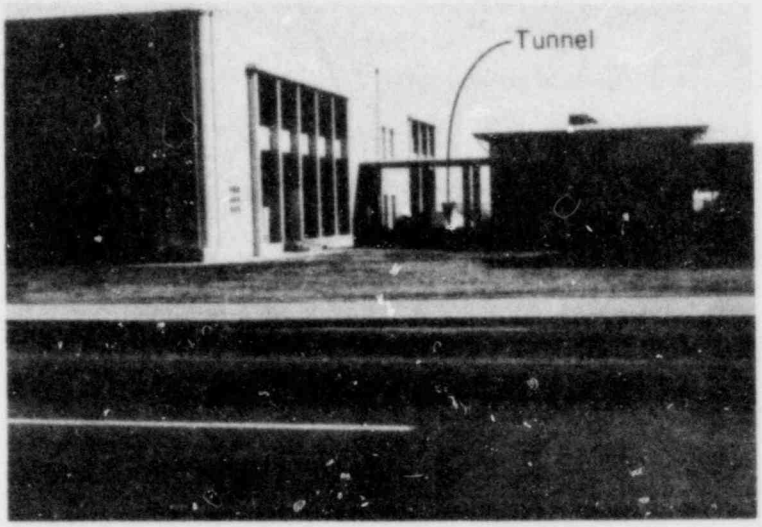
Structure: Two-story, reinforced concrete

Note: Coordinates scaled from USGS topographic quadrangle

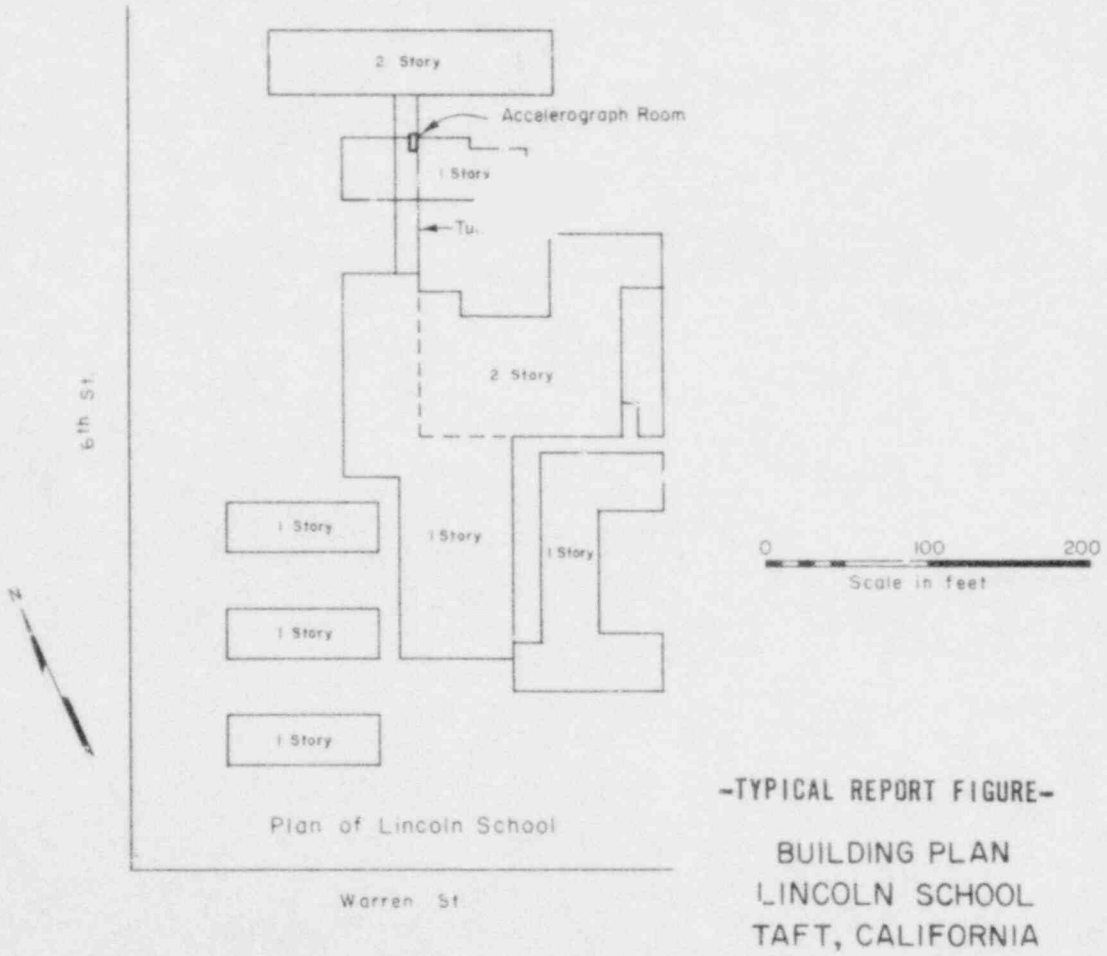
-TYPICAL REPORT FIGURE-

STATION LOCATION
LINCOLN SCHOOL
TAFT, CALIFORNIA

FIG. 6



Northeastern End of Lincoln School
View - Northeast

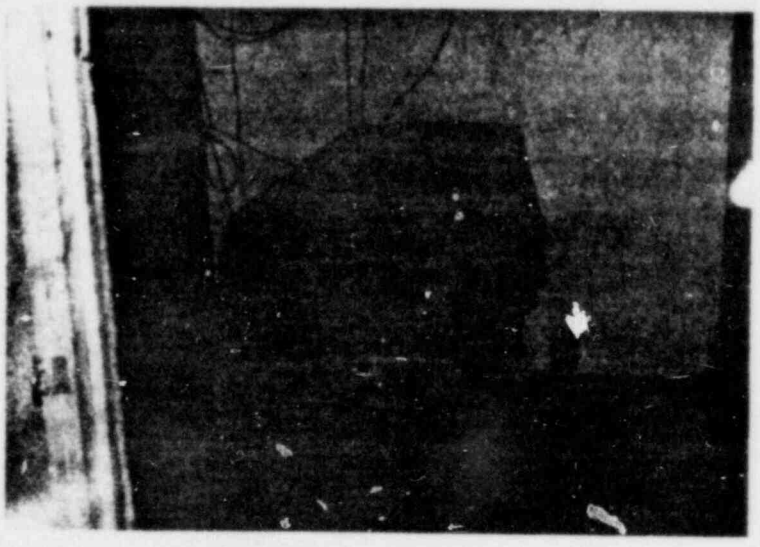


Plan of Lincoln School

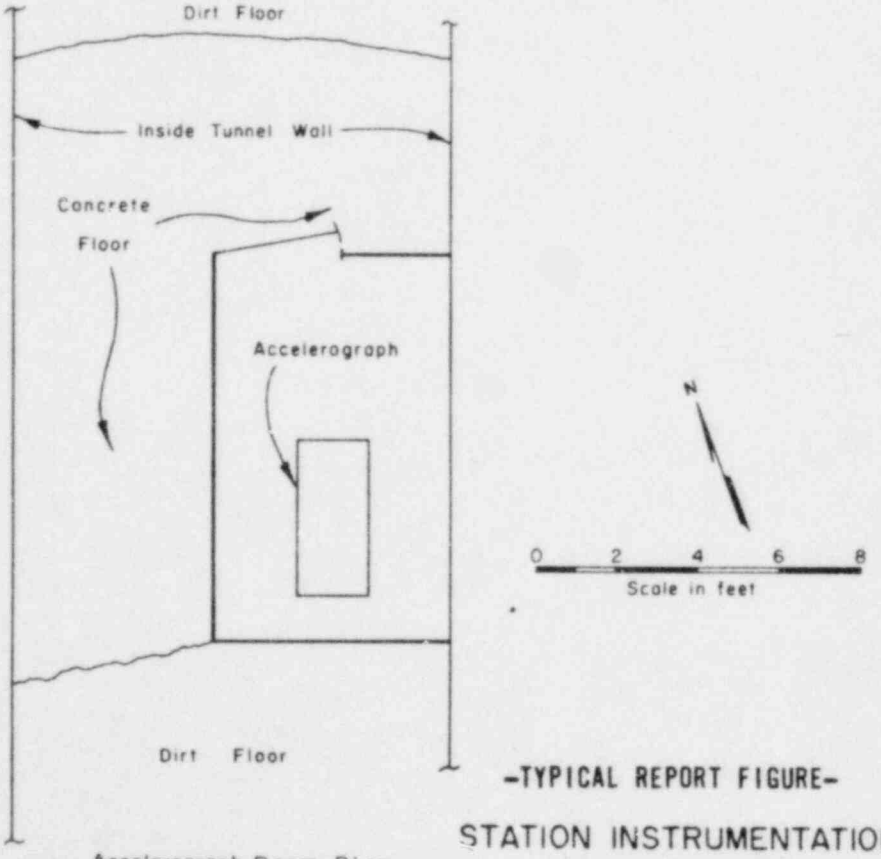
-TYPICAL REPORT FIGURE-

BUILDING PLAN
LINCOLN SCHOOL
TAFT, CALIFORNIA

FIG. 7



U.S. Coast and Geodetic Survey Accelerograph,
U.S.G.S. No. 1094

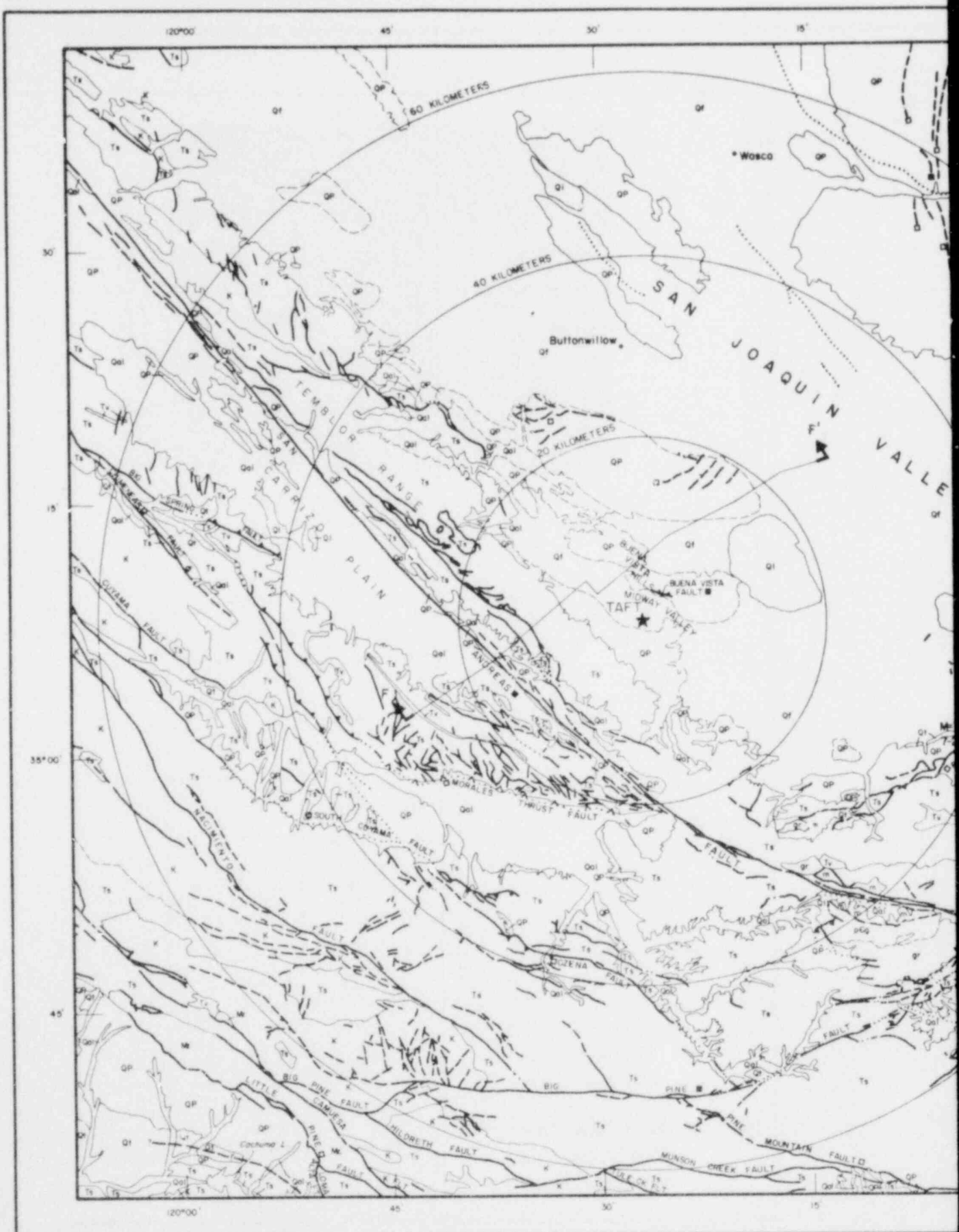


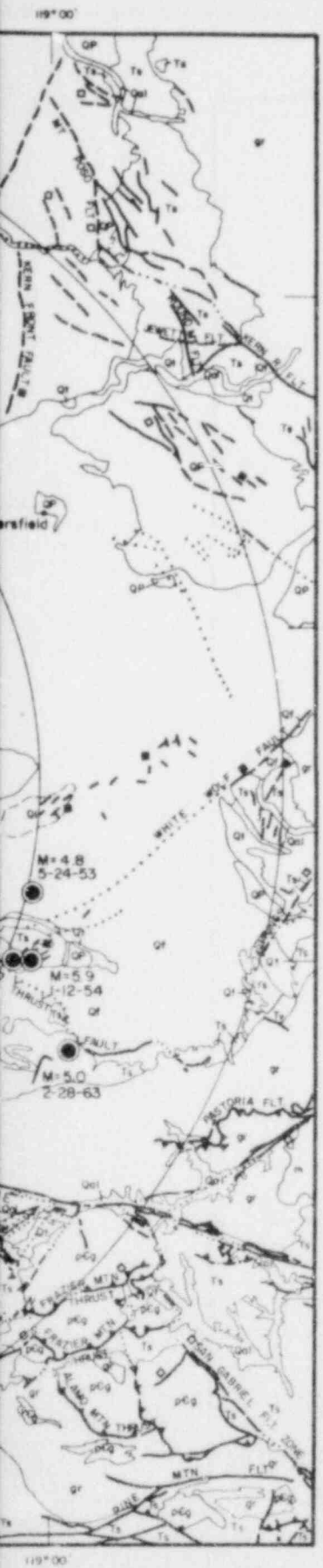
Accelerograph Room Plan

-TYPICAL REPORT FIGURE-

STATION INSTRUMENTATION
LINCOLN SCHOOL
TAFT, CALIFORNIA

FIG. 8





EXPLANATION

Qal	Alluvium, Holocene in age; includes dune deposits
Qf	Stream channel, fan, and basin deposits, Holocene in age
Ql	Lake deposits, Quaternary in age
Qt	Marine deposits, marine and nonmarine terrace deposits, Quaternary in age; includes upper Pliocene marine deposits
QP	Nonmarine sedimentary deposits, Plio-Pleistocene in age
Tv	Volcanic rocks and igneous intrusive rocks, Tertiary in age
Ts	Sedimentary rocks, Tertiary in age
K	Sedimentary rocks, Cretaceous in age
M	Mesozoic sedimentary rocks, also includes metamorphic rocks
gr	Mesozoic granitic rocks, also includes pre-Cenozoic metamorphic, volcanic, and ultramafic rocks
m	Metamorphic and metasedimentary rocks, pre-Cretaceous in age
P	Sedimentary and volcanic rocks, Paleozoic in age
pCg	Precambrian igneous and metamorphic rocks, includes crystalline rocks which may be as young as Mesozoic

Accelerograph Station location.

M=5.7 6-5-60 Epicenter location, Richter magnitude, and date of occurrence.

Faults that have moved during Quaternary time without historic record (approx. past 2 million years)

Faults that have moved during historic time (approx. 200 years)

Contact — Dashed where approximately located

Fault — Dashed where approximately located, dotted where concealed, queried where existence is uncertain

Thrust Fault — Barbs on upper plate; dashed where approximately located, dotted where concealed

Cross-section location, section F-F'

NOTES

1) Geology is simplified from Jennings and Strand (1969), Smith (1964), Jennings (1959), and Jennings (1958). To simplify, geologic map units on the above source maps have been grouped; culture, streams, and river rock and alluvium outcrops have been deleted. Major faults shown on source maps have been revised in accordance with Jennings (1973).

2) Information on fault activity (Quaternary activity, Historic activity) is from Jennings (1973). The seismic activity symbols, as used on this figure, do not necessarily mean that the entire length of the fault shows evidence of the respective activity. (See Jennings, 1973, for details).

3) Individual faults within the San Andreas fault zone show evidence of Quaternary and Historic activity (See Jennings, 1975, for details)

4) Heavy border on boxes indicates units that appear on this figure.

5) Earthquake magnitudes and epicentral locations are from United States Department of Commerce (1955, 1959, 1965), and Hudson and others (1971-1975)

Location of Geologic Map

0 5 10 15
Scale in miles

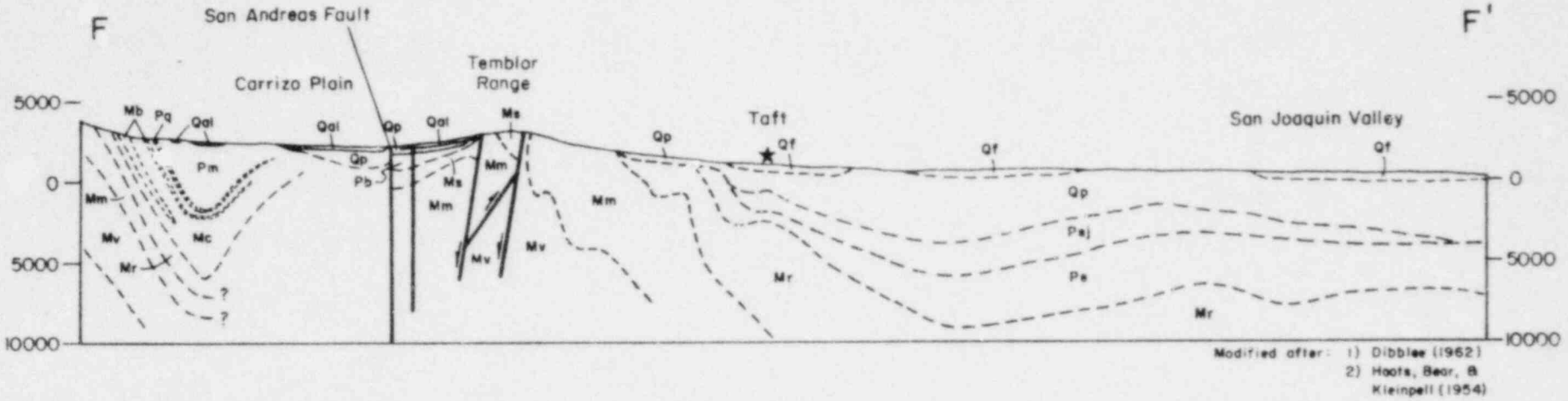
0 5 10 15 20
Scale in kilometers

N

-TYPICAL REPORT FIGURE-

GEOLOGIC MAP
LINCOLN SCHOOL
TAFT, CALIFORNIA

FIG. 9



Explanation

Qal	Alluvium, Holocene in age.	Pe	Etchegoin Formation, middle and/or lower Pliocene in age.
Qf	Alluvial fan deposits, Holocene in age.	Mc	Caliente Formation, upper Miocene in age.
Qp	Non-marine sedimentary deposits, Plio-Pleistocene in age.	Mb	Basalt flows, upper Miocene in age.
Pm	Morales Formation, Pliocene (Pleistocene?) in age.	Ms	Santa Margarita Formation, upper Miocene in age.
Pq	Quatal Formation, Pliocene in age.	Mr	Reef Ridge Formation, upper Miocene in age.
Psj	San Joaquin Formation, upper Pliocene in age.	Mm	Monterey Formation, upper and middle Miocene in age.
Pb	Bitterwater Creek Formation, middle and/or lower Pliocene in age.	Mv	Temblor and/or Vaqueros Formation, middle Miocene in age.

Contact between geologic units

Fault

★ Accelerograph station, projected

0 5 10

Scale in miles

-TYPICAL REPORT FIGURE-

GEOLOGIC CROSS-SECTION F-F'

LINCOLN SCHOOL

TAFT, CALIFORNIA

FIG. 10

BORING LOG

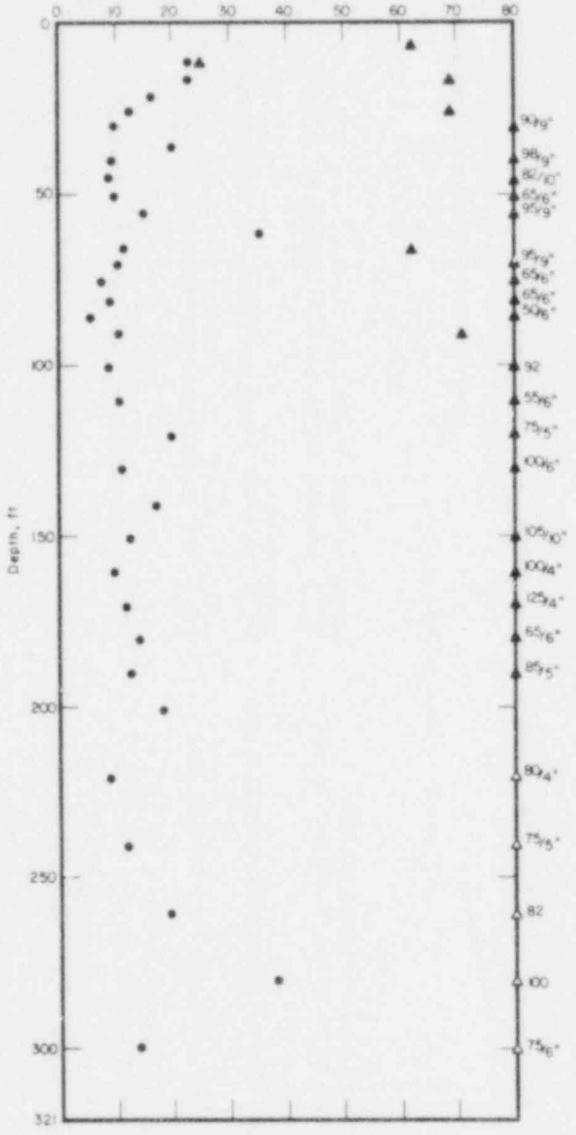
Approximate Surface Elevation 915 ft. MSL

Depth, ft.	Sampling	Undrained Shear Strength, tsf.	Dry Density, pcf	Other Tests	Description
0					Medium to very dense, light brown, silty, fine to coarse SAND with fine gravel
	S-1				
	S-2				
	S-3				
	S-4	1.4	110	CT, MA	Medium to very dense, light brown, silty, clayey, fine to coarse SAND with scattered gravels
	S-5				
	S-6				
	S-7		109		Very dense, brown, silty, fine to medium SAND with some coarse sand and some carbonate cementation
	S-8				
	S-9				
50	S-10				
	S-11				
	S-12	2.4	93	CT, MA	Very dense, brown, silty, fine to medium SAND with seams of hard, brown, fine sandy, calcareous, clayey SILT
	S-13				
	S-14				
	S-15				
	S-16				
	S-17				
	S-18				
100	S-19				
	S-20				Very dense, brown, silty, fine to medium SAND with occasional coarse sand and fine gravel
	S-21				
	S-22				
	S-23				
150	S-24	9.1	100	CT, MA	
	S-25				
	S-26				
	S-27				
	S-28				
	S-29				
200	S-30	15.0	114	CT, MA	
	S-31				
	S-32				
250	S-33				Hard, brown, fine sandy, clayey SILT to silty CLAY
	S-34				
					Hard, reddish brown, fine sandy, silty CLAY
300	S-35				
321	S-36				SANDSTONE: Moderately hard to hard, reddish-med. brown, fine to medium grained

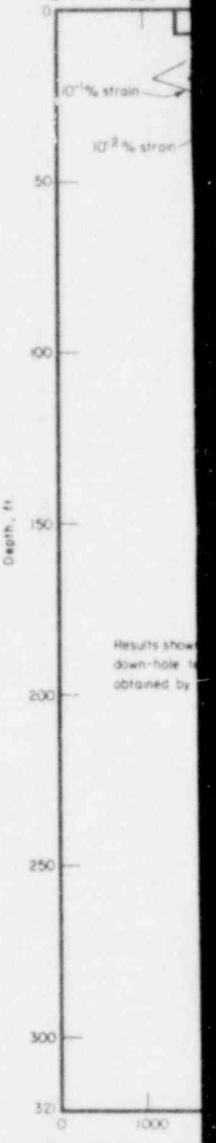
Water Table below depth of Boring reported by California Division of Oil and Gas to be at 580 to 600'

DATA SUMMARY

● Water Content, (%)
▲ Standard Penetration Resistance, (blows/ft.)
△ Driving Resistance with Jars, (blows/ft.)



SHEAR WAV... IN THE...

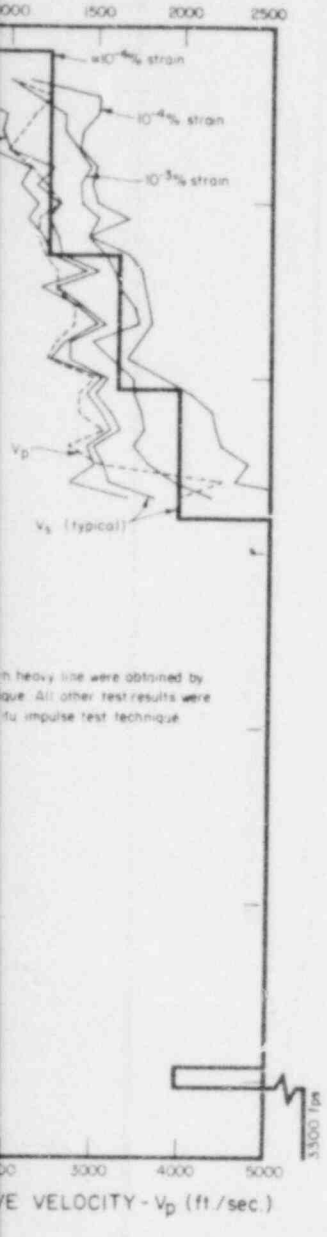


COMPRESSION ...

Notes:

1. The stratification lines in the boring log represent the approximate boundaries between soil types, and the transition may be gradual.
2. Boring elevation obtained by hand leveling from U.S.G.S. bench mark.
3. Laboratory tests performed on samples from indicated depth, as described in the "Laboratory Testing" appendix.
4. I Split spoon sample
   ▮ Undisturbed sample
   * Sample not recovered
5. Other Tests:
   CT - Cyclic Triaxial Tests
   MA - Grain Size distribution
6. Standard Penetration Resistance (▲), based on 140 lb. hammer falling 30 in., driving a 2 in. O.D. split spoon sampler.
   Driving Resistance with Jars (△), based on 289 lb. down the hole jar falling 24 in., driving a 2 in. O.D. split spoon sampler.
7. V_S determined from lab...
   $V_S = \sqrt{\frac{G}{\rho}} = \sqrt{\frac{E}{2(1+\mu)\rho}}$
   Modulus value uncorrect...

VELOCITY - V_S (ft/sec)
FIELD

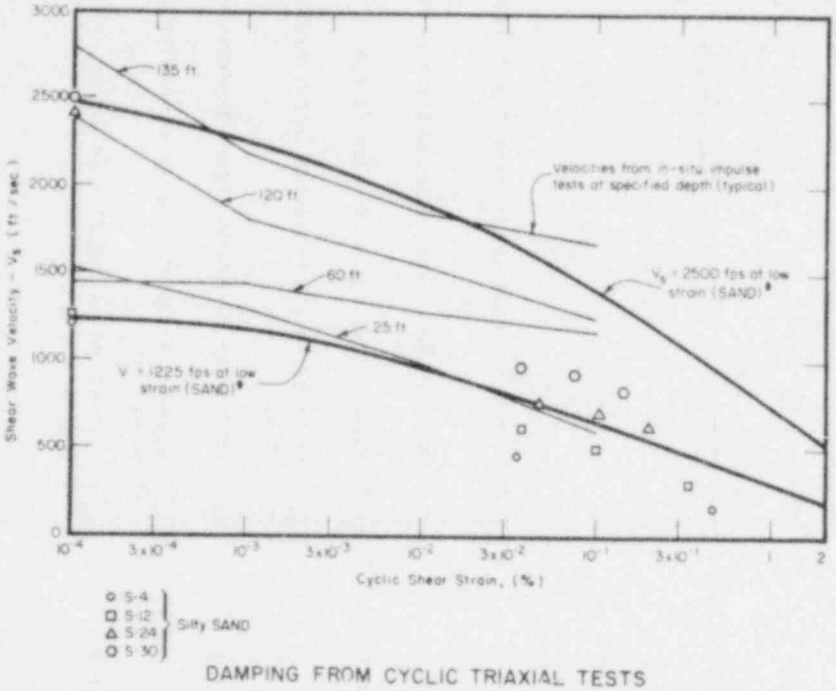


h heavy line were obtained by
ique. All other test results were
ftu impulse test technique

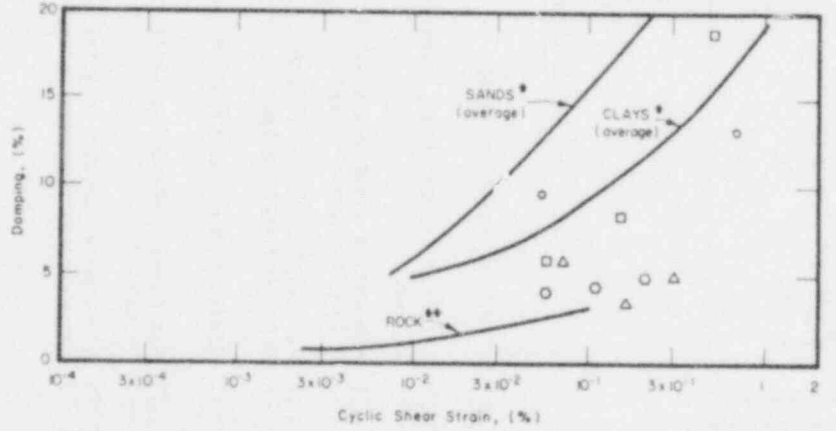
ry testing as follows
ρ = mass density
e
μ = Poisson's ratio
r possible sample disturbance

DYNAMIC PROPERTIES OF SUBSURFACE MATERIALS

SHEAR WAVE VELOCITIES FROM FIELD AND LABORATORY TEST RESULTS



DAMPING FROM CYCLIC TRIAXIAL TESTS



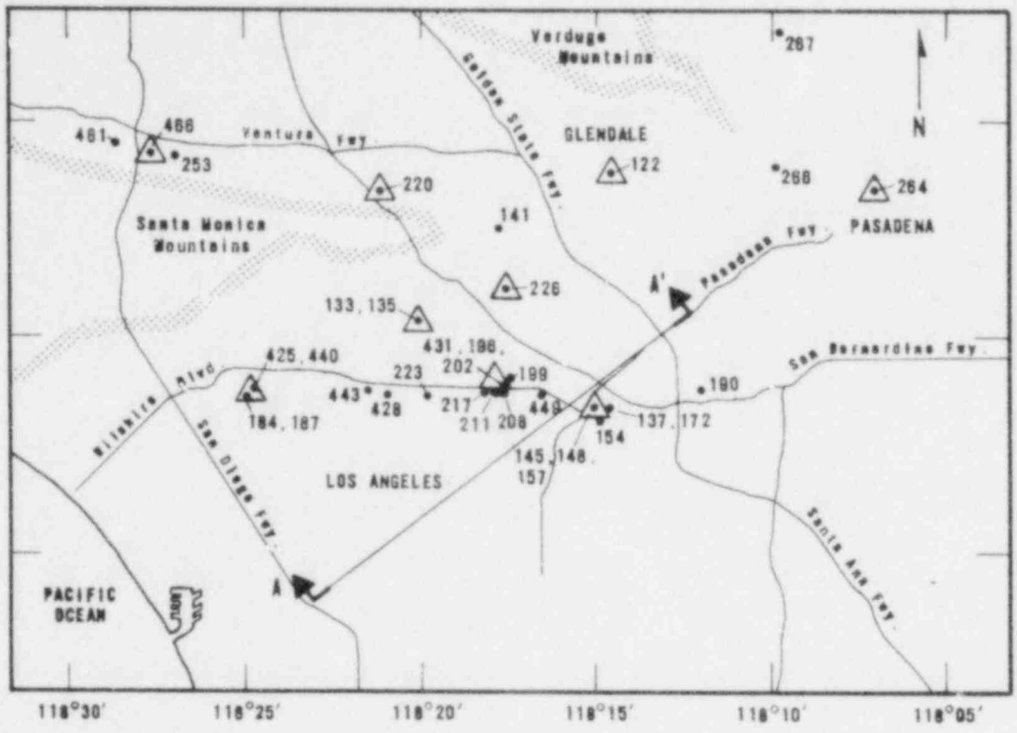
♦ From Shannon & Wilson, Inc. and Agbabian-Jacobsen Associates (1972)

♦♦ From Schnabel, Seed, and Lysmer (197.)

-TYPICAL REPORT FIGURE-

BORING LOG AND
SUMMARY OF TEST RESULTS
LINCOLN SCHOOL
TAFT, CALIFORNIA

FIG. 11



LEGEND

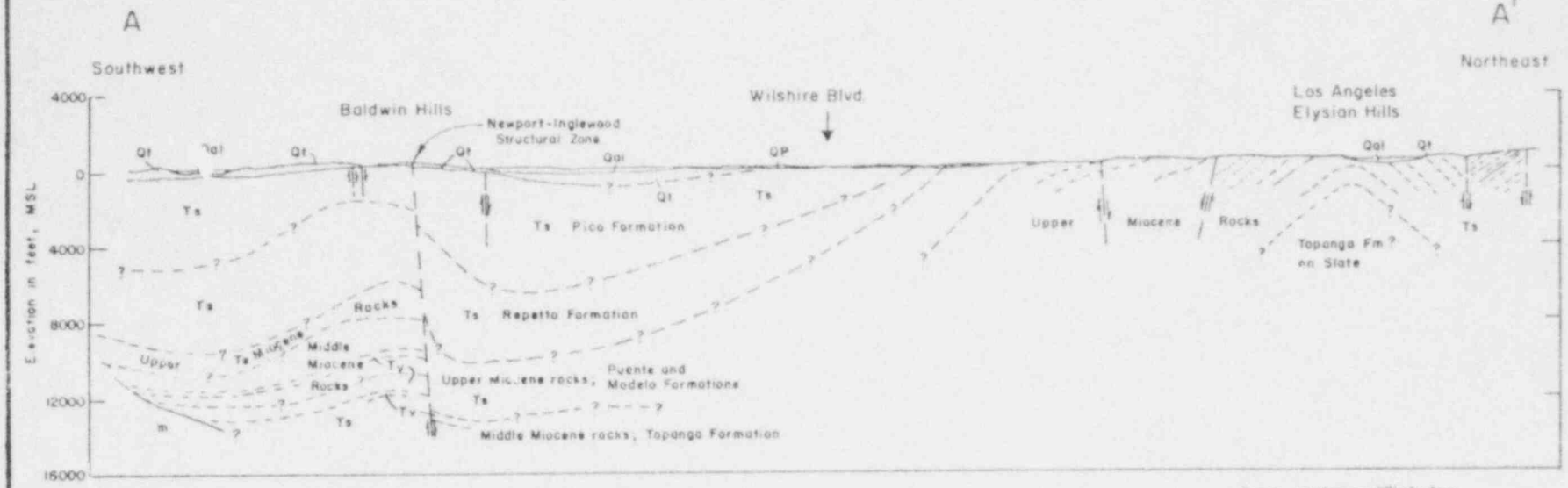
* 184	Site Location and USGS Station Number
△	Deep Boring (SW-AA Studies)

SITES CLOSE TO SW-AA BORINGS

STATION NUMBER	BORING	SW-AA REPORT
122	633 East Broadway, Glendale	1979b
133, 135	1025 North Highland Ave., L.A.	1979a
137, 145, 148, 157, 172	Figueroa Street Sites, L.A.	1979b
184, 187, 425, 440	Century City Sites, L.A.	1976c
196, 199, 208, 211 202, 217, 431	Wilshire Blvd. Sites, L.A.	1976c 1977b
220	3838 Lankershim Blvd., L.A.	1979b
226	4867 Sunset Blvd, L.A.	1979b
253, 461, 466	Ventura Blvd. Sites, L.A.	1976c
264	CIT Millikan Library, Pasadena	1976a

SITES INVESTIGATED
- LOS ANGELES AREA -

FIG. 12



Cross-section modified after Schoellhamer et al, 1954

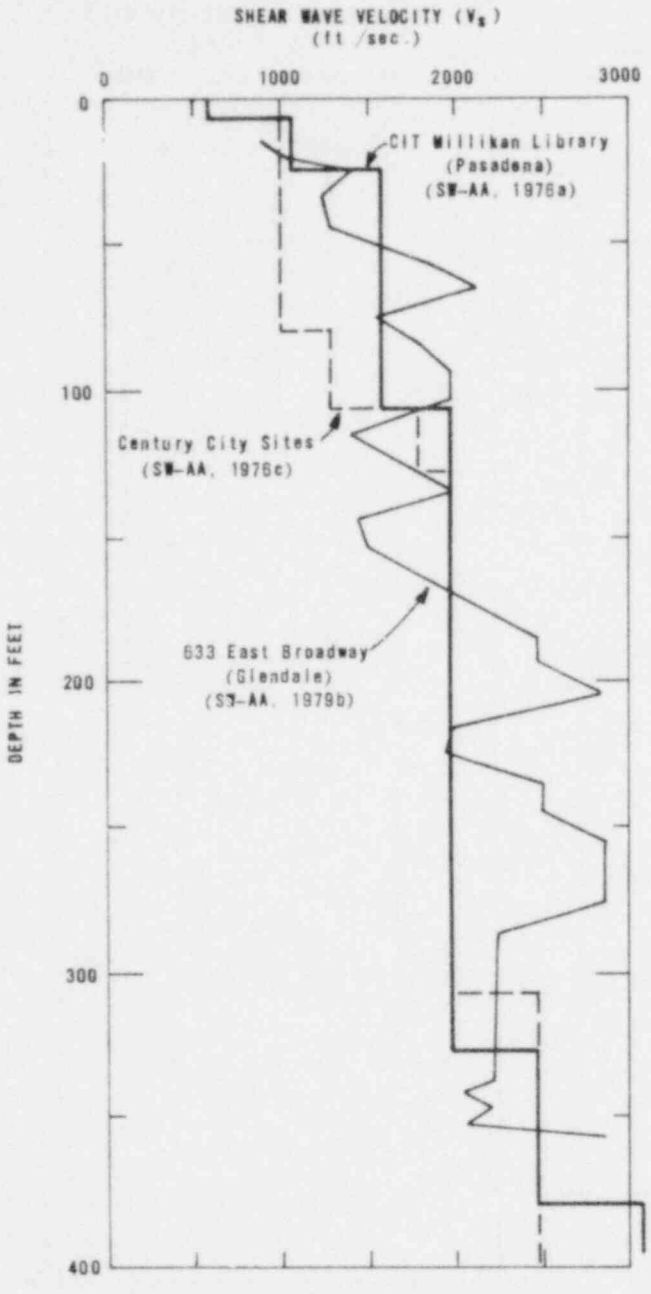
0 8000 16000
Scale in feet

EXPLANATION

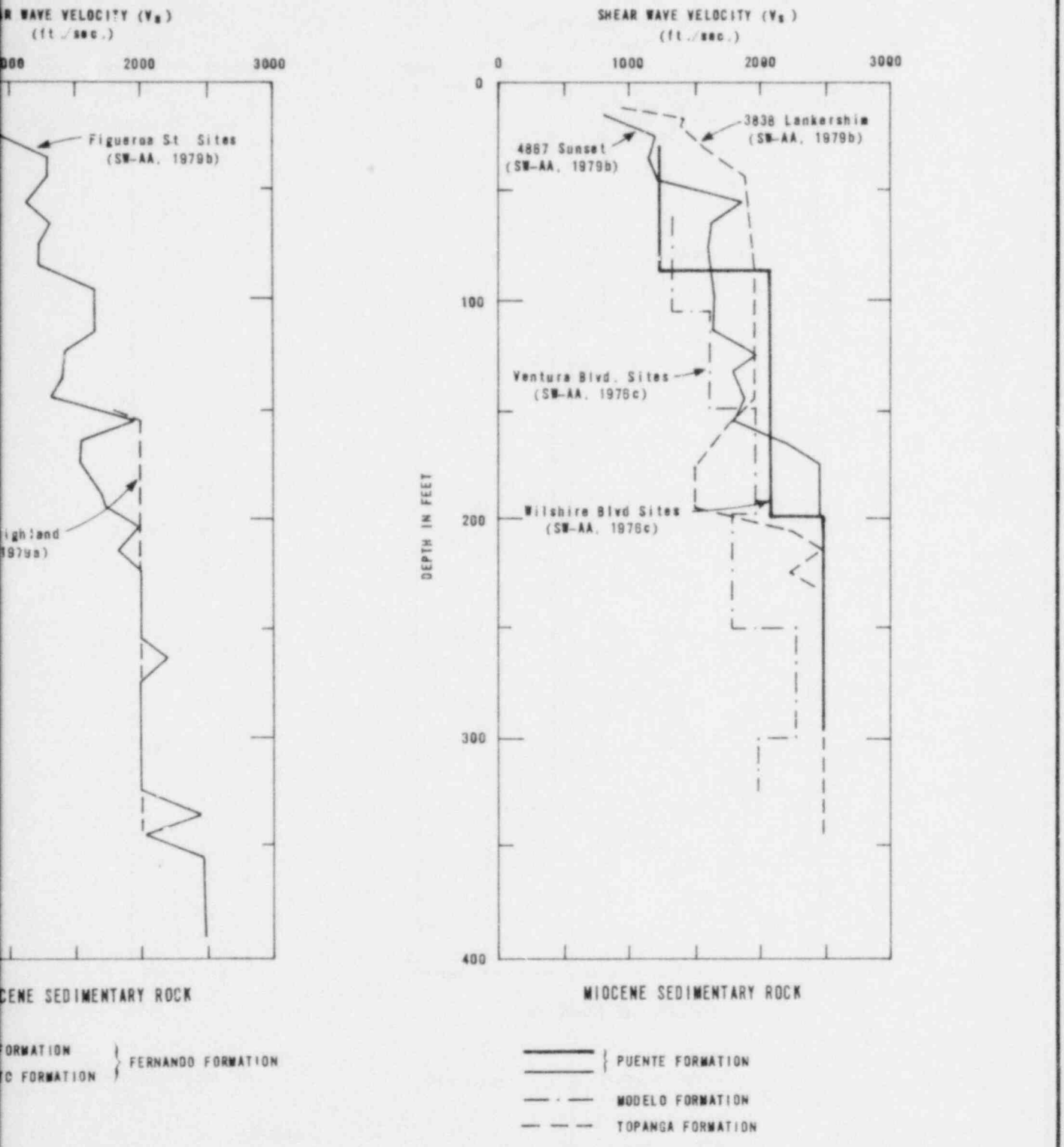
Holocene	Qal	Alluvium
Quaternary	Qt	Marine and non-marine terrace deposits
Plio-Pleistocene	QP	Non-marine sedimentary deposits
Pliocene-Miocene	Ts	Tertiary sedimentary rocks includes Pico and Repetto Formations, Puente and Modelo Formations, and the Topanga Formation
Tertiary	Tv	Volcanic rocks
Pre-Cretaceous	m	Basement rock complex; Catalina Schist west of the Newport-Inglewood fault, chiefly granitic rocks east of the fault

GEOLOGIC CROSS-SECTION A-A'
-LOS ANGELES AREA-

FIG. 13

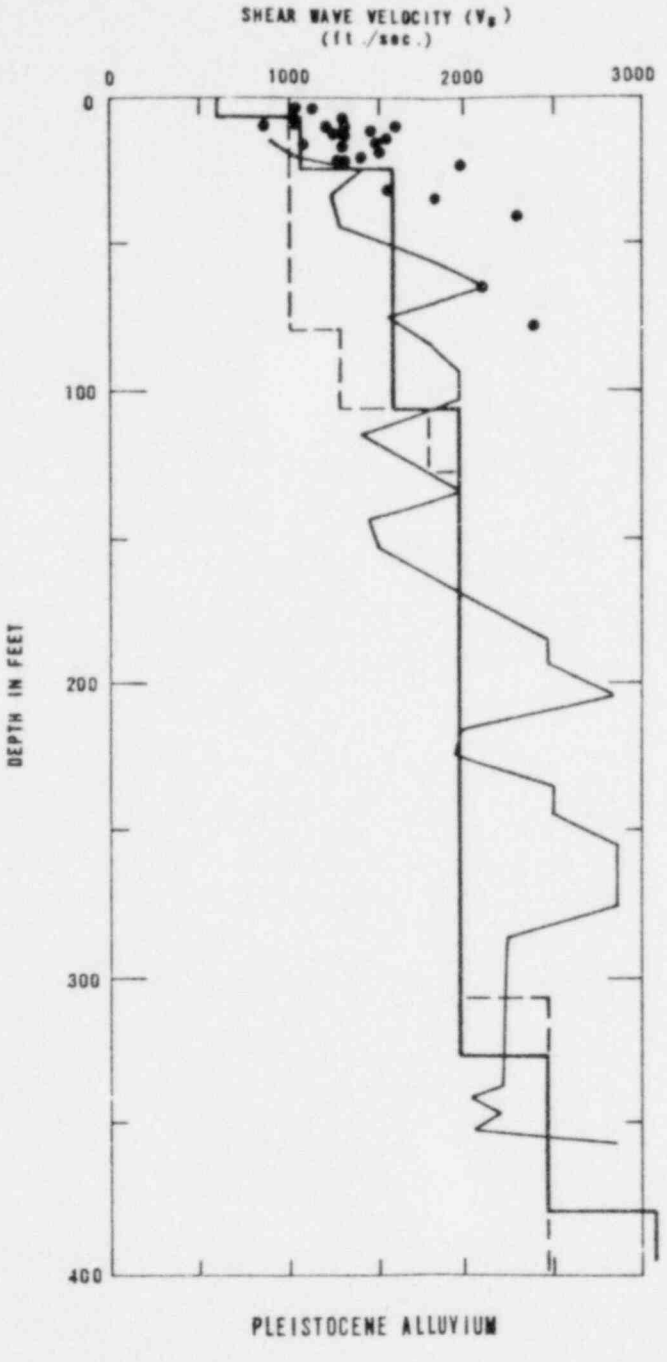


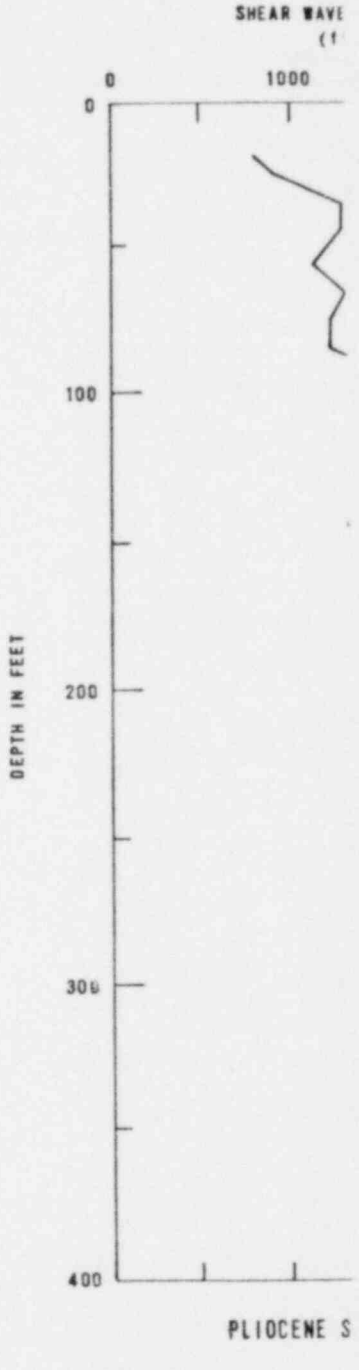
NOTE: All velocities are from downhole geophysical surveys made by the SW-AA joint venture.



SUMMARY OF SHEAR WAVE VELOCITIES
- LOS ANGELES AREA -

FIG. 14

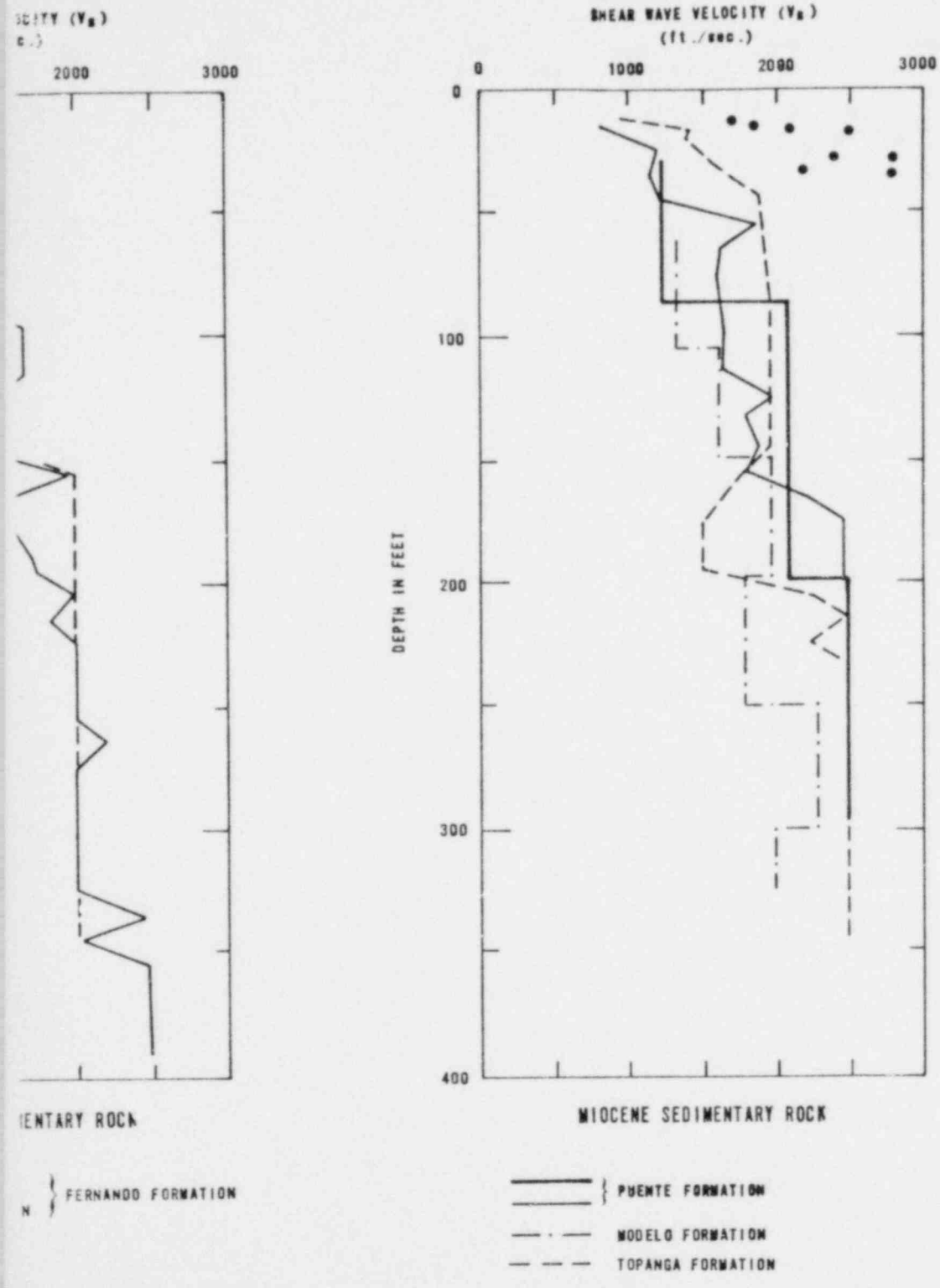




LEGEND

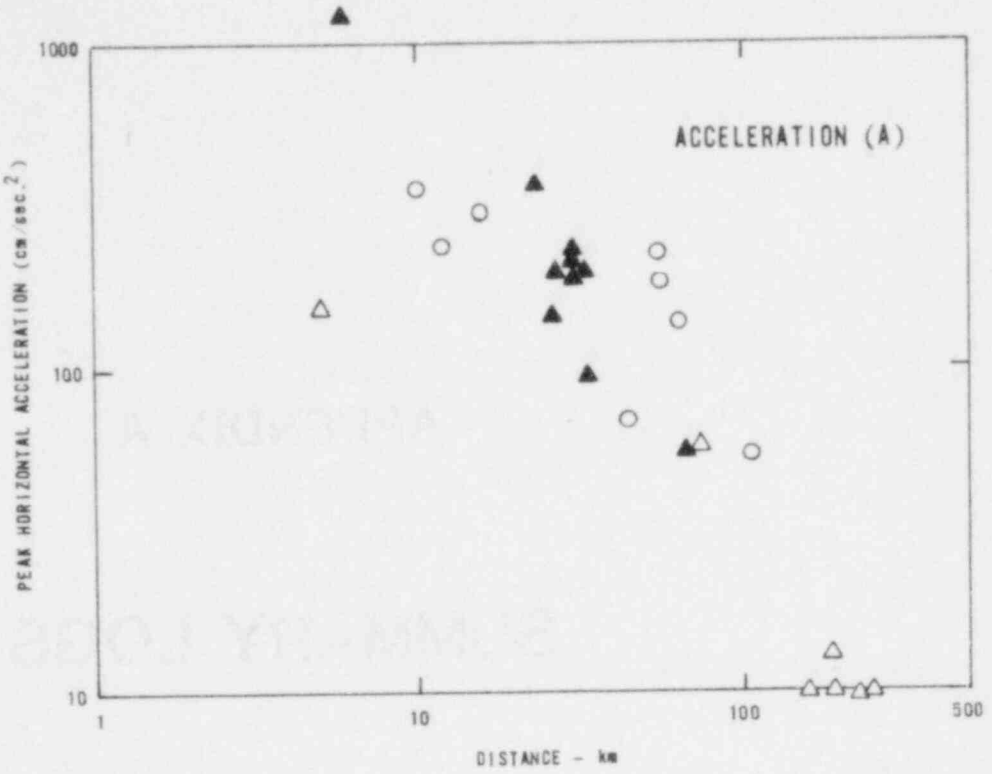
Surface refraction shear wave veloc

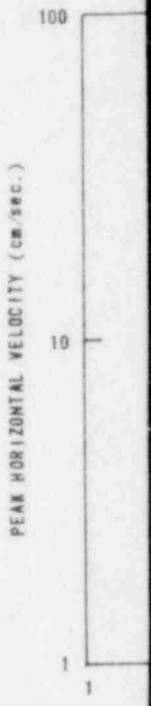
Downhole shear wave velocities from

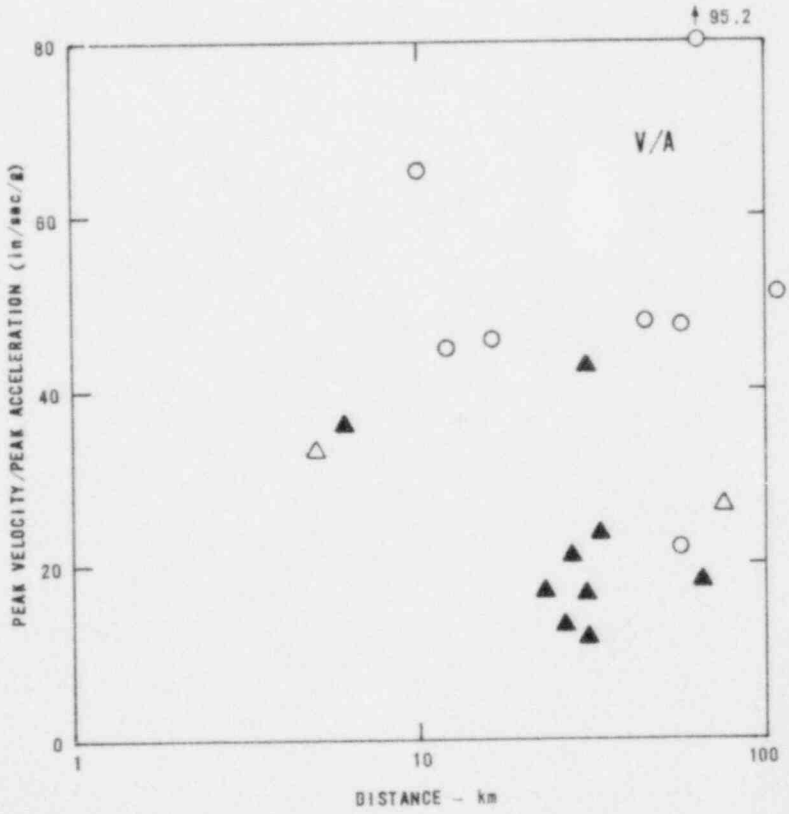


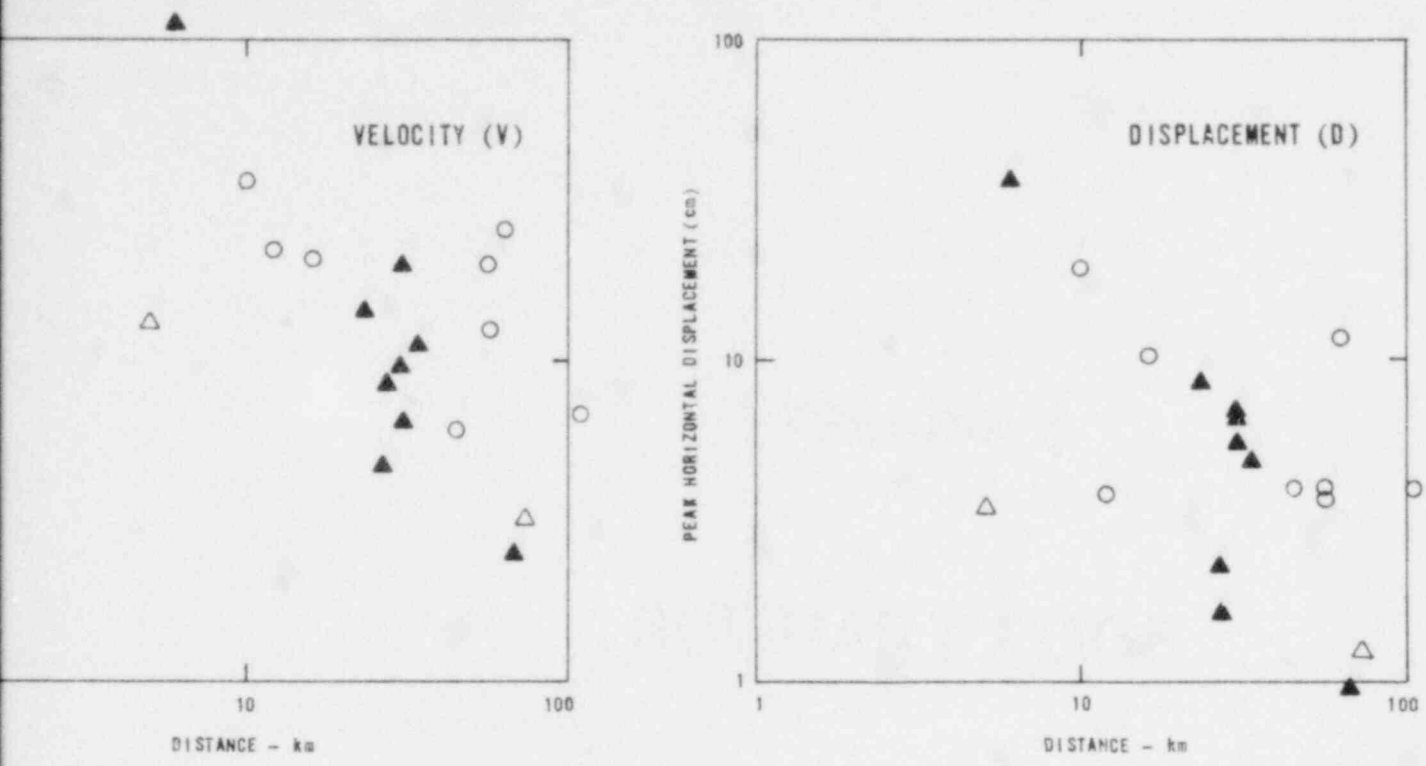
COMPARISON OF SHEAR WAVE VELOCITIES
- LOS ANGELES AREA -

FIG. 15


ACCELERATION (A)
PEAK HORIZONTAL ACCELERATION (cm/sec.²)
1000
100
10
1
10
100
500
DISTANCE - km


PEAK HORIZONTAL VELOCITY (cm/sec.)
100
10
1
1


95.2
V/A
PEAK VELOCITY/PEAK ACCELERATION (in/sec/g)
80
60
40
20
0
1
10
100
DISTANCE - km



LEGEND

ROCK SITES	DEEP SOIL SITES	
▲	—	SAN FERNANDO RECORDS
△	○	NON SAN FERNANDO RECORDS

NOTE: ALL DATA FROM MAGNITUDE 6.0 - 7.0 EARTHQUAKES

GROUND MOTION PLOTS
- ROCK AND DEEP SOIL SITES -

FIG. 16

APPENDIX A

SUMMARY LOGS

APPENDIX A
SUMMARY LOGS

LIST OF TABLES

APPENDIX A
SUMMARY LOGS

LIST OF FIGURES

APPENDIX A

SUMMARY LOGS

LIST OF FIGURES (Cont'd)

APPENDIX A
SUMMARY LOGS

LIST OF FIGURES (Cont'd)

APPENDIX A

SUMMARY LOGS

LIST OF FIGURES (Cont'd)

APPENDIX A

SUMMARY LOGS

LIST OF FIGURES (Cont'd)

TABLE A-1

CROSS INDEX OF USGS STATION NOS. AND SITES

USGS No.	STATION	Summary Log Figure No.
	SOUTHERN CALIFORNIA	
104	Santa Anita Dam	A-69
108	Carbon Canyon Dam	A-3
110*	Castaic, Old Ridge Route	A-4
111	Cedar Springs, Miller Canyon Guard Sta.	A-5
112*	Cedar Springs, Pump House	A-6
114	Costa Mesa, 666 W. 19th	A-10
117	El Centro, Terminal Substation	A-12
121	Fairmont Reservoir	A-14
122	Glendale, 633 E. Broadway	A-18
125*	Lake Hughes Station 1	A-21
126	Lake Hughes Station 4	A-22
127	Lake Hughes Station 9	A-23
128	Lake Hughes Station 12	A-24
133	Los Angeles, 1025 N. Highland Ave. (Bsmt.)	A-35
135	Los Angeles, 1025 N. Highland Ave. (PE Lot)	A-35
137	Los Angeles, 111 N. Hope	A-36
141	Los Angeles, Griffith Observatory	A-34
145	Los Angeles, 222 Figueroa	A-29
148	Los Angeles, 234 Figueroa	A-30
154	Los Angeles, 420 S. Grand	A-33
157	Los Angeles, 445 Figueroa	A-31
172	Los Angeles, 800 W. First	A-32
184	Los Angeles, 1900 Ave. of the Stars	A-25
187	Los Angeles, 1901 Ave. of the Stars	A-26
190	Los Angeles, 2011 Zonal	A-53

TABLE A-1

CROSS INDEX OF USGS STATION NOS. AND SITES (Cont'd)

USGS No.	STATION	Summary Log Figure No.
	SOUTHERN CALIFORNIA (Cont'd)	
196	Los Angeles, 3345 Wilshire	A-45
199	Los Angeles, 3407 W. Sixth	A-39
202	Los Angeles, 3411 Wilshire	A-46
208	Los Angeles, 3470 Wilshire	A-47
211	Los Angeles, 3550 Wilshire	A-48
217	Los Angeles, 3710 Wilshire	A-49
220	Los Angeles, 3838 Lankershim	A-37
223	Los Angeles, 4680 Wilshire	A-50
226	Los Angeles, 4867 Sunset	A-40
253	Los Angeles, 14724 Ventura	A-41
264	Pasadena, CIT Millikan Library	A-59
266*	Pasadena, CIT Old Seismic Lab	A-60
267	Pasadena, 4800 Oak Grove (JPL)	A-61
278	Puddingstone Reservoir	A-63
279	Pacoima Dam	A-57
280	San Onofre, Nuclear Power Plant	A-68
282*	Goleta, UCSB Fluid Mech. Lab	A-19
283	Santa Barbara, County Courthouse	A-70
284*	Santa Felicia Dam	A-71
290*	Wrightwood, 6074 Park Drive	A-73
411	Palos Verdes, 2516 Via Tejon	A-58
425	Los Angeles, 1800 Century Park East	A-27
428	Los Angeles, 5900 Wilshire	A-57
431	Los Angeles, 616 S. Normandie Ave.	A-38
440	Los Angeles, 1880 Century Park East	A-28
443	Los Angeles, 6200 Wilshire	A-52

TABLE A-1

CROSS INDEX OF USGS STATION NOS. AND SITES (Cont'd)

USGS No.	STATION	Summary Log Figure No.
	SOUTHERN CALIFORNIA (Cont'd)	
449	Los Angeles, 2500 Wilshire	A-44
461	Los Angeles, 15910 Ventura	A-43
466	Los Angeles, 15250 Ventura	A-42
828	See 125*	
991*	Edmonston Pumping Plant	A-11
933*	Oso Pumping Plant	A-56
998*	Fort Tejon	A-16
	NORTHERN CALIFORNIA	
1013	Cholame - Shandon Array, Station 2	A-7
1022	Eureka, Federal Building	A-13
1023	Ferndale, Fire Station	A-15
1027*	Same as 991*	
1028	Hollister, City Hall	A-20
1049	Oakland, City Hall	A-55
1052*	Same as 993*	
1065	San Francisco, Alexander Building	A-64
1080	San Francisco, State Building	A-66
1083	San Luis Obispo, City Rec. Building	A-67
1094	Taft, Lincoln School Tunnel	A-72
1096*	Same as 998*	
1097	Cholame - Shandon Array, Temblor II	A-9
1117	San Francisco, Golden Gate Park	A-65
1211*	Melendy Ranch Barn	A-54

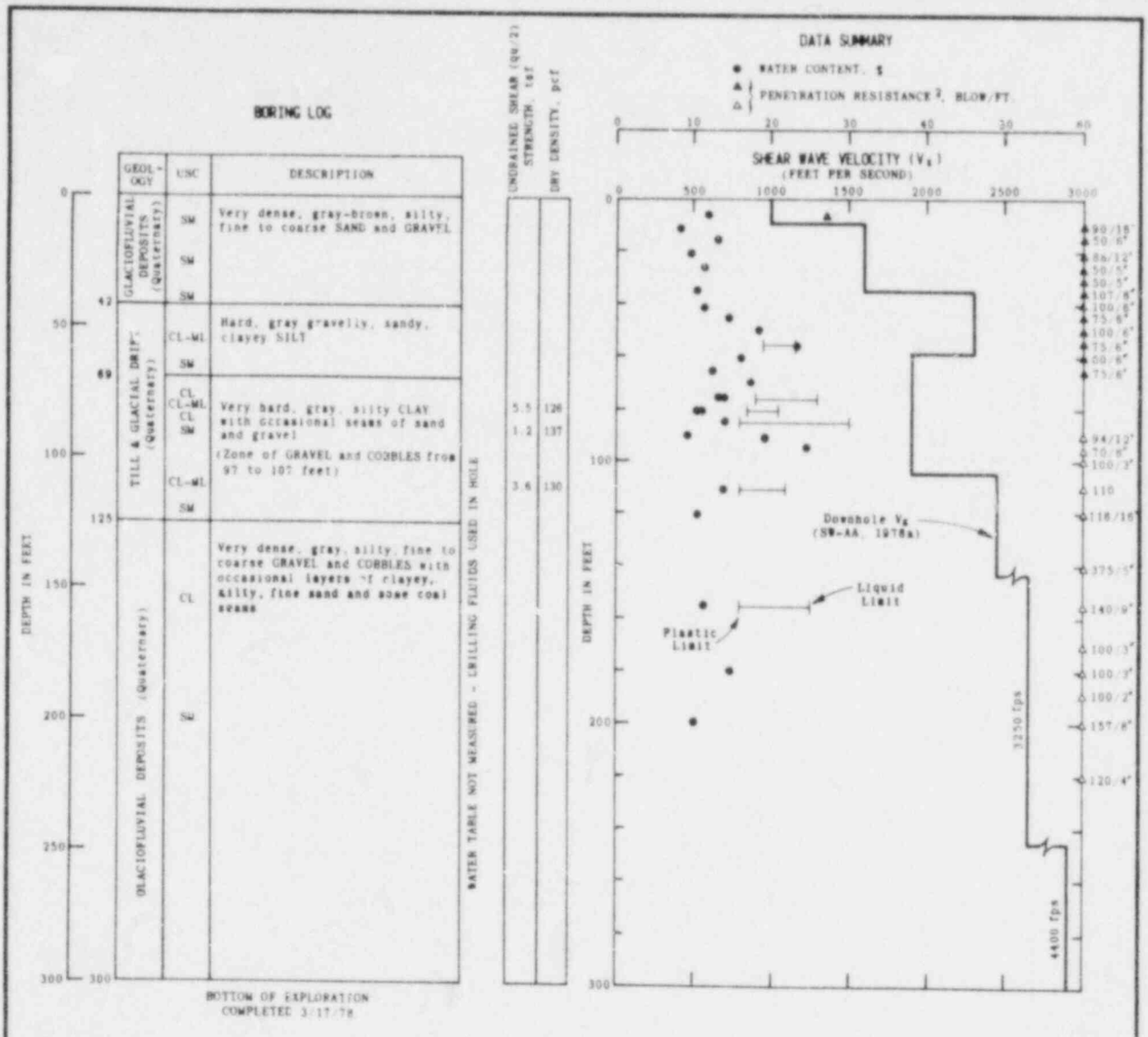
TABLE A-1

CROSS INDEX OF USGS STATION NOS. AND SITES (Cont'd)

USGS No.	STATION	Summary Log Figure No.
	NORTHERN CALIFORNIA (Cont'd)	
1250	Gilroy, Gavilan College	A-17
1398	Petrolia, General Store	A-62
1438*	Cholame - Shandon Array, Temblor	A-8
	PACIFIC NORTHWEST	
2101	WA: Olympia, Highway Test Lab	A-81
2102	WA: Seattle, Federal Office Building	A-82
2104	WA: Tacoma, County-City Building	A-83
2110*	OR: Portland, State Office Building	A-79
2172	OR: Portland, PSU Cramer Hall	A-78
	NORTHERN ROCKIES	
2202	MT: Helena, Carroll College	A-76
2203	UT: Logan, USU Old Main Building	A-80
2205	MT: Bozeman, MSU Roberts Hall	A-75
2229*	MT: Helena, Federal Building	A-77
	MISSISSIPPI VALLEY	
2420	MO: New Madrid, Noranda Aluminum Plant	A-74
	ALASKA	
2702	Anchorage, AMU Gould Hall	A-1
2721	Fairbanks, UA Duckering Hall	A-2

* Station discontinued.

Sheet 4 of 4



BORING

Elevation: 212 feet, MSL[1]

Location: 130 feet Northwest of Gould Hall

Data Source: SW-AA (1978)

Equipment: Mayhew 2000 Rotary Drill; samples with a Split Spoon Drive Barrel and a Pitcher Barrel

VELOCITIES

Data Source: SW-AA (1978)

Location: Testing performed in above boring

Date: June 1978

BUILDING: Gould Hall is a 2-story structure with a daylight basement (extends about 5 feet below grade) where the accelerograph is located.

REPORT: SW-AA (1978)

NOTES: 1) Elevation interpolated from a topographic map of the AMU campus.

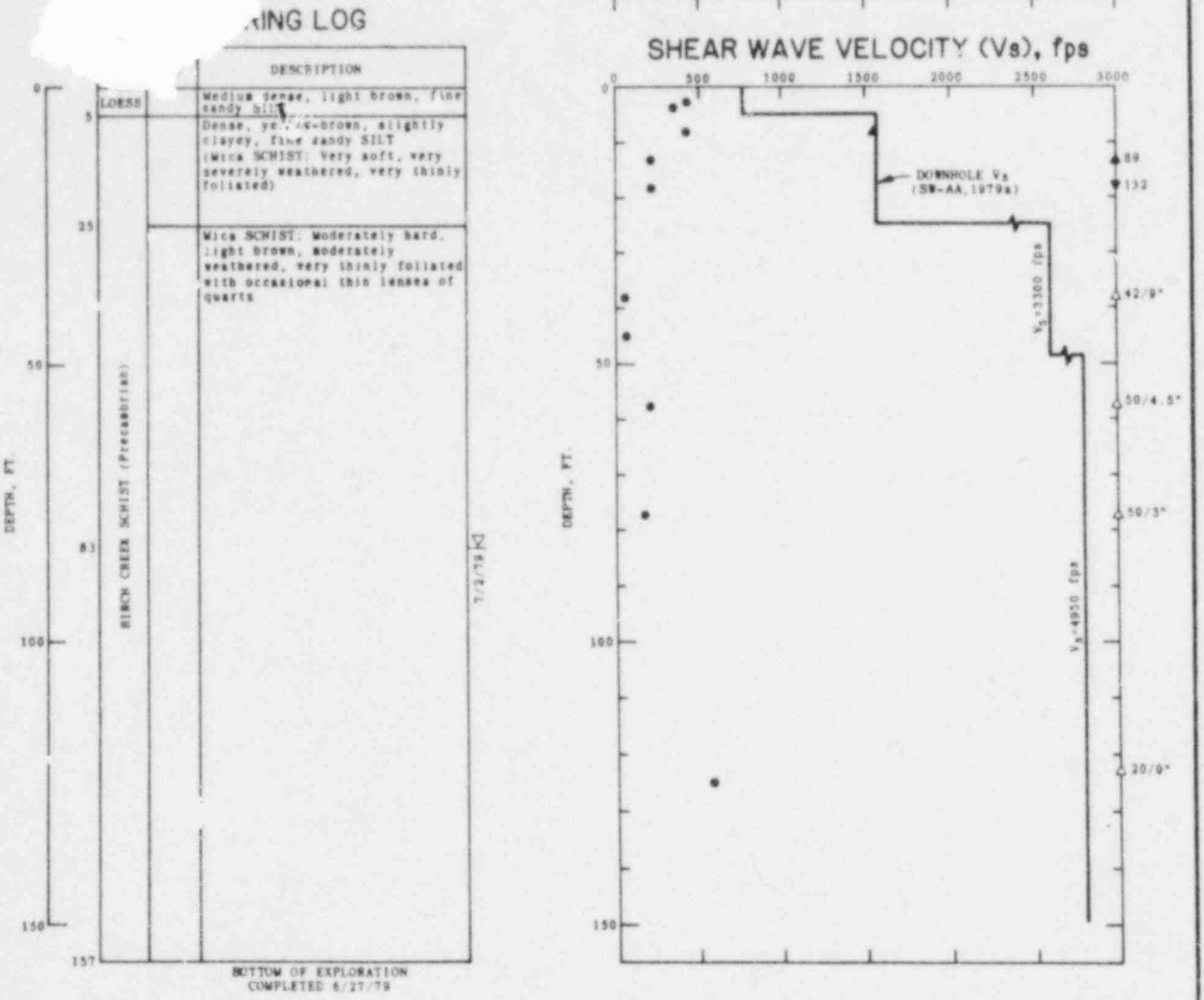
2) Penetration resistances are based on driving a 3-inch O.D. split spoon sampler with a hammer dropped a distance of 30 inches.

▲ - 250-lb. hammer

△ - 350-lb. hammer

SUMMARY LOG
AMU GOULD HALL
ANCHORAGE, ALASKA

FIG. A-1



BORING

Elevation:	500 feet, MSL (Interpolated from USGS topographic quad. and structural drawings)
Location:	56 feet Northeast of the Southeast corner of Duckering Hall
Data Source:	SW-AA (1979a)
Equipment:	Mobile B-61, 3-3/8 inch I.D. hollow stem auger, augered to 94.5 feet, rotary drill with air 94.5 to 157 feet. Limited sampling with a Shelby Tube and a split spoon drive barrel.

VELOCITIES

Source:	SW-AA (1979a)
Location:	Downhole testing performed in above boring
Date:	July 10, 1979
REPORT:	SW-AA (1979a)
BUILDING	Duckering Hall (University of Alaska) is a 3-story structure with a daylight basement. The accelerograph is located in the basement, about 5 feet below grade.

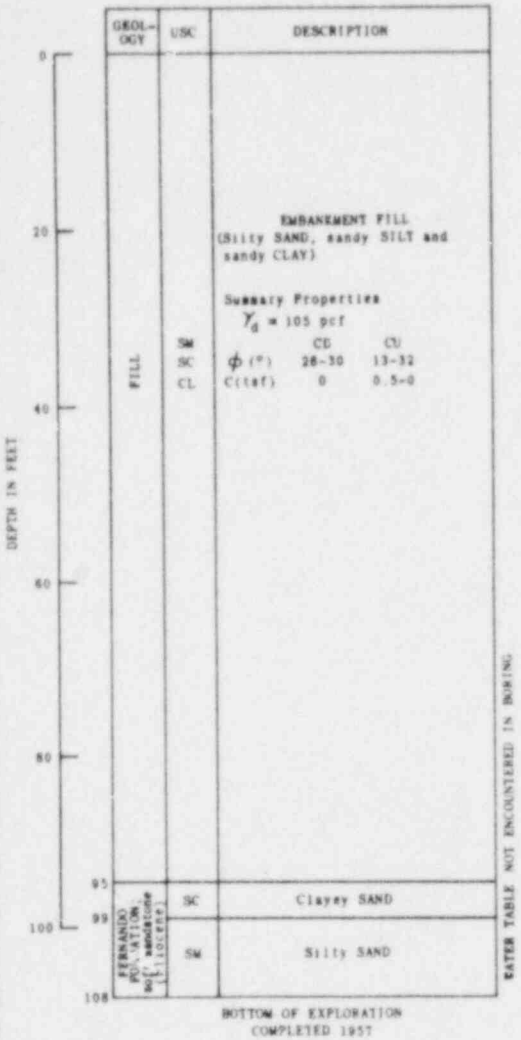
* PENETRATION RESISTANCES WERE OBTAINED WITH THE FOLLOWING EQUIPMENT:

▲ 2" O.D. Split Spoon; 140 lb. weight at 30"
▼ 3" O.D. Split Spoon; 340 lb. weight at 30"
△ 2" O.D. Split Spoon; 340 lb. weight at 30"

SUMMARY LOG
UA DUCKERING HALL
FAIRBANKS, ALASKA

FIG. A-2

BORING LOG[1]



BORING

Elevation: Crest of dam - 499 Feet, MSL
Boring - 424 Feet, MSL

Location: 100 feet North of Accelerograph Site[1]

Data Source: U.S. Army Corps of Engineers (1957) Geology and Soils Report for Carbon Canyon Dam Boring TH-104 along outlet works

VELOCITIES Not available

REPORT SW-AA (1977b)

BUILDING The original accelerograph was located on the crest of the 100 foot high earthfill dam, in a standby generator building (one-story concrete structure with a slab-on-grade). The instrument was removed in June 197; and replaced with three accelerographs located on the left and right abutments and crest (center) of the dam.

NOTE: 1) Subsurface conditions are for the standby generator house which contained the original accelerograph. Approximately 20 feet of overburden was stripped in the area of the outlet works (standby generator house).

SUMMARY LOG
CARBON CANYON DAM
CALIFORNIA

FIG. A-3

LOG [1,2]

GEOL-OGY	USC	DESCRIPTION
CASTAIC FORMATION; sort shale, siltstone and sandstone (Miocene)		Medium to moderately hard, weathered SANDSTONE

DEPTH IN FEET

0
10
20

SHEAR WAVE VELOCITY (V_s)
(FEET PER SECOND)

0 500 1000 1500 2000 2500 3000

DEPTH IN FEET

0
50
100

Subsurface Model "B" [3]
(Duke, et al., 1971)

Surface Refraction V_s
(Shannon & Wilson, 1973)

VELOCITIES

Data Source: Shannon & Wilson, Inc. (1973)

Location: Two perpendicular lines intersecting at Southeast Corner of Accelerograph Station [2]

Date: September 1973

Results: Indicated V_s values are the averages from the two lines

REPORT: SW-AA (1977b)

BUILDING: The accelerograph, originally located in a small instrument shelter founded at grade, has been relocated to Castaic Dam.

- Duke, et al. (1971); Site No. 27, subsurface model "B"
- 700 feet Northwest of Accelerograph Station (line elevation 2475 feet MSL)
- October 4, 1971

NOTES: 1) No borings were made at the site. Material denoted on log corresponds to that observed during our site reconnaissance (SW-AA, 1977b).

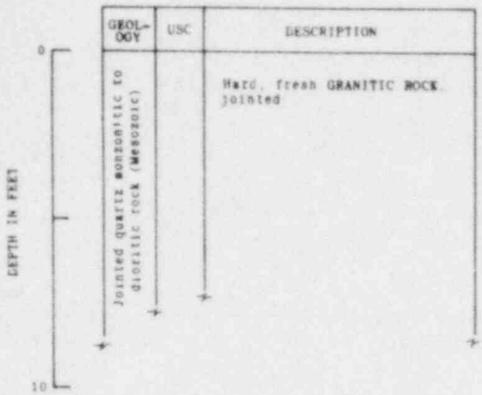
2) Surface elevation approximately 2560 feet, MSL (USGS topographic quad.).

3) Velocities based on refraction measurements to 50 feet. Below 50 feet, velocities were estimated based on site geology.

SUMMARY LOG
OLD RIDGE ROUTE
CASTAIC, CALIFORNIA

FIG. A-4

LOG[1,2]



VELOCITIES Not available

BUILDING The Miller Canyon Guard Station (formerly the Allen Ranch) is a one-story garage with a daylight basement. The accelerograph is located at grade level in the basement.

REPORT SW-AA (1977b)

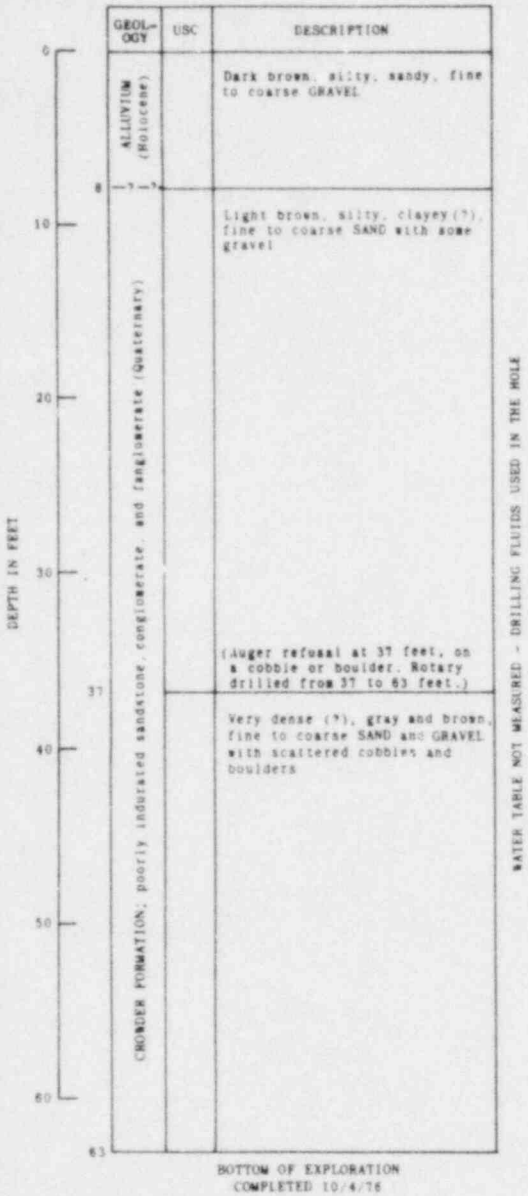
NOTES: 1) No borings were made at the site. Material descriptions denoted on the log correspond to that observed during our reconnaissance. (SW-AA, 1977b).

2) Site elevation approximately 3490 feet MSL (USGS topographic quad.).

SUMMARY LOG
MILLER CANYON GUARD STATION
CEDAR SPRINGS, CALIFORNIA

FIG. A-5

BORING LOG[1]



BOTTOM OF EXPLORATION
COMPLETED 10/4/76

BORING

Elevation: Approximately 3230 feet, MSL (USGS Topographic Quad.)

Location: 25 feet North of Accelerograph Station

Data Source: SW-AA (1977b)

Mobile B-61 hollow stem auger

Equipment: Augered 0-37 feet with only grab sampling of cuttings. Rotary drilled below 37 feet, with two drive samples taken below 50 feet.

VELOCITIES: Not available

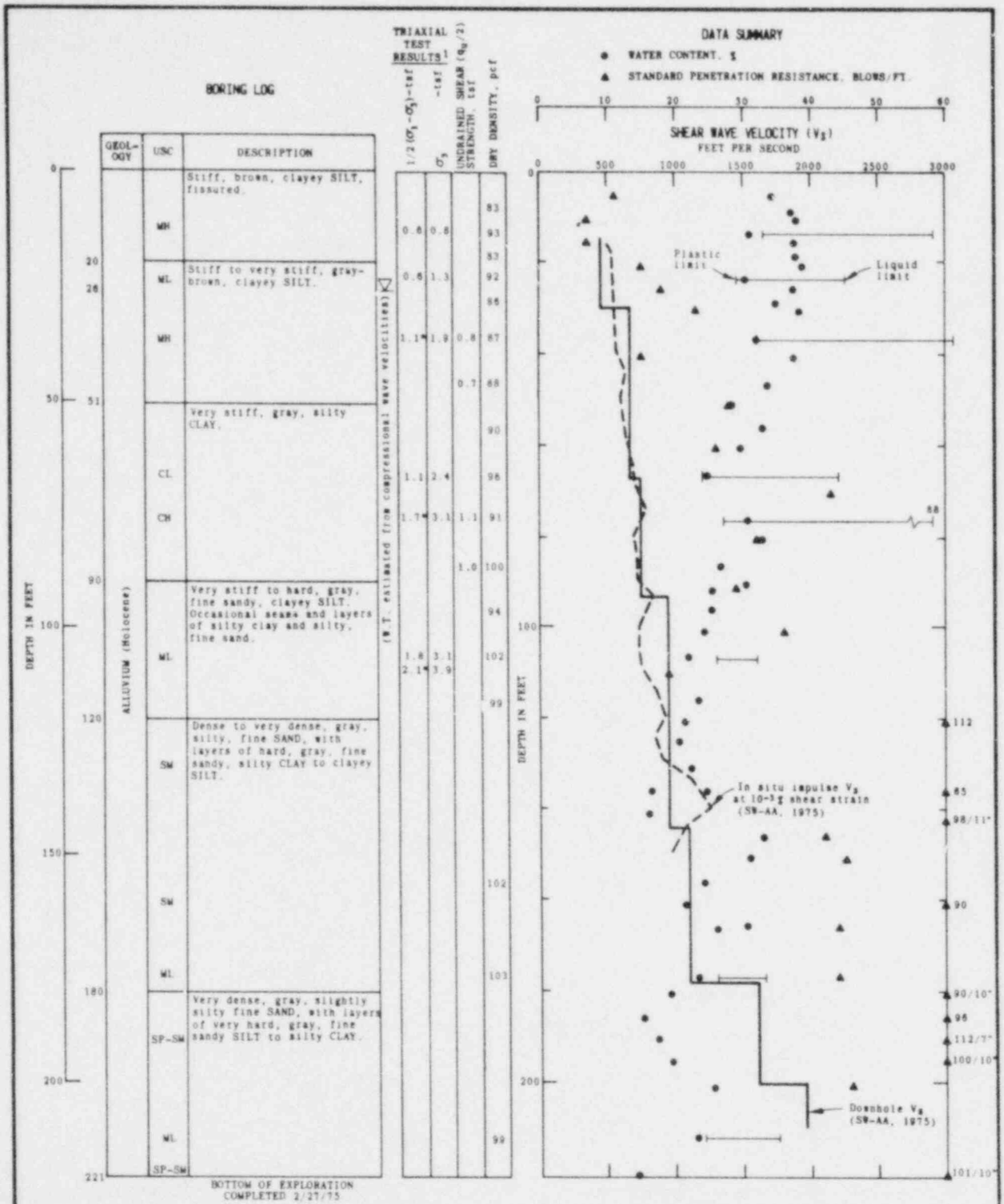
REPORT: SW-AA (1977b)

BUILDING: The pumphouse was a small one-story structure founded at grade.

NOTE: 1) Bedrock was not encountered within the depth of the boring.

SUMMARY LOG
PUMP HOUSE
CEDAR SPRINGS, CALIFORNIA

FIG. A-6



BORING

Elevation: Approximately 1136 feet, MSL

Location: Approximately 100 feet Southeast of the original station 2 (560 feet Northeast of the relocated station).

Data Source: SW-AA (1975)

Equipment: Failing 1500 Rotary drill; sampling with a SPT split spoon, Shelby tubes and a Pitcher barrel

VELOCITIES

Source: SW-AA (1975)

Location: Testing performed in above boring

Date: March 1975

REPORT: SW-AA (1975)

BUILDING: The accelerograph is housed in a small instrument shelter founded at grade.

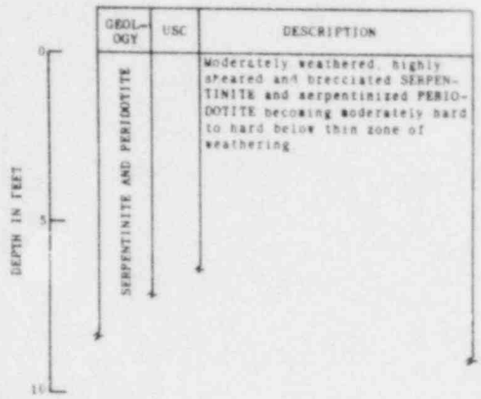
NOTE: 1) Values of shear strength are from U-U or C-U* tests.

SUMMARY LOG
STATION 2
CHOLAME-SHANDON ARRAY
CALIFORNIA

FIG. A-7

TEMBLOR
(original station)

LOG[1]



VELOCITIES Not available

REPORT SW-AA (1977b)

BUILDING Although the station has been discontinued the accelerograph was located in a small instrument shelter founded at grade.

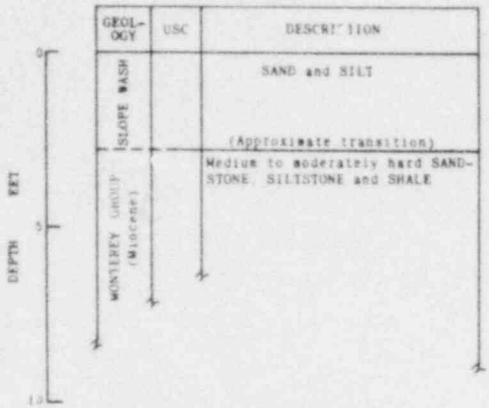
NOTE: 1) No borings were made at the site. The materials indicated on the log correspond to those observed during our site reconnaissance (SW-AA, 1977b).

SUMMARY LOG
TEMBLOR
CHOLAME–SHANDON ARRAY
CALIFORNIA

FIG. A-8

TEMBLOR II
(relocated station)

LOG[1]



VELOCITIES — Not available

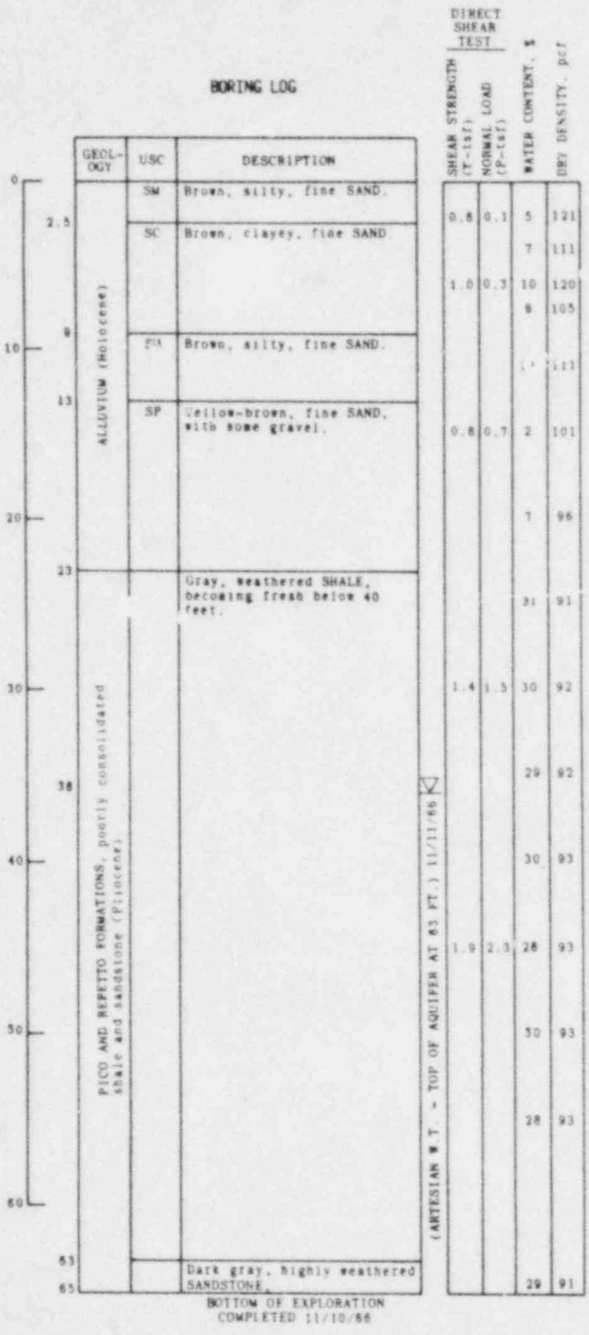
REPORT — SW-AA (1977b)

BUILDING — The accelerograph is located in a small instrument shelter founded at grade.

NOTE: 1) No borings were made at the site. The materials indicated on the log correspond to those observed during our site reconnaissance (SW-AA, 1977b).

SUMMARY LOG
TEMBLOR II
CHOLAME–SHANDON ARRAY
CALIFORNIA

FIG. A-9



BORING

Elevation: Approximately 95 feet MSL (USGS topographic quad.)

Location: 666 West 19th Street Building.

Data Source: LeRoy Crandall & Associates (1966)
Boring No. B-1

Equipment: Bucket Auger

VELOCITIES Not available within the vicinity of the site.

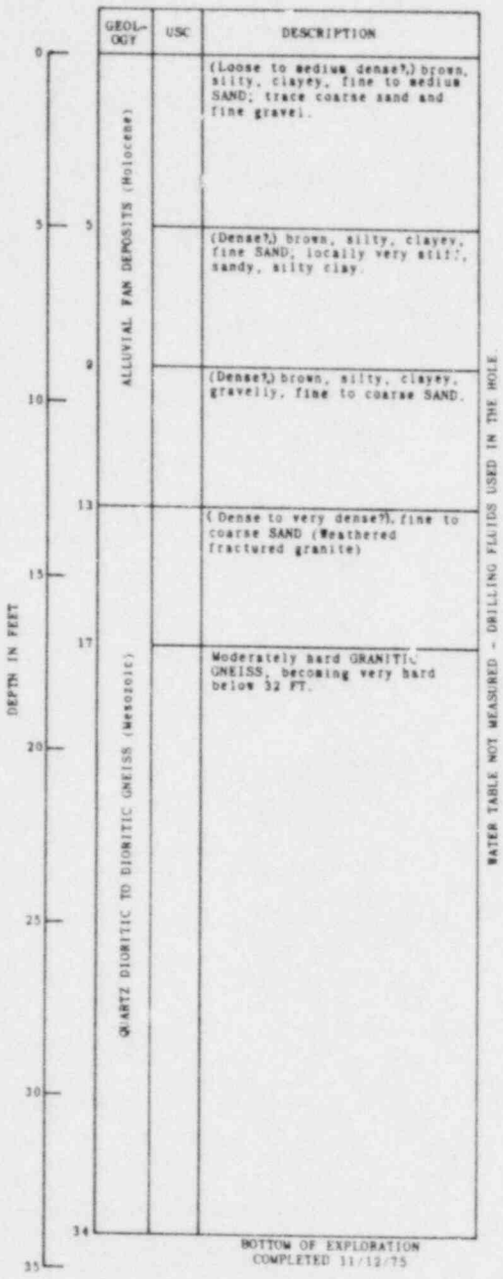
REPORT SM-AA (1977b)

BUILDING Bethel Towers (666 West 19th Street) is an 18-story high rise founded at grade. The accelerograph is located on the ground floor.

SUMMARY LOG
666 WEST 19th STREET
COSTA MESA, CALIFORNIA

FIG. A-10

BORING LOG



BORING

Elevation:	Approximately 1380 feet MSL (USGS topographic quad.)
Location:	Within 20 feet of original accelerograph station
Data Source:	SW-AA (1976b)
Equipment:	0-3.5 feet : Hand Auger 3.5-34 feet: Failing 1500 Rotary Drill, hole logged by observing drill action and cutting returns.

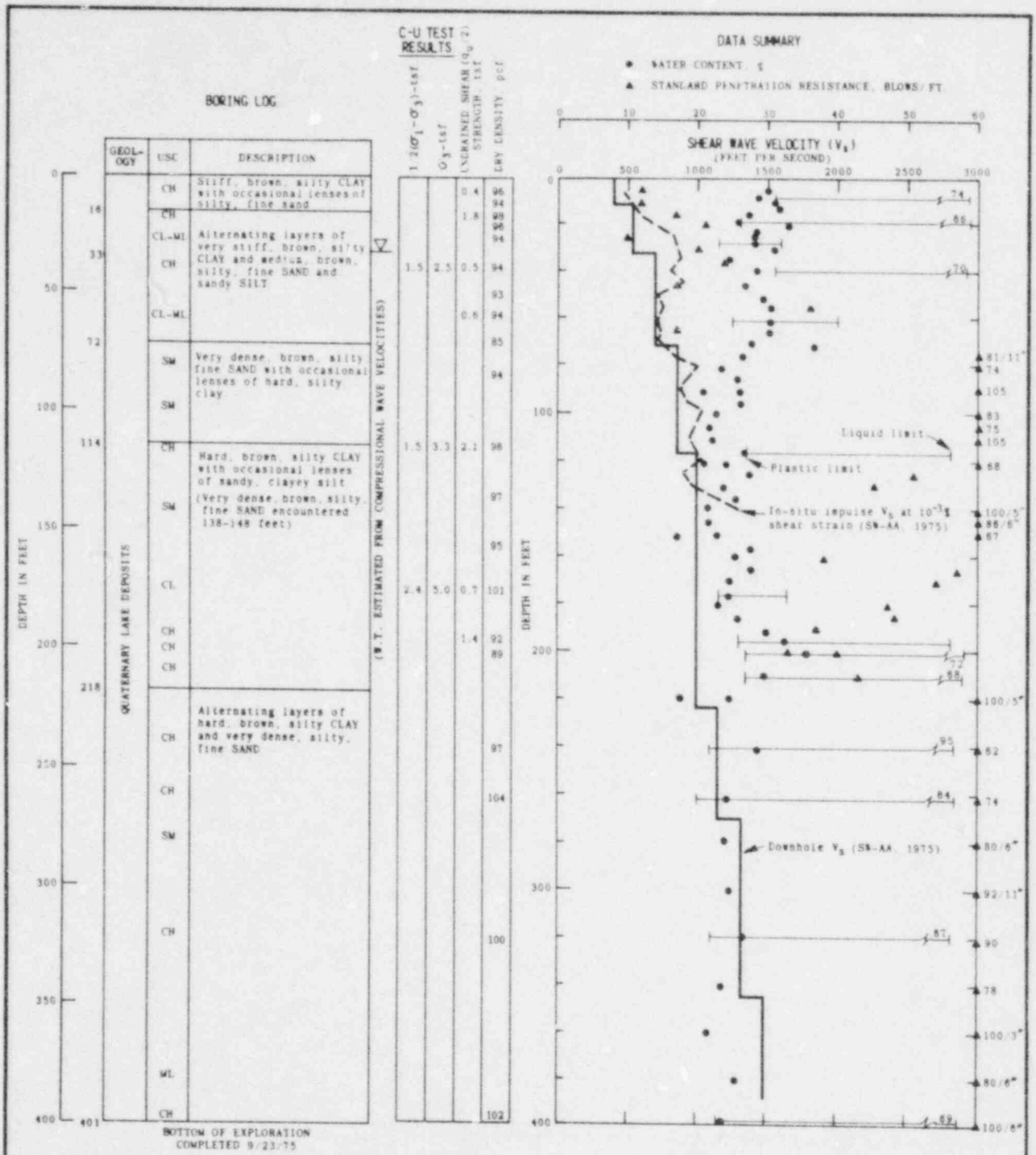
VELOCITIES — Not available within the vicinity of the site

REPORT — SW-AA (1976b)

BUILDING — The original accelerograph was housed in a small, free-field instrument shelter, located at grade. The accelerograph was later relocated to the transformer yard at the plant.

SUMMARY LOG
EDISTON PUMPING PLANT
CALIFORNIA

FIG. A-11



BORING

Elevation: -47 feet, MSL

Location: 120 feet west of the terminal substation

Data Source: SW-AA (1975)

Equipment: Failing 1500 rotary drill; sampling with a SPT split spoon, shelby tubes and a pitcher barrel

VELOCITIES

Data Source: SW-AA (1975)

Location: Downhole and in situ impulse testing performed in above boring

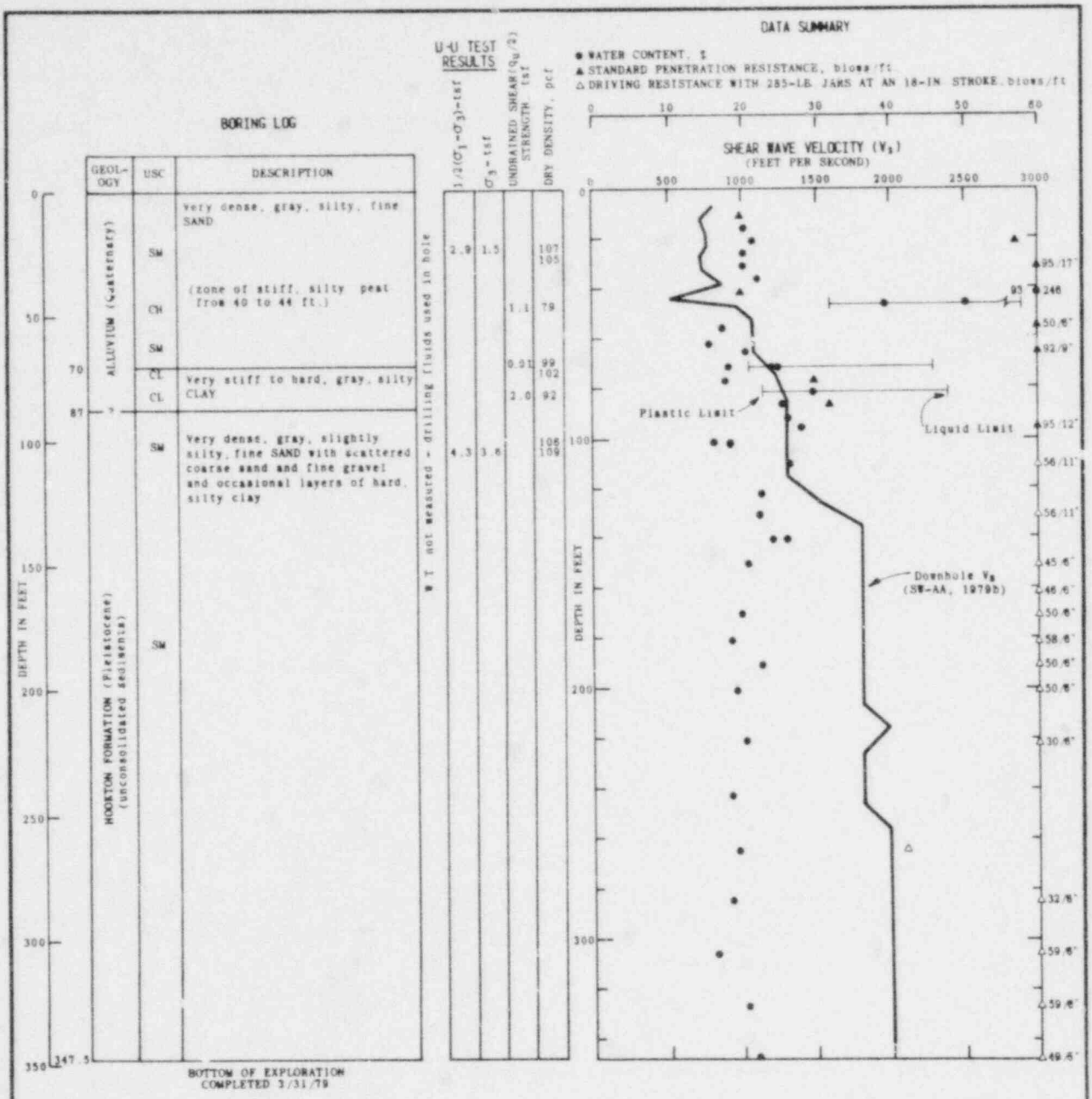
Data: In situ impulse - April 1975
Downhole - April 1975 and October 1975

REPORT: SW-AA (1975)

BUILDING The terminal substation is a 2-story building with a daylight basement (extends about 3 feet below grade) where the accelerograph is located.

SUMMARY LOG
TERMINAL SUBSTATION
302 COMMERCIAL AVE.
EL CENTRO, CALIFORNIA

FIG. A-12



BORING

Elevation: 40 feet, MSL (interpolated from USGS topo quad)

Location: 12 feet south of the Federal Building

Data Source: SW-AA (1979b)

Equipment: Failing 1500 rotary drill; sampling with a 2" O.D. split spoon drive barrel and a Pitcher barrel.

VELOCITIES

Source: SW-AA (1979b)

Location: Downhole testing performed in above boring

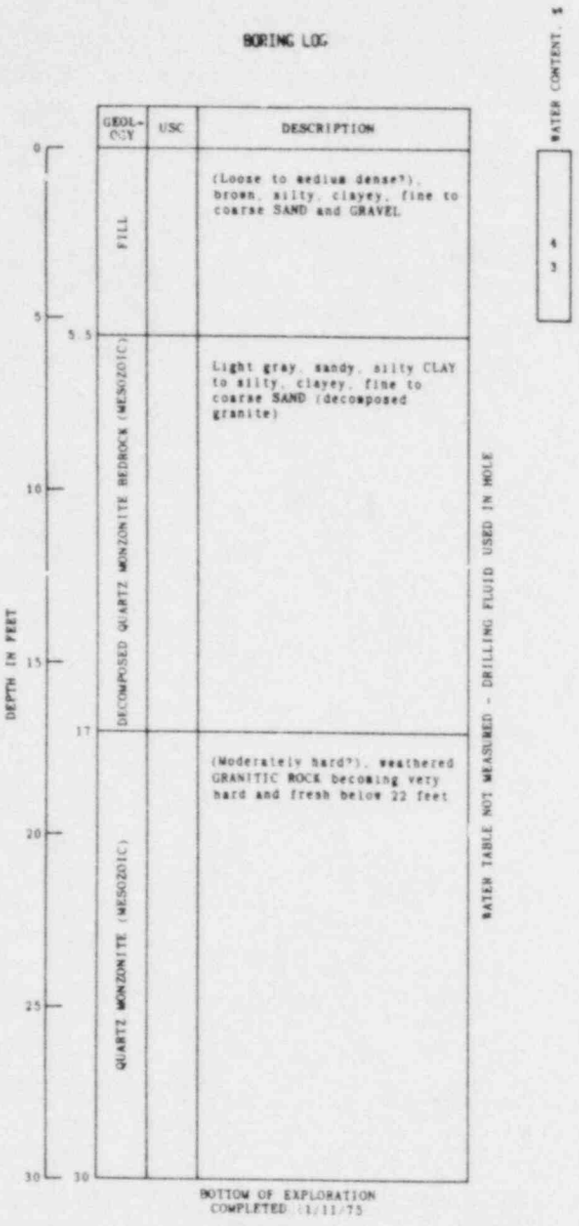
Date: May 31, 1979

REPORT: SW-AA (1977b, 1979b)

BUILDING: The Federal Building (500 "H" St.) is a three-story structure with one basement. The accelerograph is located in the basement, about 10 feet below grade.

SUMMARY LOG
FEDERAL BUILDING
EUREKA, CALIFORNIA

FIG. A-13



BORING

Elevation: Approximately 3055 feet, MSL (USGS topographic quad.)

Location: 13 feet Southwest of accelerograph station

Data Source: SW-AA (1976b)

Equipment: 0-3.5 feet: Hand auger

3.5-30 feet: Failing 1500 Rotary drill; hole logged by observing drill action and cutting returns.

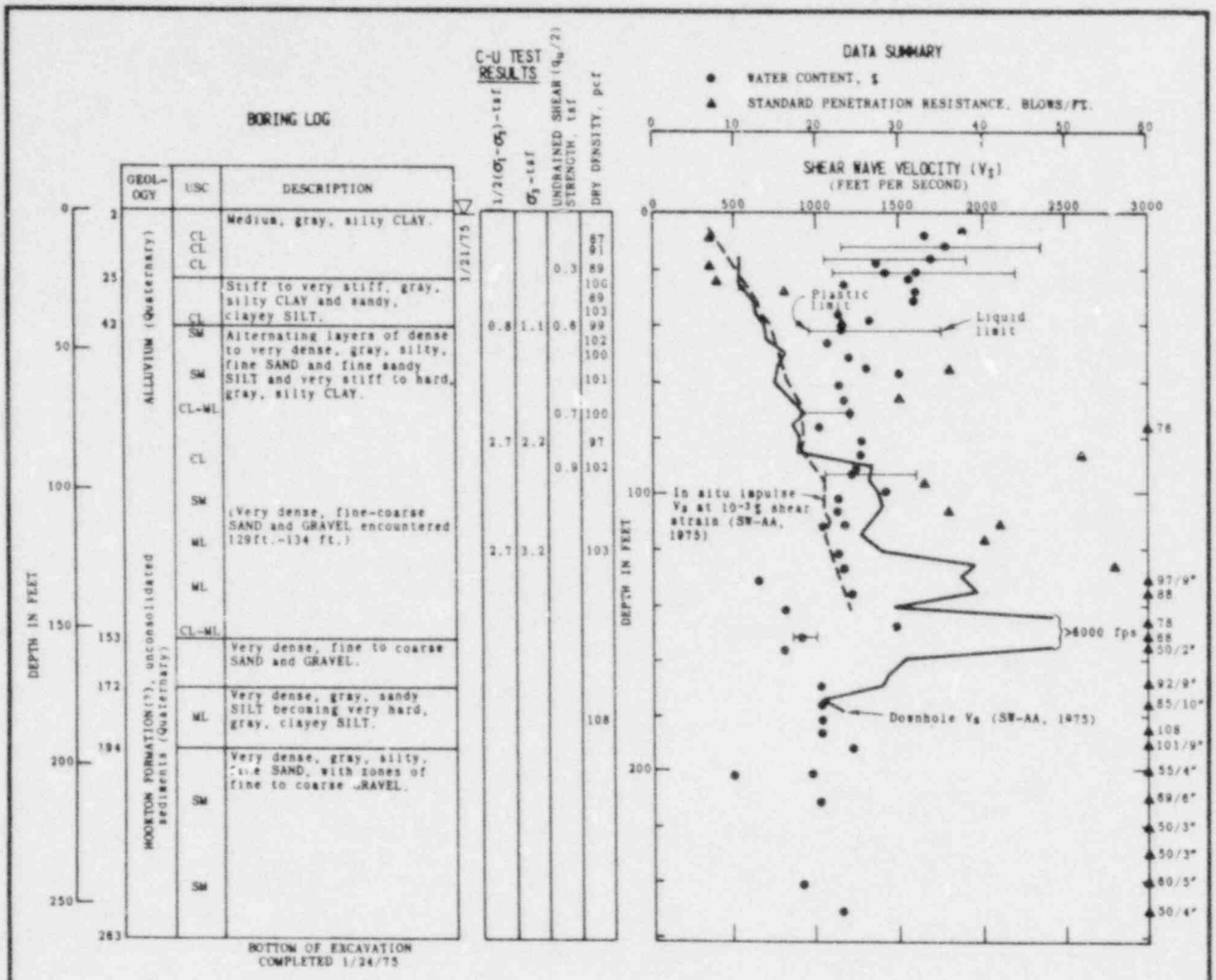
VELOCITIES: Not available within vicinity of the site

REPORT: SW-AA (1976b)

BUILDING: The accelerograph is housed in a one-story barn founded at grade on the right abutment of the dam.

SUMMARY LOG
FAIRMONT RESERVOIR
CALIFORNIA

FIG. A-14



BORING

Elevation: 51 feet, MSL

Location: 40 feet West of accelerograph station

Data Source: SW-AA (1975)

Equipment: Failing 1500 Rotary drill: sampling with a SPT split spoon, Shelby tubes and a Pitcher barrel

VELOCITIES

Source: SW-AA (1975)

Location: All testing performed in above boring

Date: February 1975

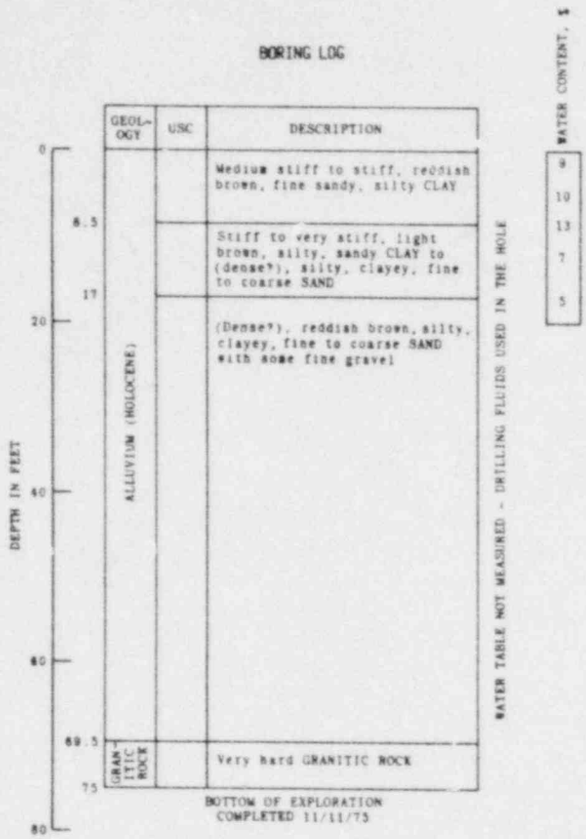
REPORT: SW-AA (1975)

BUILDING: The Ferndale Fire Station (formerly the City Hall) is a 2-story structure founded at grade.

SUMMARY LOG
FIRE STATION
FERNDALE, CALIFORNIA

FIG. A-15

BORING LOG



BORING

Elevation:	Approximately 3400 feet, ± (USGS topographic quad.)
Location:	10 feet South of Fort Tejon Accelerograph Station
Data Source:	SW-AA (1976b)
Equipment:	0 - 18 feet: Hand Auger 18 - 75 feet: Failing 1500 Rotary Drill; hole logged by observing drill action and cutting returns.

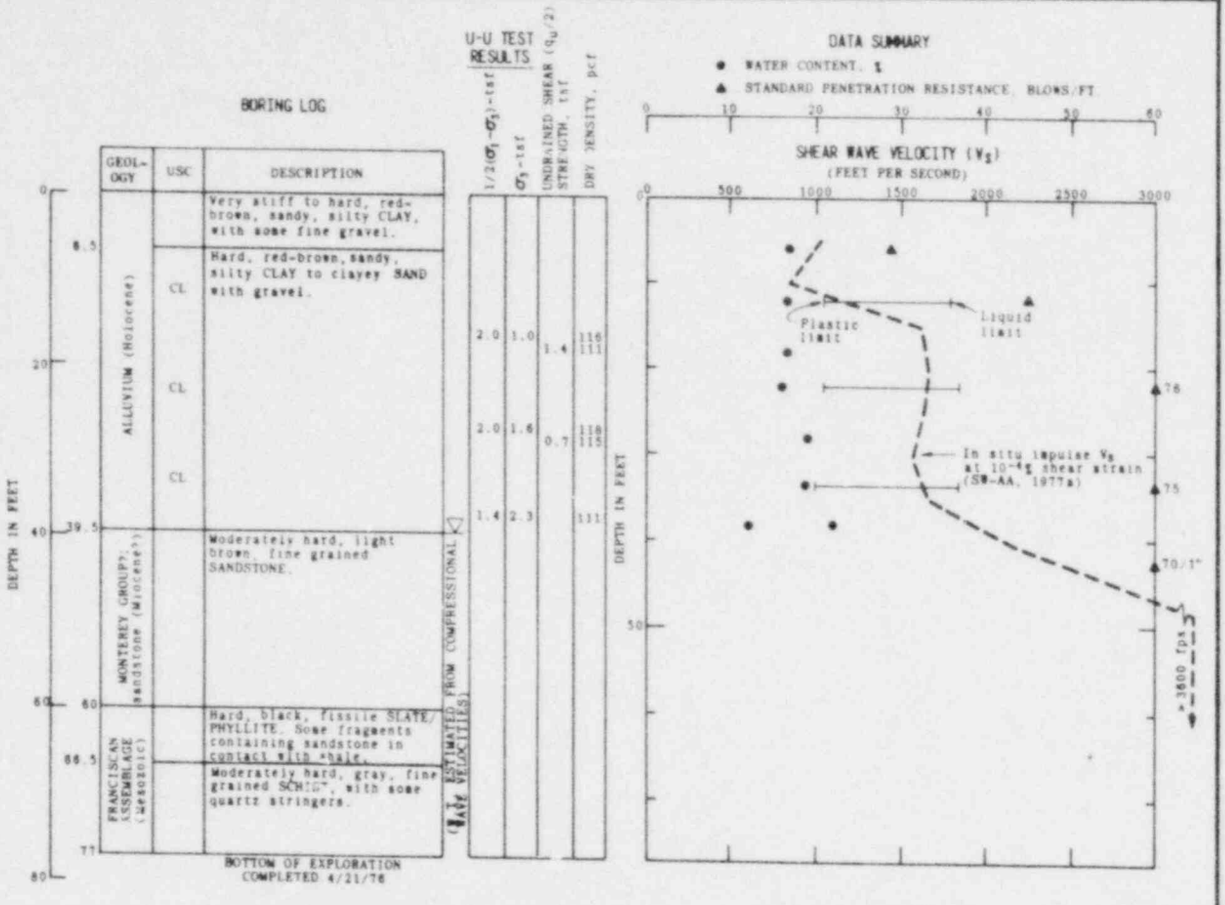
VELOCITIES Not available within vicinity of the site

REPORT SW-AA (1976b)

BUILDING Although the station has been discontinued, the accelerograph originally at Fort Tejon was housed in a 4-car garage founded at grade.

SUMMARY LOG
FORT TEJON
CALIFORNIA

FIG. A-16



BORING

Elevation: 245 Feet, MSL (USGS topographic quad.)

Location: 92 Feet East of PH Science Building

Data Source: SW-AA (1977a)

Equipment: Failing 1500 Rotary drill: sampling with a SPT split spoon sampler and a Pitcher barrel to a depth of 45 feet. Below 45 feet, only drill cuttings sampled

VELOCITIES

Source: SW-AA (1977a)

Location: Testing performed in above boring

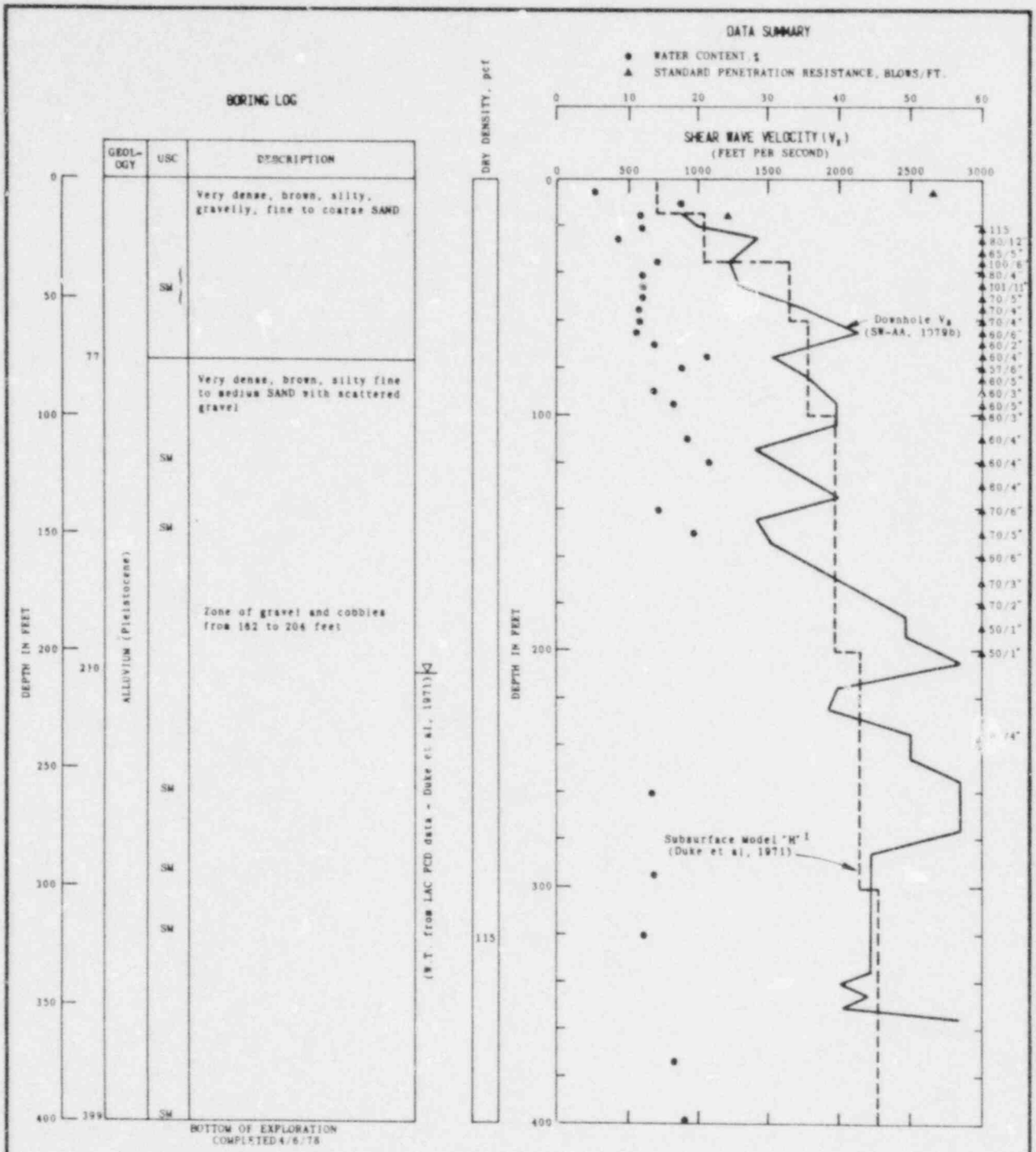
Date: April 1976

REPORT SW-AA (1977a)

BUILDING The Physical Science (Geology) Building is a one-story structure founded at grade.

SUMMARY LOG
PHYSICAL SCIENCE BLDG.
GAVILAN COLLEGE
GILROY, CALIFORNIA

FIG. A-17



BORING

Elevation: 569.5 feet, MSL

Location: 209 feet North of 633 E. Broadway

Data Source: SW-AA (1979b)

Drill Rig: Failing 1500 Rotary Drill; Sampling with a SPT Split Spoon and a Pitcher Barrel

VELOCITIES

a) Source: SW-AA (1979b)
Location: Testing performed in above boring
Date: June 7, 1978

b) Source: Duke, et al. (1971)
Location: Subsurface model "H" developed for 633 E. Broadway[1]
Date: Aug. 1971

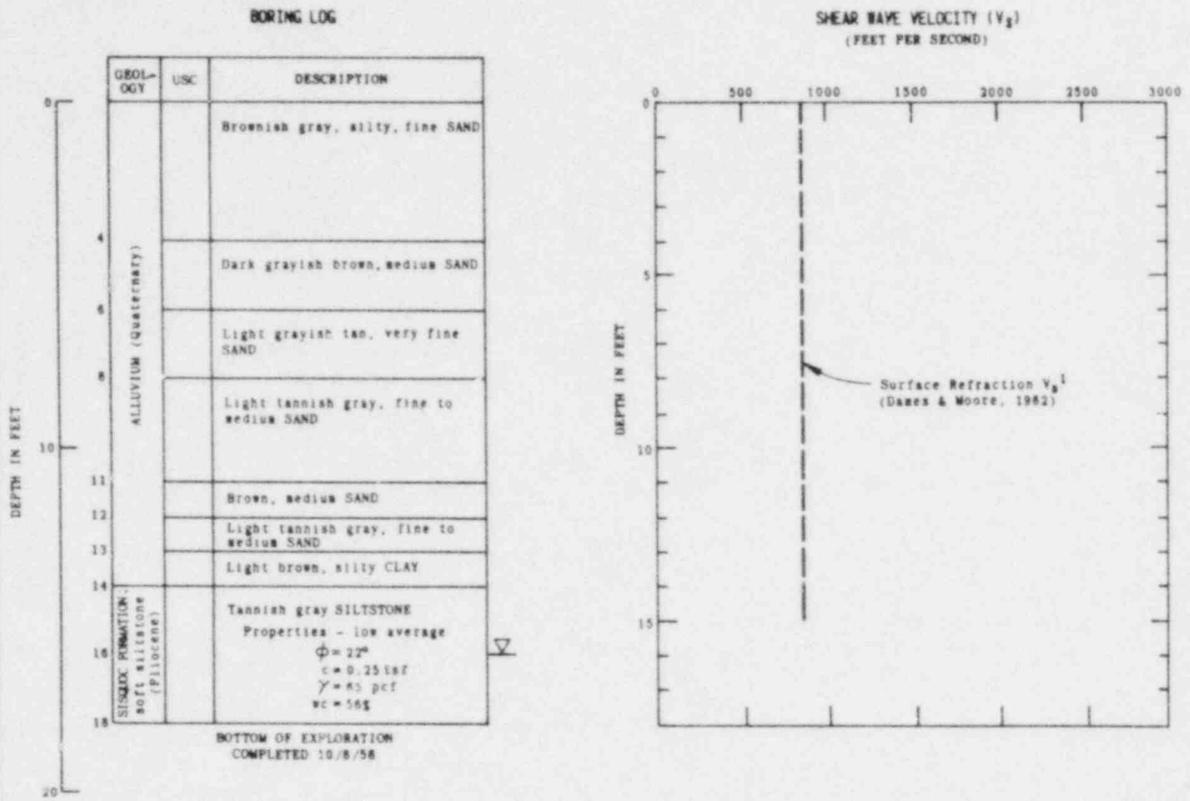
REPORT: SW-AA (1977b, 1979b)

BUILDING: The Municipal Services Bldg. (633 E. Broadway) is a 3-story structure supported on 4 pedestals which separate the first floor from grade level by about 15 feet. The accelerograph is located in a partial basement about 20 feet below grade (Fl. El. 549.5 ft.).

NOTE: 1) Velocities from 0-35 ft. correspond to surface refraction measurements made at the Glendale High School (Site 12 - Approximately 5000 feet east of 633 E. Broadway). Below 35 ft., velocities were estimated from site geology.

SUMMARY LOG
633 E. BROADWAY
GLENDALE, CALIFORNIA

FIG. A-18



BORING

Elevation: 44.7 feet

Location: Center of Arts Building (accelerograph station)

Data Source: L.T. Evans (1956)
Foundation Investigation for Arts Building
Boring No. 2 in report

Equipment: 18 inch diameter bucket auger

VELOCITIES

Source: Dames and Moore (1962)

Location: 200 feet West of station

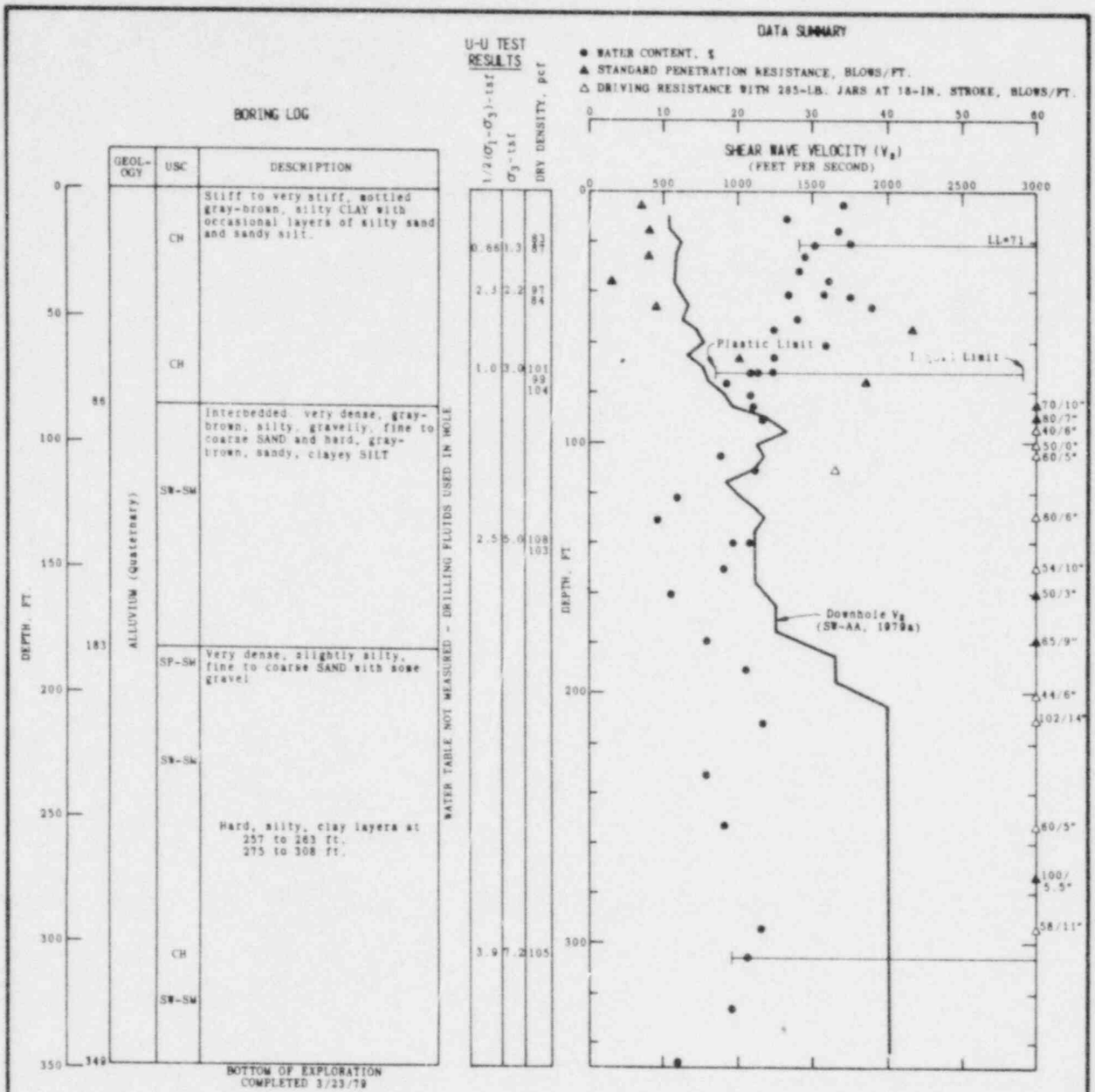
REPORT: SW-AA (1977b)

BUILDING: The U.C. Santa Barbara Arts Building (which contained the Fluid Mechanics Laboratory) is a 2-story structure with a partial basement (about 15 feet below grade). The accelerograph was originally located in the basement; however, the station has been discontinued.

NOTE: 1) The overburden has a compressional wave velocity of 1600 fps. Below 15 feet, velocities are probably affected by the water table and, hence, they are not reported here.

SUMMARY LOG
UCSB FLUID MECHANICS LAB
GOLETA, CALIFORNIA

FIG. A-19



BORING

Elevation:	285 ft. MSL (interpolated from USGS topo quad)
Location:	700 ft. west of the City Hall.
Data Source:	SW-AA (1979a)
Equipment:	Failing 1500 rotary drill; sampling with a 2" O.D. split spoon drive barrel, shelby tubes, pitcher sampler and modified pitcher.

VELOCITIES

Source:	SW-AA (1979a)
Location:	Downhole testing performed in above boring.
Date:	May 28, 1979

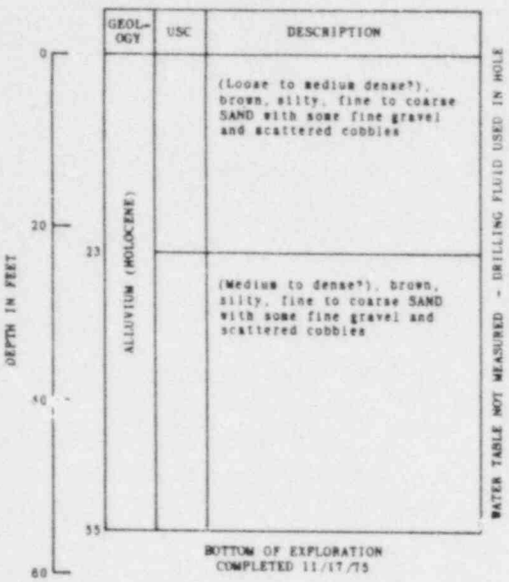
REPORT: SW-AA (1979a)

BUILDING: The City Hall (formerly Carnegie Library) at 375 Fifth St., is a one story structure with a daylight basement. The accelerograph is located in the basement, about 3 feet below grade.

SUMMARY LOG
CITY HALL
HOLLISTER, CALIFORNIA

FIG. A-20

BORING LOG



BORING

Elevation: Approximately 3280 feet, MSL (USGS topographic quad.)

Location: 25 feet North of existing Lake Hughes No. 1 accelerograph station (Fire Station No. 78)

Data Source: SW-AA (1976b)

Equipment: Failing 1500 Rotary drill; hole logged by observing drill action and cutting returns.

VELOCITIES Duke et al. (1971)[3]

REPORT SW-AA (1976b)

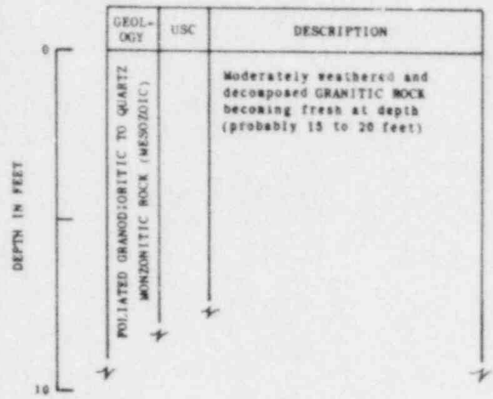
BUILDING The accelerograph is located in a one-story Fire Station which is founded at grade.

NOTES:
1) The above boring was terminated at a depth of 55 feet due to difficulty in maintaining circulation of the drilling fluid. Rock was not encountered within the depth of the boring.
2) The log from a water well drilled 500 feet East of the station indicates the presence of sand and clay for at least a depth of 800 feet.
3) The site is located within the San Andreas Fault zone and the depth to rock may be quite variable within the vicinity of the station. Surface refraction measurements made by Duke et al. (1971) were 300 feet northwest of the station and may not represent conditions at the site.

SUMMARY LOG
STATION 1 AND 1A
LAKE HUGHES ARRAY
CALIFORNIA

FIG. A-21

LOG[1,2]



VELOCITIES — Not Available

REPORT — SW-AA (1977b)

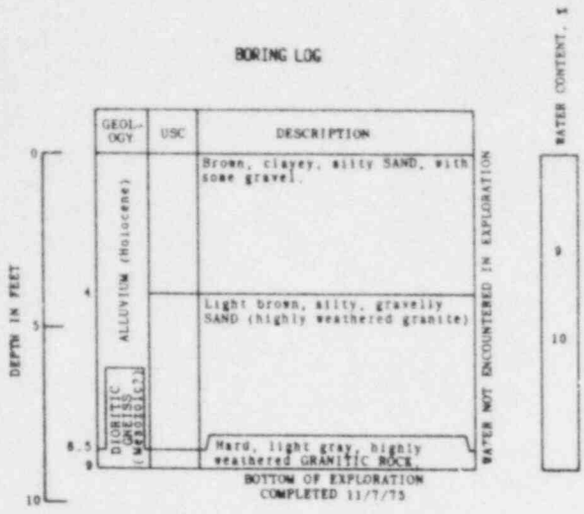
BUILDING — The accelerograph is located in a small instrument shelter with a slab-on-grade foundation.

NOTES: 1) No borings were made at the site. Depth of weathering is based upon a rock exposure in a nearby road cut. (SW-AA, 1977b).

2) Site Elevation approximately 3040 feet, MSL (USGS topographic quad.).

SUMMARY LOG
STATION 4
LAKE HUGHES ARRAY
CALIFORNIA

FIG. A-22



BORING

Elevation:	Approximately 2080 feet, MSL (USGS topographic quad.)
Location:	8 feet South of Accelerograph station
Data Source:	SW-AA (1976b)
Equipment:	Hand auger

VELOCITIES — Not available within vicinity of the site

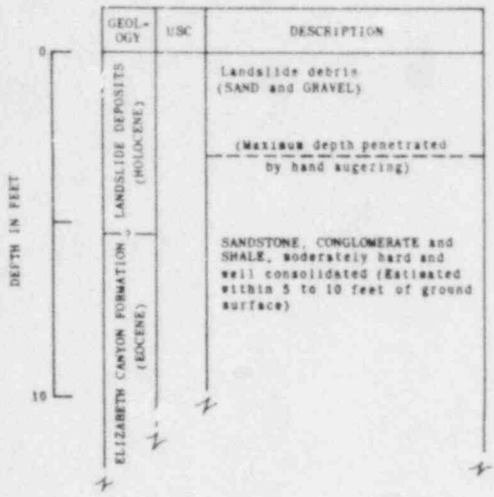
REPORT — SW-AA (1976b)

BUILDING — The accelerograph is located in a one-room shed with a concrete slab-on-grade foundation. The soil beneath a portion of the shed has been eroded, leaving the slab partially suspended.

SUMMARY LOG
STATION 9
LAKE HUGHES ARRAY
CALIFORNIA

FIG. A-23

BORING LOG



BORING

Elevation: Approximately 1640 feet, MSL (USGS topographic quad.)

Location: Adjacent to accelerograph station

Source: SW-AA (1977b)

Equipment: Hand augered to 3 or 4 feet

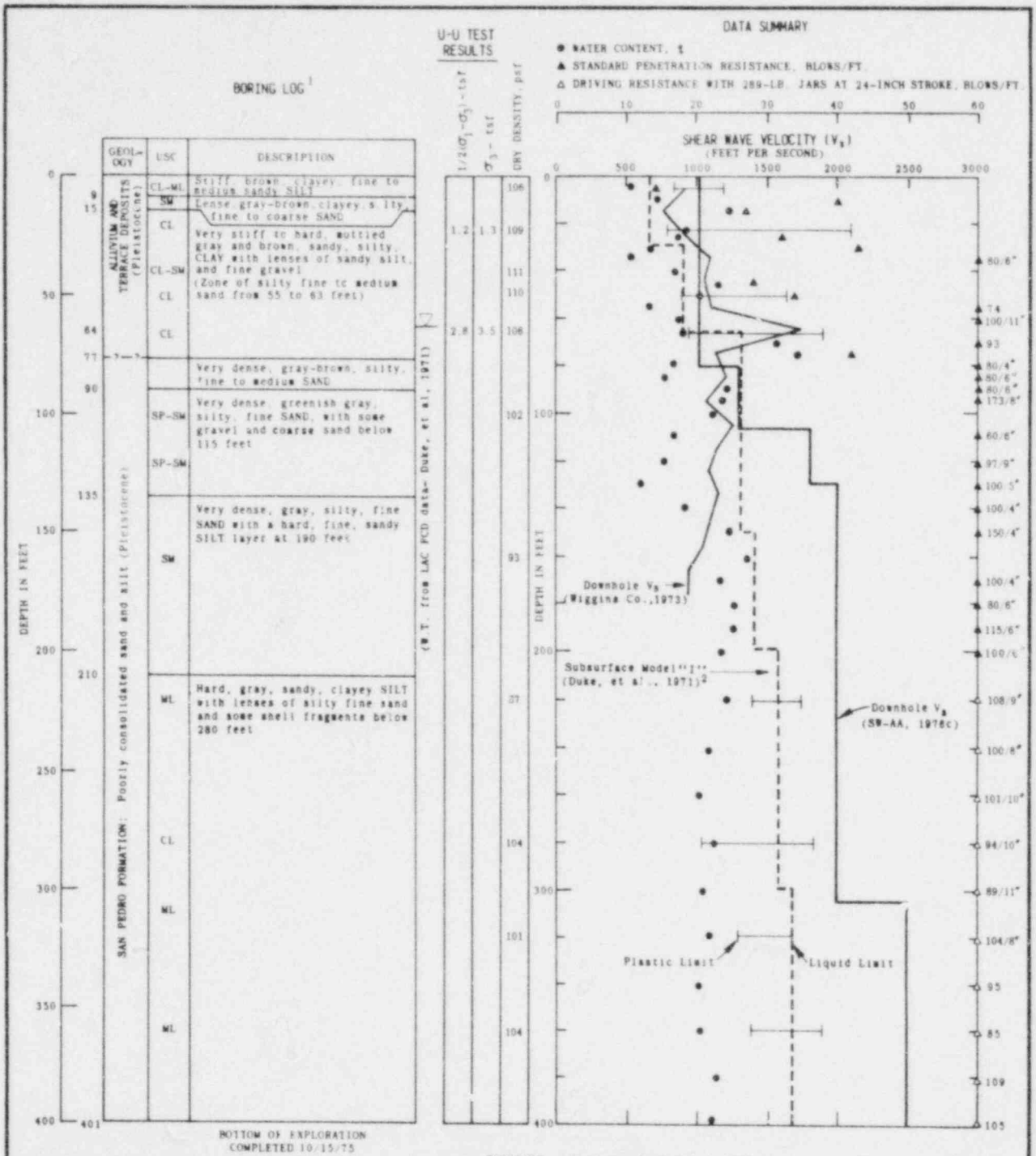
VELOCITIES: Not available

REPORT: SW-AA (1977b)

BUILDING: The accelerograph is located in a small instrument shelter founded at grade.

SUMMARY LOG
STATION 12
LAKE HUGHES ARRAY
CALIFORNIA

FIG. A-24



BORING

Elevation: 279 feet MSL
Location: 700 feet southeast of intersection of Century Park East and Santa Monica Blvd. (600 feet northeast of 1900 Avenue of the Stars)
Data Source: SW-AA (1976c) Century City Sites
Equipment: Failing 1500 Rotary drill; sampling with a 2" O.D.SPT split spoon sampler and a pitcher barrel

VELOCITIES

a) Data Source: SW-AA (1976c) Century City Sites
Location: Survey performed in above boring
Date: November 1975

b) Data Source: J. H. Wiggins Co. (1973)
Location: Century Plaza Hotel Site (1,400 feet southeast of 1900 Avenue of the Stars)
Date: June 1973

c) Data Source: Duke et al (1971)
Location: Site No. 18: Avenue of the Stars and Constellation (600 feet south of 1900 Avenue of the Stars)
Date: May 9, 1971

REPORT SW-AA (1976c)

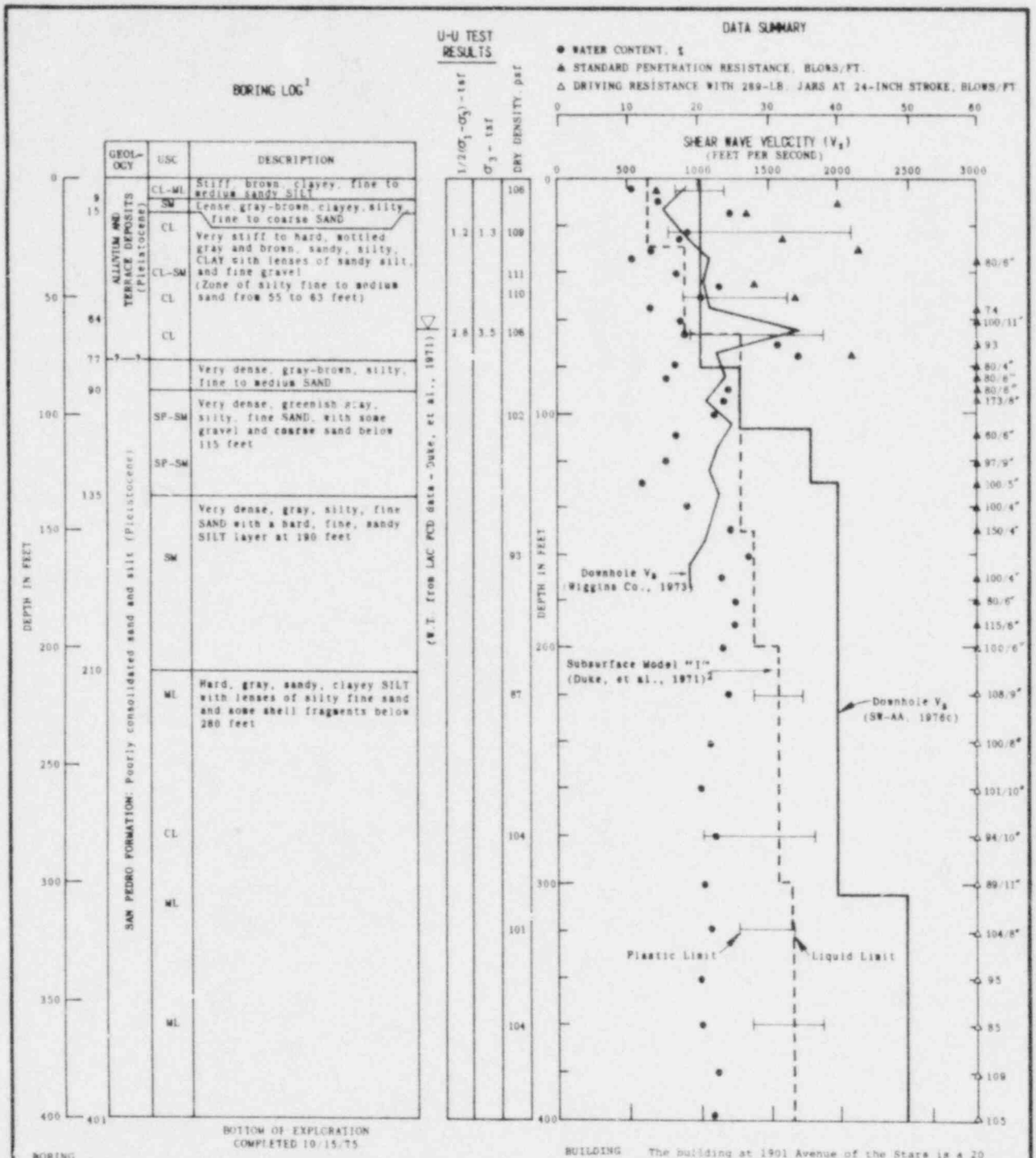
BUILDING The Union Bank Bldg. (1900 Avenue of the Stars) is a 27-story high rise with 4 levels of basement parking, the lowest of which is 30' below grade. The lowest level accelerograph is at the "D" level or foundation level of the building.

NOTES: 1) Geologic studies of the Century City area indicate sedimentary deposits of sands, silts and clays extend to about + 500 feet, at which depth they overlie sedimentary rocks.

2) Velocities based on surface refraction measurements to about 50 feet, and estimated from site geology below this depth.

SUMMARY LOG
1900 AVE. OF THE STARS
LOS ANGELES, CALIFORNIA

FIG. A-25



BORING

Elevation: 279 feet, MSL
Location: 700 feet southeast of intersection of Century Park East and Santa Monica Blvd.
(1,100 feet northeast of 1901 Avenue of the Stars)
Data Source: SW-AA (1976c) Century City Sites
Equipment: Failing 1500 Rotary Drill; sampling with a 2" O.D. SPT split spoon sampler and a pitcher barrel

VELOCITIES

a) Data Source: SW-AA (1976c) Century City Sites
Location: Survey performed in above boring
Date: November, 1975

b) Source: J.H. Wiggins Co. (1973)
Location: Century Plaza Hotel site
(1400 feet Southeast of 1901 Avenue of the Stars)
Date: June 1973

c) Source: Duke, et al. (1971)
Location: Site No. 18; Avenue of the Stars & Constellation
(400 feet Southeast of 1901 Avenue of the Stars)
Date: May 9, 1971

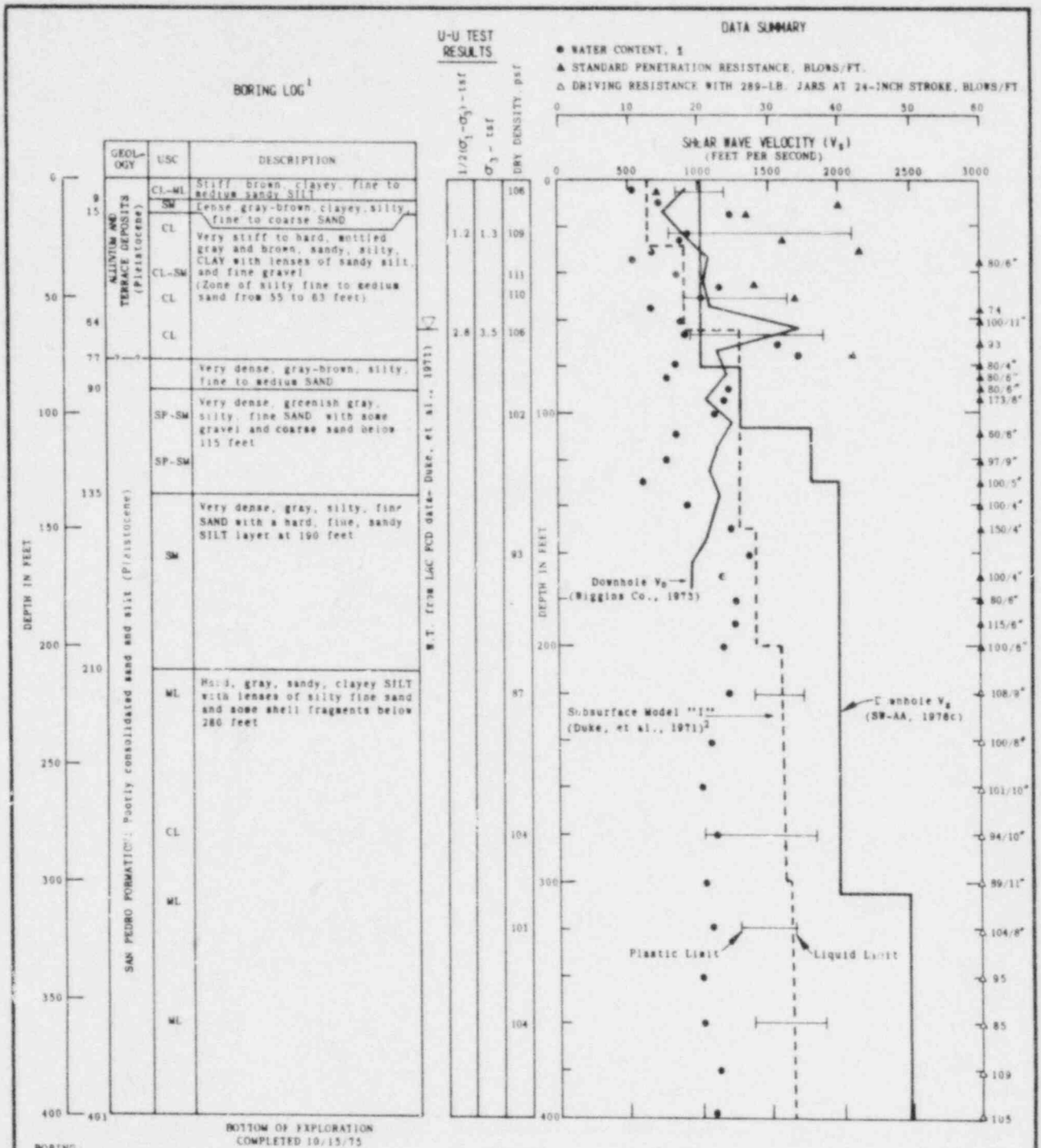
REPORT SW-AA (1976c)

BUILDING The building at 1901 Avenue of the Stars is a 20 story high rise with 4 levels of basement parking, the lowest of which is 45 feet below grade. The basement accelerograph is located at the "D" level or foundation level of the building.

NOTES:
1) Geologic studies of the Century City area indicate sedimentary deposits of sands, silts and clays extend to about + 500 feet, at which depth they overlie sedimentary rocks.
2) Velocities based on surface refraction measurments to to about 50 feet, and estimated from site geology below this depth.

SUMMARY LOG
1901 AVE. OF THE STARS
LOS ANGELES, CALIFORNIA

FIG. A-26



BORING

Elevation: 279 feet, MSL
Location: 700 feet southeast of intersection of Century Park East and Santa Monica Blvd.
(400 feet south of 1800 Century Park East)
Data Source: SW-AA (1976c) Century City sites
Equipment: Failing 1500 rotary drill; sampling with a 2"O.D. SPT split spoon sampler and a pitcher barrel

VELOCITIES

a) Source: SW-AA (1976c) Century City sites
Location: Survey performed in above boring
Date: November 1975

b) Source: J.H. Wiggins Co. (1973)
Location: Century Plaza Hotel site
(2300 feet south of 1800 Century Park East)
Date: June 1973

c) Source: Duke, et al. (1971)
Location: Site No. 18; Ave. of the Stars & Constellation
Date: (1500 feet southeast of 1800 Century Park East)
May 9, 1971

REPORT SW-AA (1976c)

BUILDING

The Northrup Building (1800 Century Park East) is a 15-story high-rise with 3 levels of basement parking, the lowest of which is 35 feet below grade. The basement accelerograph is located in the lowest level of the building.

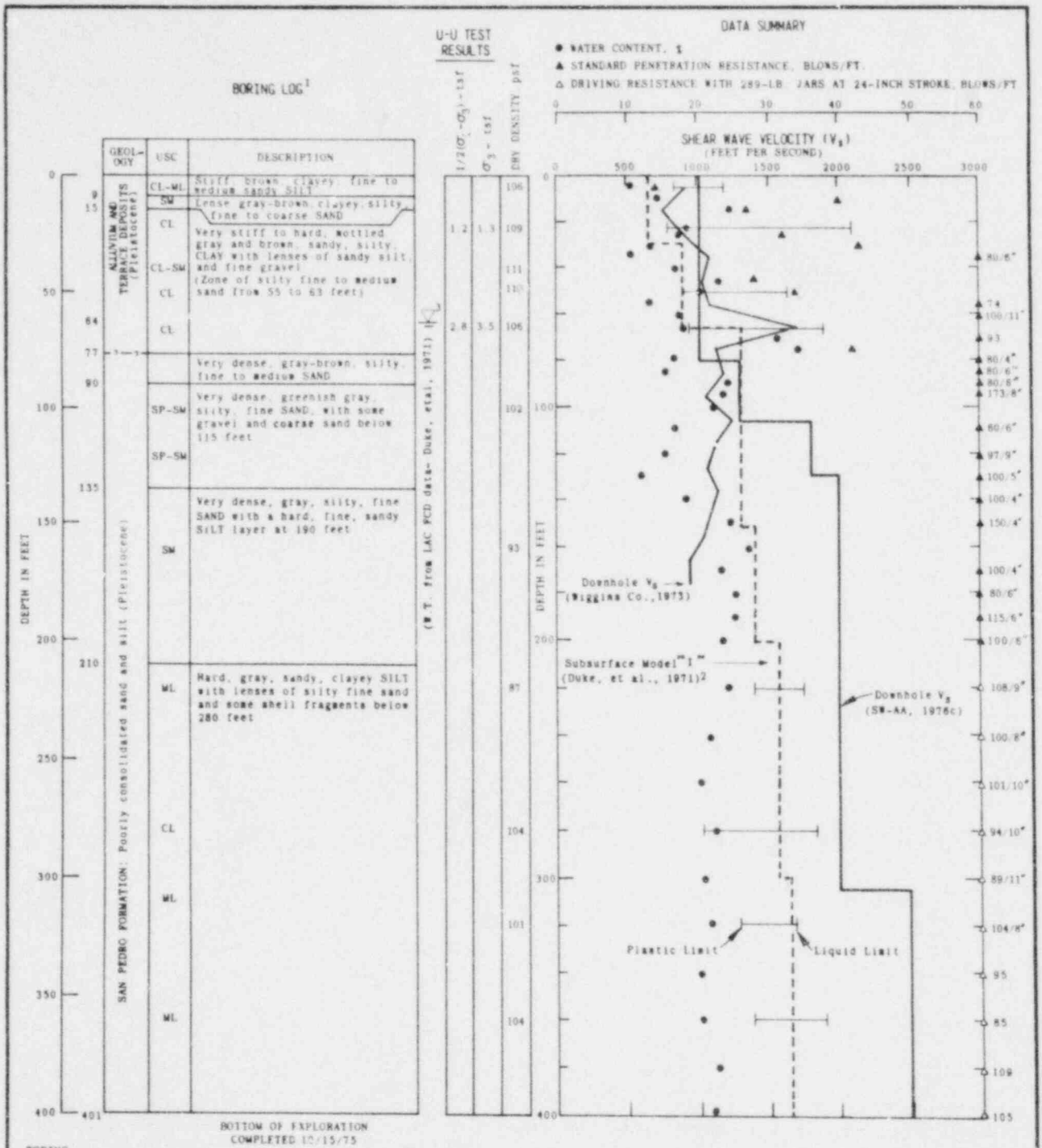
NOTES:

1) Geologic studies of the Century City area indicate sedimentary deposits of sands, silts, and clays to extend about + 500 feet at which depth they overlie sedimentary rocks.

2) Velocities based on surface refraction measurements to about 30 feet, and estimated from site geology below this depth.

SUMMARY LOG
1800 CENTURY PARK EAST
LOS ANGELES, CALIFORNIA

FIG. A-27



BORING

Elevation: 279 feet, MSL
Location: 700 feet southeast of intersection of Century Park East and Santa Monica Blvd. (100 feet southwest of 1880 Century Park East)
Data Source: SW-AA (1976c) Century City sites
Equipment: Failing 1500 rotary drill; sampling with a 2" O.D. SPT split spoon sampler and a pitcher barrel

VELOCITIES

a) Source: SW-AA (1976c) Century City sites
Location: Survey performed in above boring
Date: November 1975

b) Data Source: J.H. Wiggins Co. (1973)
Location: Century Plaza Hotel site (2600 feet south of 1880 Century Park East)
Date: June 1973

c) Data Source: Duke, et al. (1971)
Location: Site No. 18; Ave. of the Stars & Constellation (1300 feet southeast of 1880 Century Park East)
Date: May 9, 1971

REPORT SW-AA (1976c)

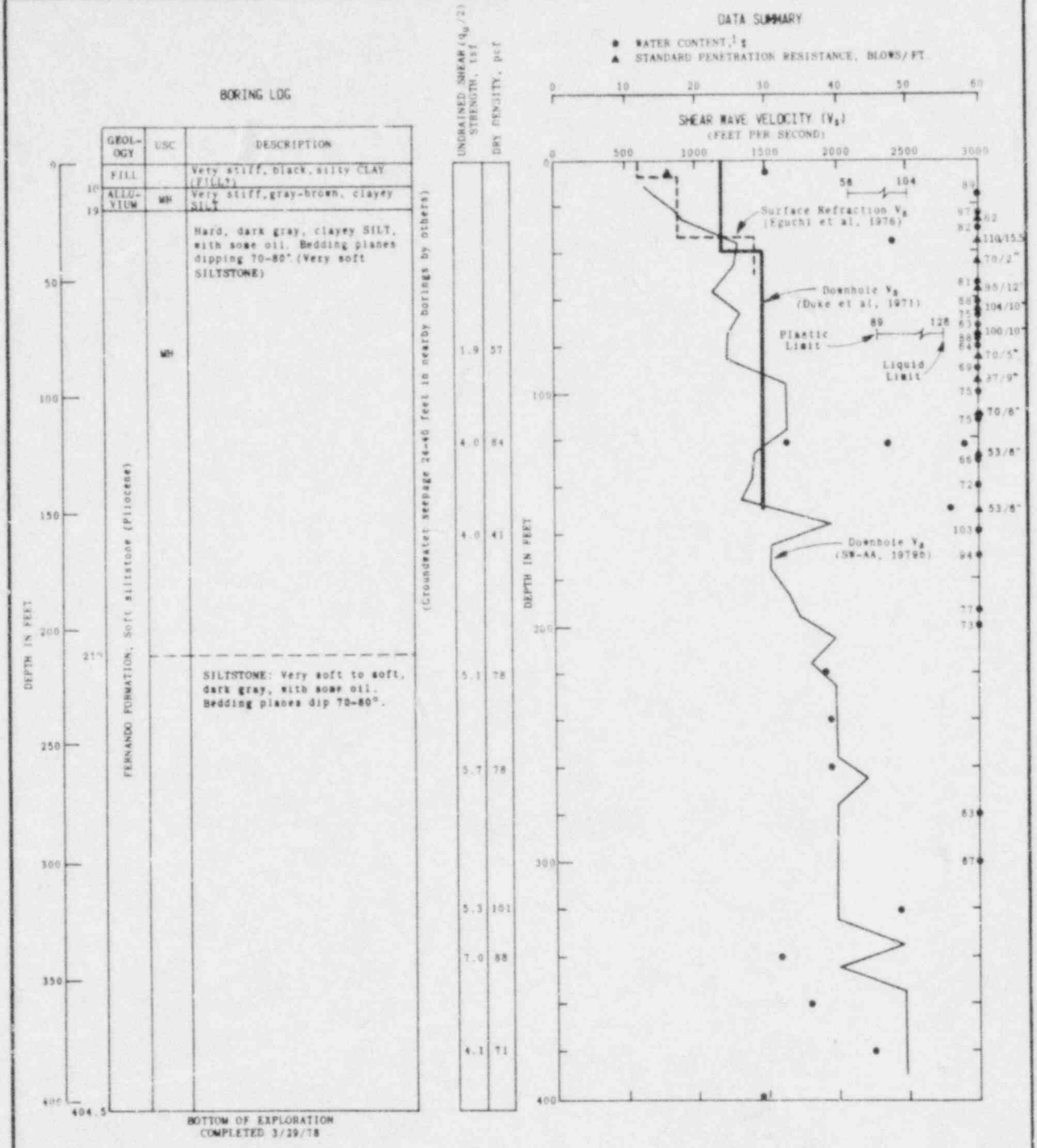
BUILDING The Property Research Building (1880 Century Park East) is a 15-story high-rise with 3 levels of basement parking, the lowest of which is 30 feet below grade. The basement accelerograph is located at the level 1 parking, 2 levels above the base of the building.

NOTES: 1) Geologic studies of the Century City area indicate sedimentary deposits of sands, silts and clays to extend to about 1,500 feet, at which depth they overlie sedimentary rocks.

2) Velocities based on surface refraction measurements to about 50 feet and estimated from site geology below this depth.

SUMMARY LOG
1880 CENTURY PARK EAST
LOS ANGELES, CALIFORNIA

FIG. A-28



BORING

Elevation: 317 feet, MSL
Location: 3rd & Figueroa Street
500 feet southwest of 222 Figueroa
Data Source: SW-AA (1979b) Figueroa Street Sites
Equipment: Failing 1500 rotary drill; sampling with a SPT split spoon sampler and a pitcher barrel

VELOCITIES

a) Source: SW-AA (1979b) Figueroa Street Sites
Location: Survey performed in above boring
Date: March 30 and 31, 1978

b) Source: Duke, et al. (1971)
Location: Site No. 26; Security Pacific National Bank
1000 feet south of 222 Figueroa Street (176-foot boring)
Date: August 1970

c) Source: Eguchi, et al. (1976)
Location: Site No. 36; Figueroa & 3rd Streets
400 feet west of 222 Figueroa Street
Date: February 1975

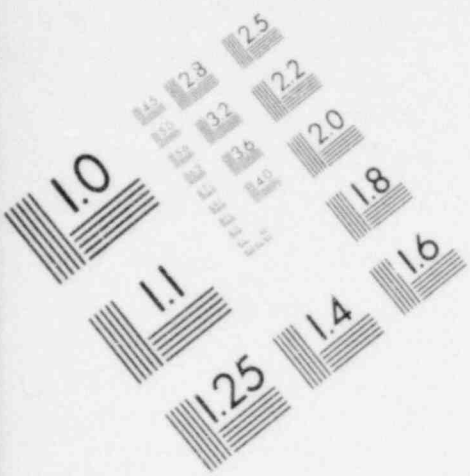
REPORT: SW-AA (1976b, 1979b)

BUILDING: The west tower of Bunker Hill Towers (222 Figueroa) is a 17-story high-rise with a daylight basement. The lowest level accelerograph is in the basement, about 5 feet below grade.

NOTES: 1) Similarly high values of water content were obtained by LeRoy Crandall and Associates in their foundation investigation for the 234 Figueroa Street building. Equipment used was a bucket auger.

SUMMARY LOG
222 FIGUEROA ST.
LOS ANGELES, CALIFORNIA

FIG. A-29



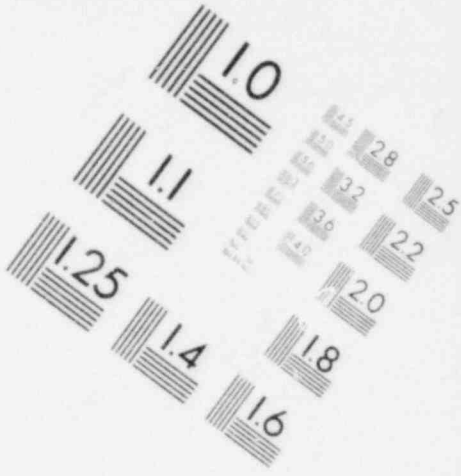
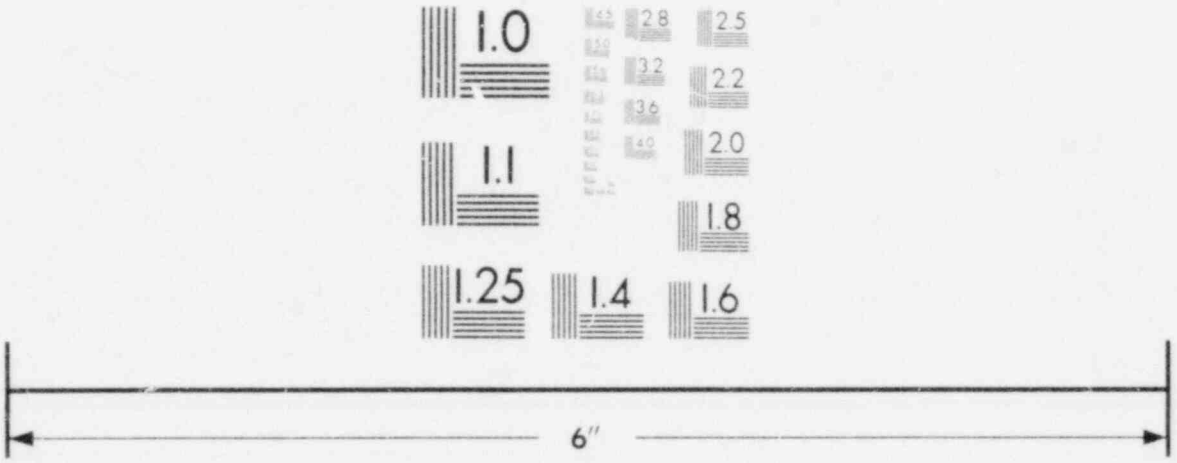
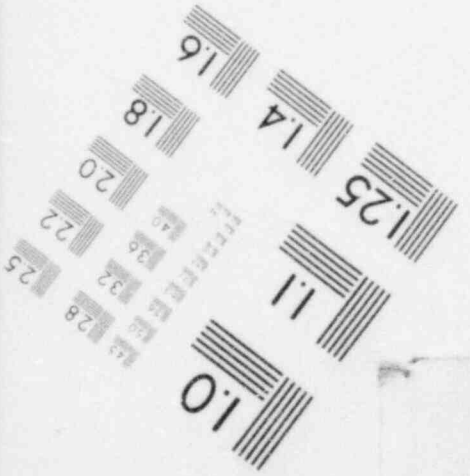
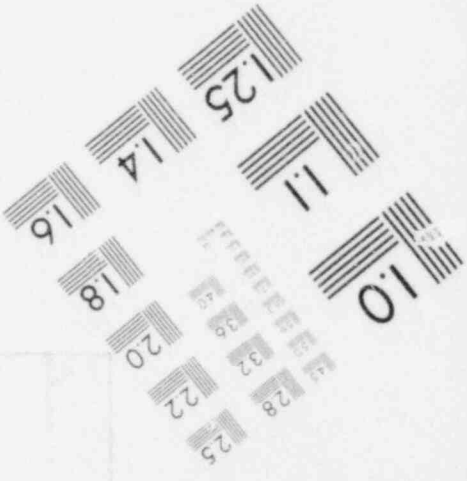


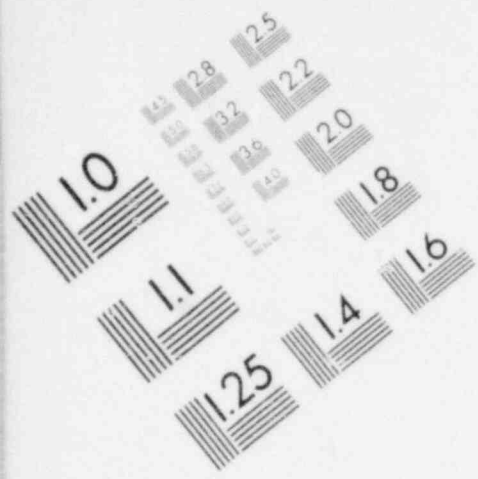
IMAGE EVALUATION
TEST TARGET (MT-3)



MICROCOPY RESOLUTION TEST CHART







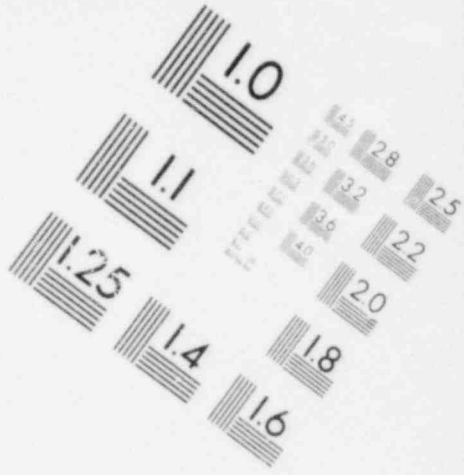
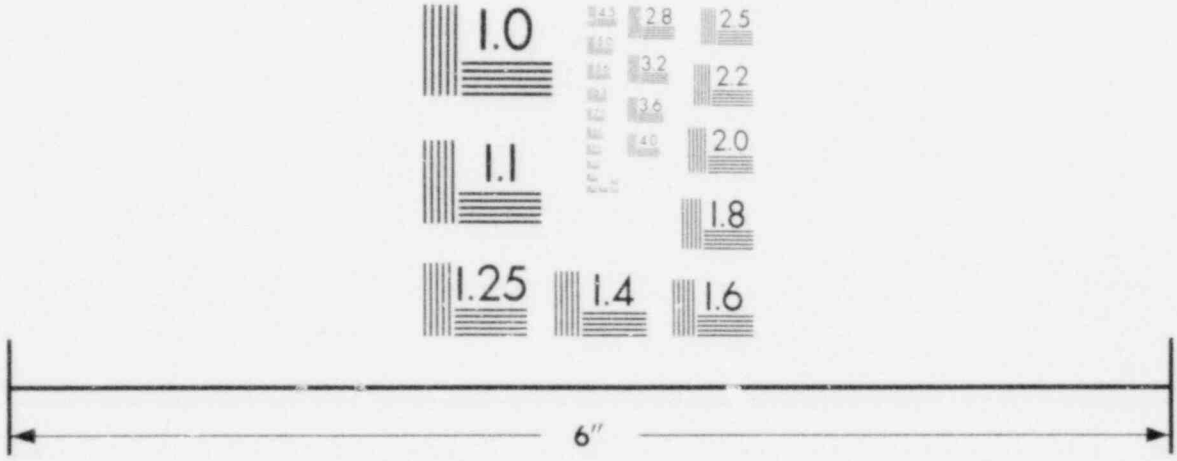
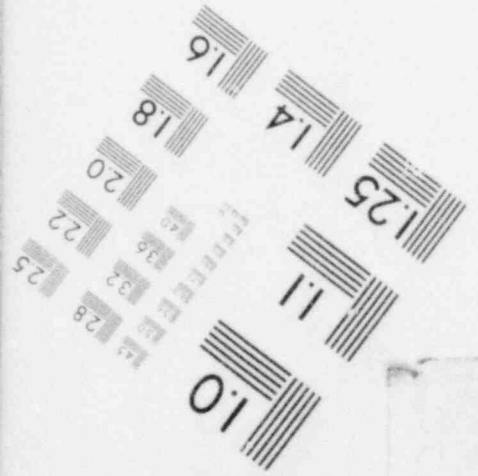
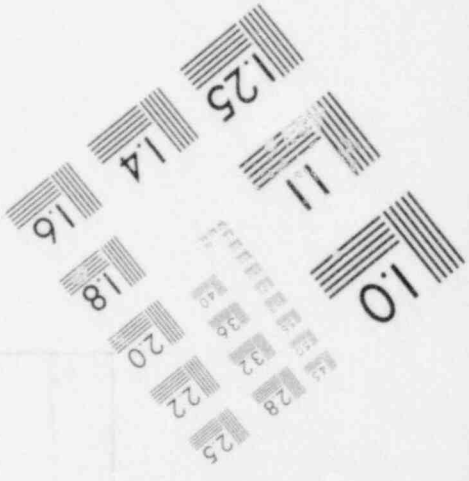


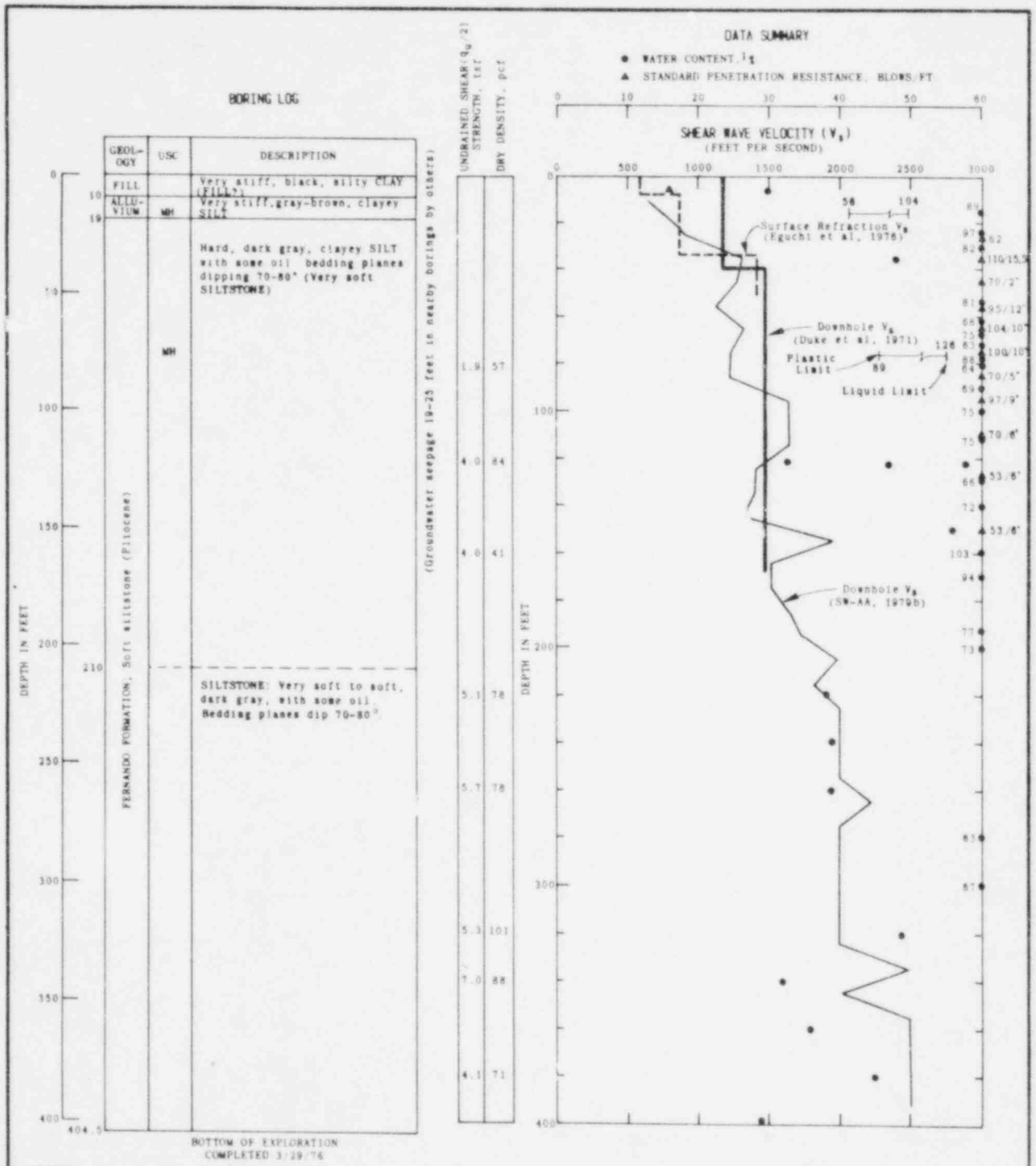
IMAGE EVALUATION
TEST TARGET (MT-3)



MICROCOPY RESOLUTION TEST CHART







BORING

Elevation: 317 feet, MSL
Location: 3rd and Figueroa Street
309 feet west of 234 Figueroa
Data Source: SW-AA (1979b) Figueroa Street Sites
Equipment: Failing 1500 rotary drill; sampling with a SPT split spoon sampler and a pitcher barrel

VELOCITIES

a) Source: SW-AA (1979b) Figueroa Street Sites
Location: Survey performed in above boring
Date: March 30 and 31, 1978

b) Source: Duke, et al. (1971)
Location: Site No. 26; Security Pacific National Bank
800 feet south of 234 Figueroa (176-foot boring)
Date: August 1970

c) Source: Eguchi, et al. (1976)
Location: Site No. 36; Figueroa Street & 3rd Street
300 feet north of 234 Figueroa Street
Date: February 1975

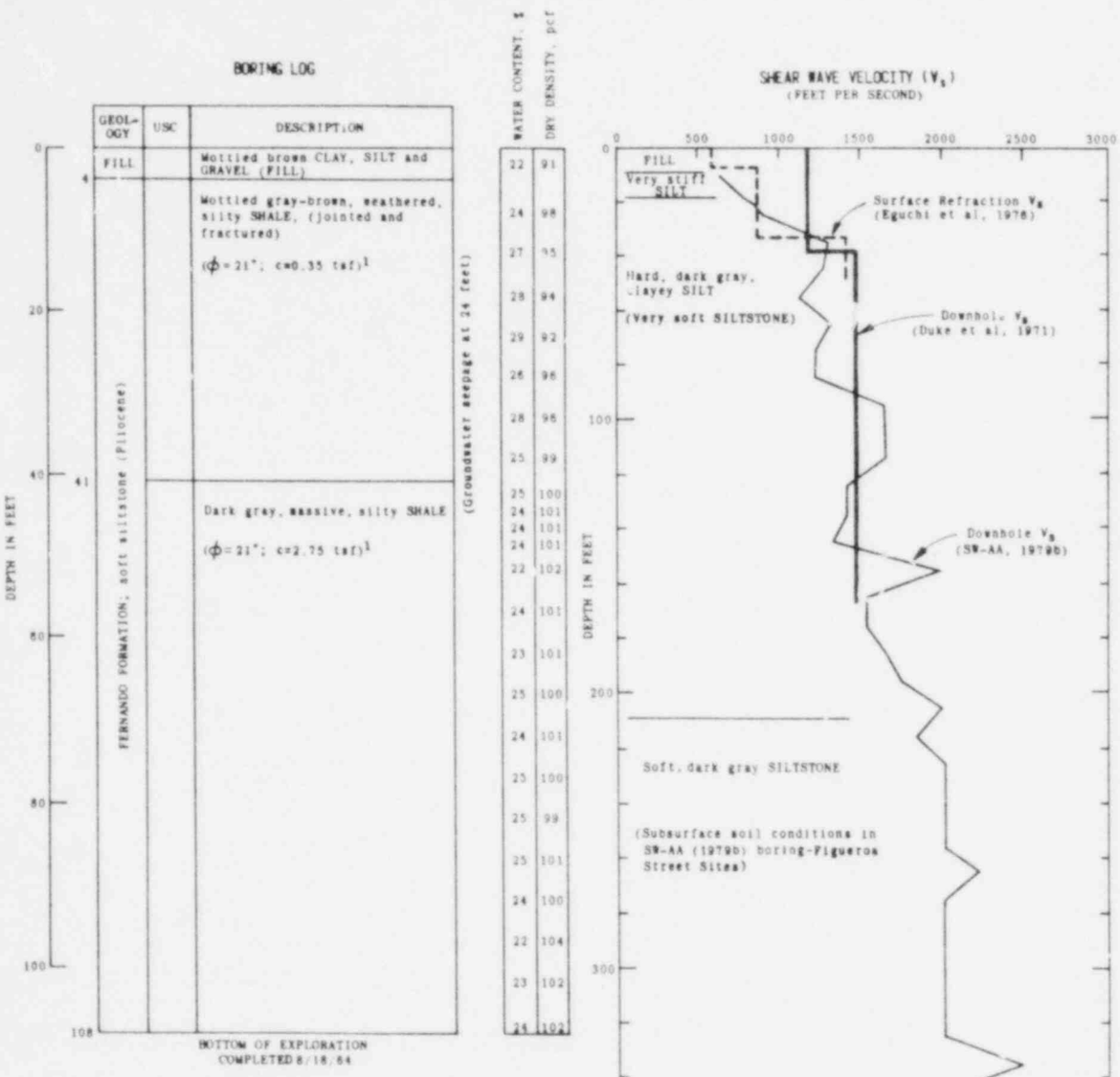
REPORT: SW-AA (1976b, 1979b)

BUILDING: The South Tower of the Bunker Hill Towers (234 Figueroa) is a 17-story high-rise with one basement. The lowest level accelerograph is in the basement, about 10-15 feet below grade.

NOTES: 1) Similarly high values of water content were obtained by LeRoy Crandall and Associates in their foundation investigation for the 234 Figueroa Street building. Equipment used was a bucket auger.

SUMMARY LOG
234 FIGUEROA ST.
LOS ANGELES, CALIFORNIA

FIG. A-30



BORING

Elevation: 328 feet, MSL
Location: 445 Figueroa Street
Data Source: LeMoy Crandall and Associates Foundation Investigation for Union Bank Building Boring B-1 in report (Job No. 64509)
Equipment: Bucket auger

VELOCITIES

a) Source: SW-AA (1979b) Figueroa Street Sites
Location: 3rd & Figueroa Street
1000 feet northeast of 445 Figueroa Street
Date: March 30 and 31, 1978

b) Source: Duke, et al. (1971)
Location: Site No. 26; Security Pacific National Bank
800 feet east of 445 Figueroa (176-foot boring)
Date: August 1970

c) Source: Eguchi, et al. (1978)
Location: Site No. 36; Figueroa & 3rd Street
1200 feet northeast of 445 Figueroa Street
Date: February 1975

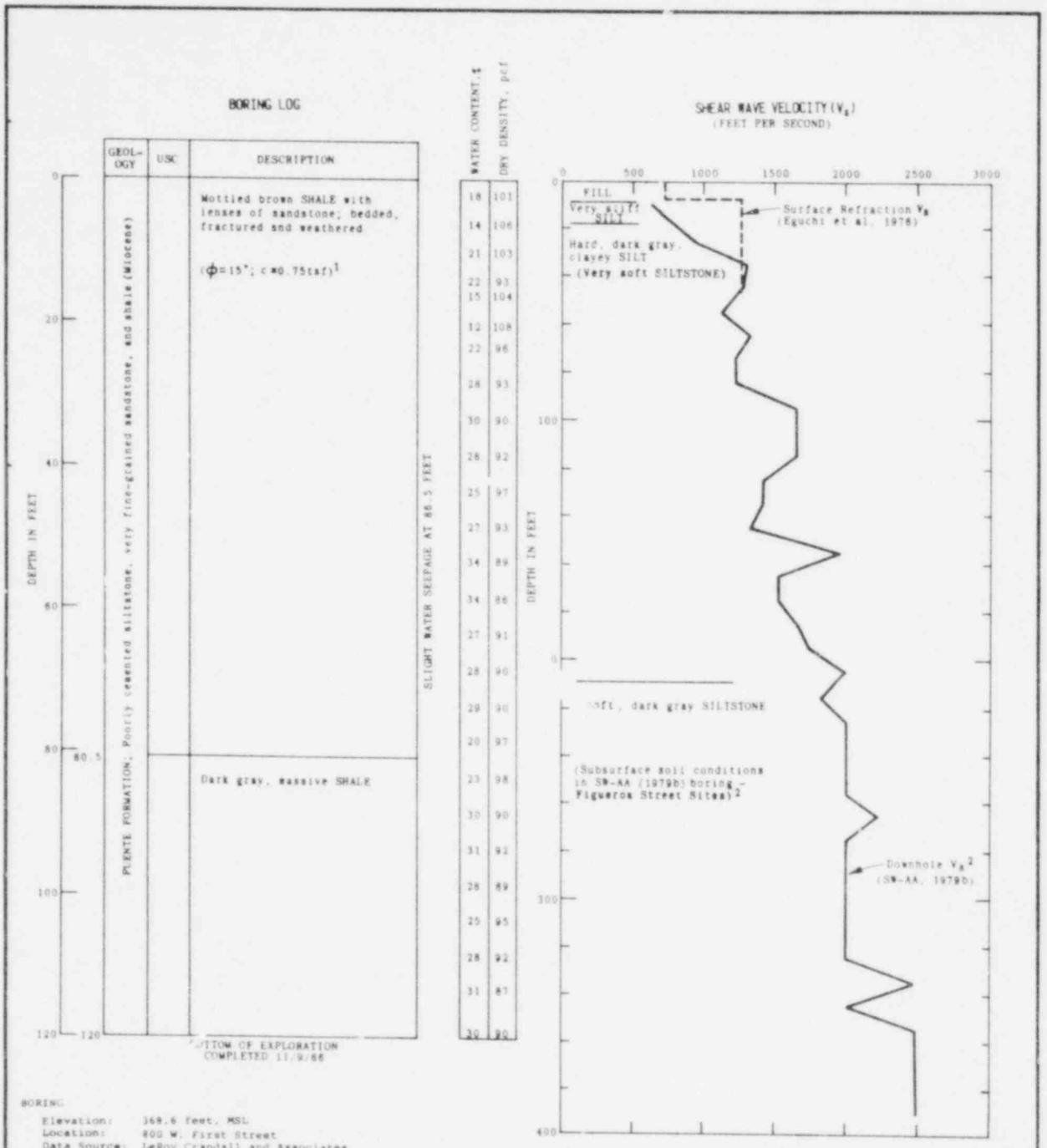
d) Used: SW-AA (1976b, 1979b)

BUILDING: The Union Bank Building (445 Figueroa) is a 40-story high-rise with 3 basements (base is about 40 feet below grade). The lowest level accelerograph is located at the foundation level.

NOTES: 1) Soil properties are from C-U triaxial tests on the "brown" and "gray" shales reported in the foundation investigation for the Union Bank Building.

SUMMARY LOG
445 FIGUEROA ST.
LOS ANGELES, CALIFORNIA

FIG. A-31



BORING:

Elevation: 369.6 feet, MSL
Location: 800 W. First Street
Data Source: LeRoy Crandall and Associates Foundation Investigation for Bunker Hill Tower Boring B-3 in report
Equipment: Bucket auger

VELOCITIES

a) Source: SW-AA (1979b) Figueroa Street Sites
Location: 3rd & Figueroa Street
1100 feet southwest of 800 W. First Street
Date: March 30 and 31, 1978

b) Source: Eguchi, et al. (1976)
Location: Site No. 35; 1st & Hope Street
400 feet east of 800 W. First St.
Date: July 1975

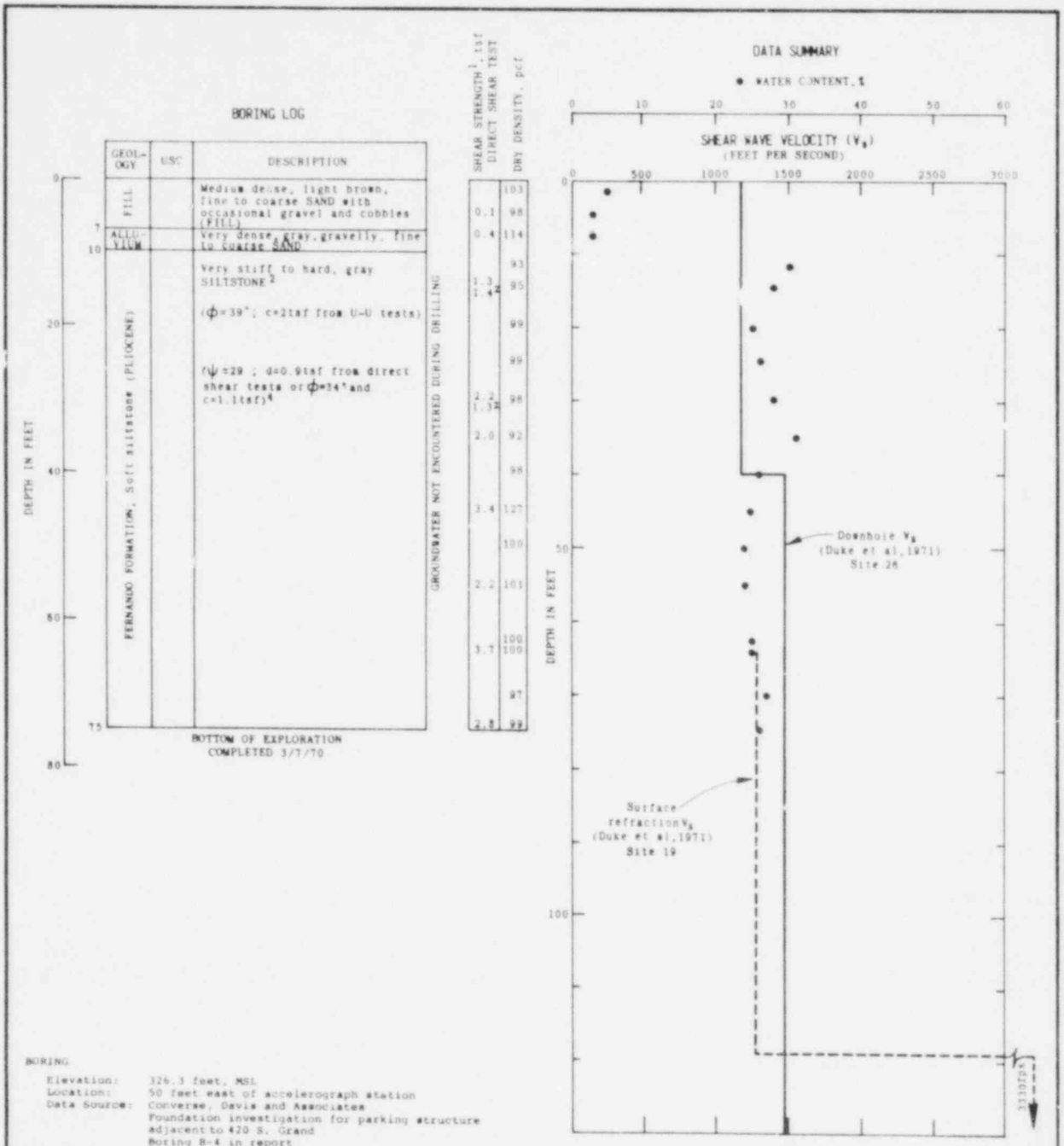
REPORT: SW-AA (1976b; 1979b)

BUILDING: The Center Tower of the Bunker Hill Tower (800 W. First Street) is a 32-story high-rise with no basement. The structure is partially embedded in a hillside, with the northeast entrance on the fourth floor and the southwest entrance on the first floor. The lowest level accelerograph is located on the 1st floor (ground level).

NOTES:
1) Soil properties are from C-U tests reported in the foundation investigation for the Bunker Hill Tower.
2) The SW-AA (1979b) boring was advanced in the lower Fernando Formation rather than the uppermost Puente Formation which underlies the 800 W. First Street building.

SUMMARY LOG
800 W. FIRST ST.
LOS ANGELES, CALIFORNIA

FIG. A-32



BORING

Elevation: 326.3 feet, MSL
Location: 50 feet east of accelerograph station
Data Source: Converse, Davis and Associates Foundation investigation for parking structure adjacent to 420 S. Grand Boring B-4 in report

VELOCITIES

Source: Duke, et al. (1971)
Location: Site No. 26: Security Pacific National Bank 800 feet north of 420 S. Grand (Elevation 368 feet)
Date: August 1970

- Duke, et al. (1971)
- Site No. 19: Subway Terminal Bldg. 300 Feet Southeast of 420 S. Grand (Subway tunnel, Elevation 295 feet)
- August 8, 1970

REPORT SW-AA (1977b)

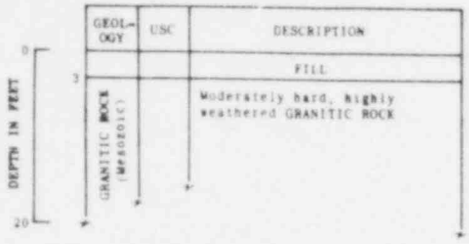
BUILDING The Pacific Telephone Building (420 S. Grand Ave.) is a 16-story high-rise with 14 floors above grade and 2 below. The lowest level accelerograph is located on the 2nd floor (lowest level within building), about 25 feet below street level.

NOTES: 1) Assumes direct shear tests run at overburden pressure.
2) Drained and saturated test.

SUMMARY LOG
420 S. GRAND AVE.
LOS ANGELES, CALIFORNIA

FIG. A-33

LOG [1,2]



VELOCITIES: Not available in the immediate vicinity of the site.[3]

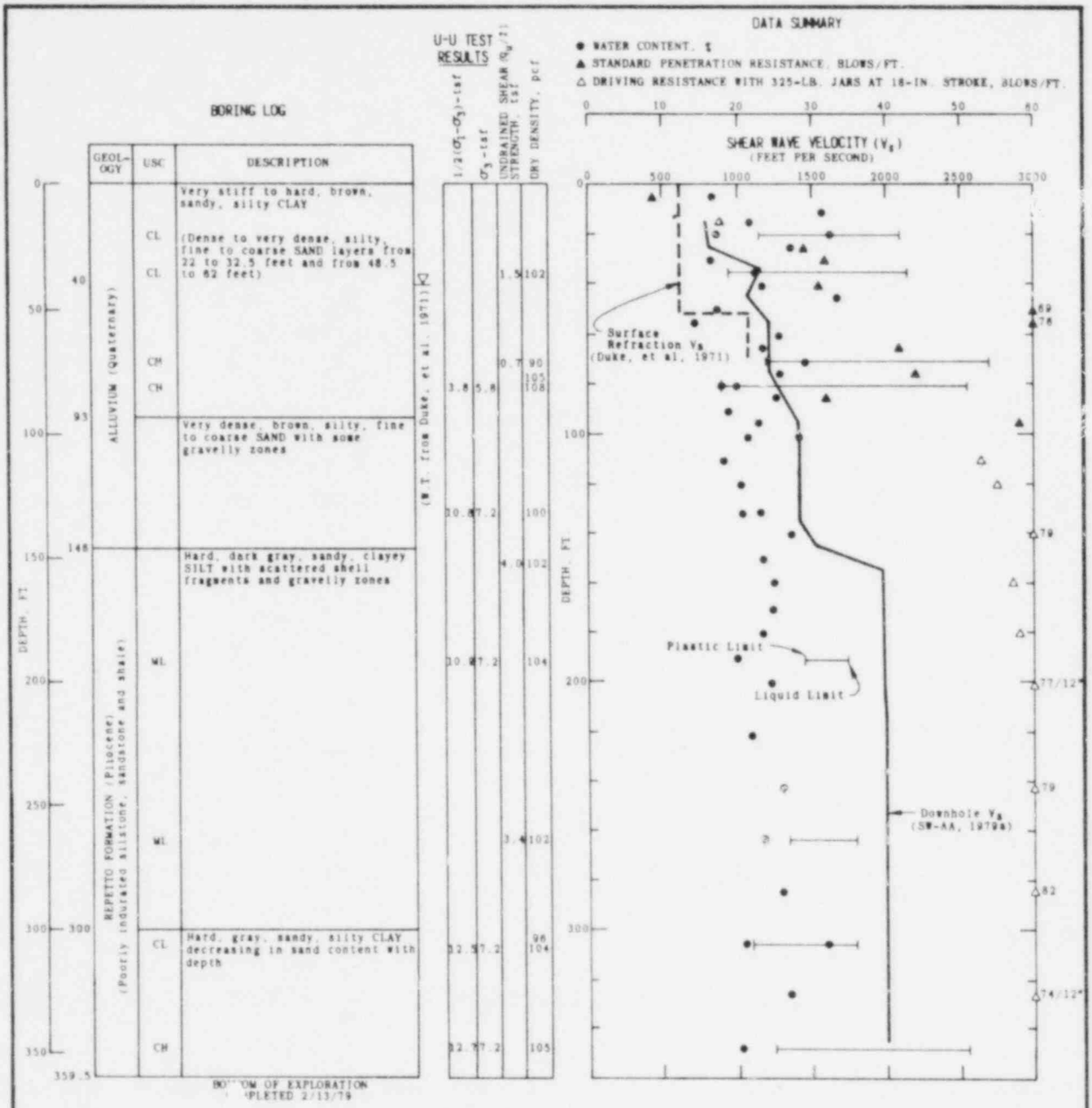
REPORT: SW-AA (1977b)

BUILDING: The Observatory is built directly on granitic rock, with a 2+ or 3-foot fill beneath the instrument slab.

NOTES:
1) No borings were made at the site. Materials indicated on the log were observed in an outcrop during our site reconnaissance (SW-AA, 1977b).
2) The elevation of the observatory is approximately 1120 feet, MSL. (USGS Topographic quad).
3) Duke, et al (1971) obtained surface refraction measurements at a location 1500' East of the Observatory (Site No. 13). From the results of their survey, it is inferred that the rock at site 13 is mantled by about 50 feet of overburden. This does not represent the conditions at the observatory.

SUMMARY LOG
GRIFFITH OBSERVATORY
LOS ANGELES, CALIFORNIA

FIG. A-34



BORING

Elevation: 290 ft. MSL (interpolated from USGS Topo Quad.)

Location: 25 ft. south of the Hollywood Storage Building

Data Source: SW-AA (1979a)

Equipment: Failing 1500 rotary drill; sampling with a 2" O.D. split spoon drive barrel and a pitcher barrel.

VELOCITIES

a) Source: SW-AA (1979a)

Location: Downhole testing performed in above boring

Date: May 23, 1979

b) Source: Duke, et al (1971)

Location: Site No. 14: Santa Monica Blvd. & Hansfield Ave. (300 ft. Northwest of 1025 N. Highland)

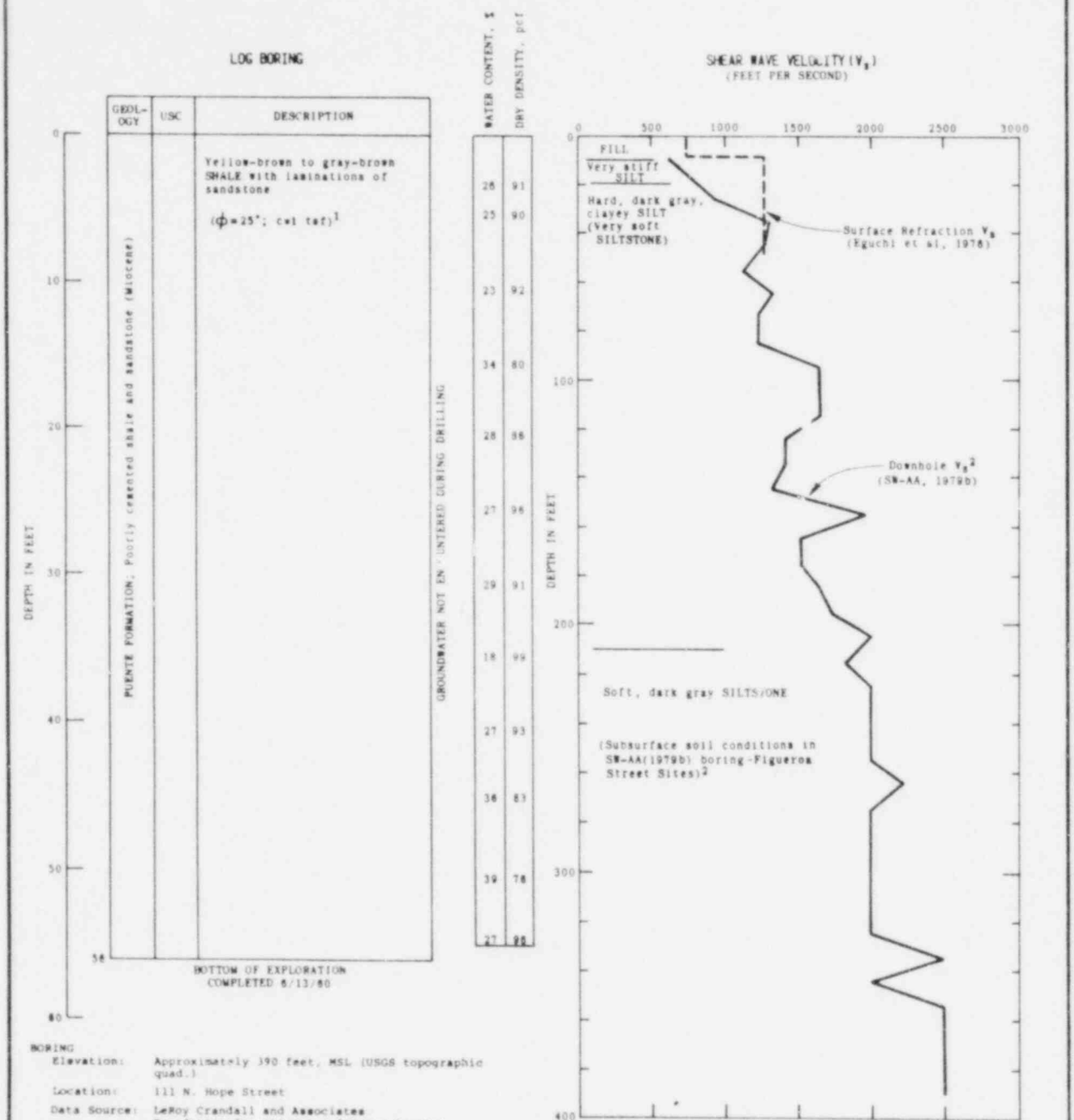
Date: Oct. 19, 1966

REPORT: SW-AA (1979a)

BUILDING: The Hollywood Storage Building (1025 N. Highland Ave.) is a 14-story structure with a basement. Instrumentation at the site includes an accelerograph in the basement (about 12 feet below grade) and an accelerograph in a free field instrument shelter.

SUMMARY LOG
HOLLYWOOD STORAGE BUILDING
1025 N. HIGHLAND AVE.
LOS ANGELES, CALIFORNIA

FIG. A-35



BORING

Elevation: Approximately 390 feet, MSL (USGS topographic quad.)

Location: 111 N. Hope Street

Data Source: LeRoy Crandall and Associates
Foundation Investigation for Los Angeles Water and Power Building
Boring B-7 in report

Equipment: Bucket auger

VELOCITIES

a) Source: SW-AA (1979b) Figueroa Street Sites
Location: 3rd and Figueroa Street
2000 feet Southwest of 111 N. Hope Street
Date: March 30 and 31, 1978

b) Source: Eguchi et al (1976)
Location: Site Number 35: 1st and Hope Street
600 feet Southwest of 111 N. Hope St.
Date: July 1975

REPORT: SW-AA (1976b, 1979b)

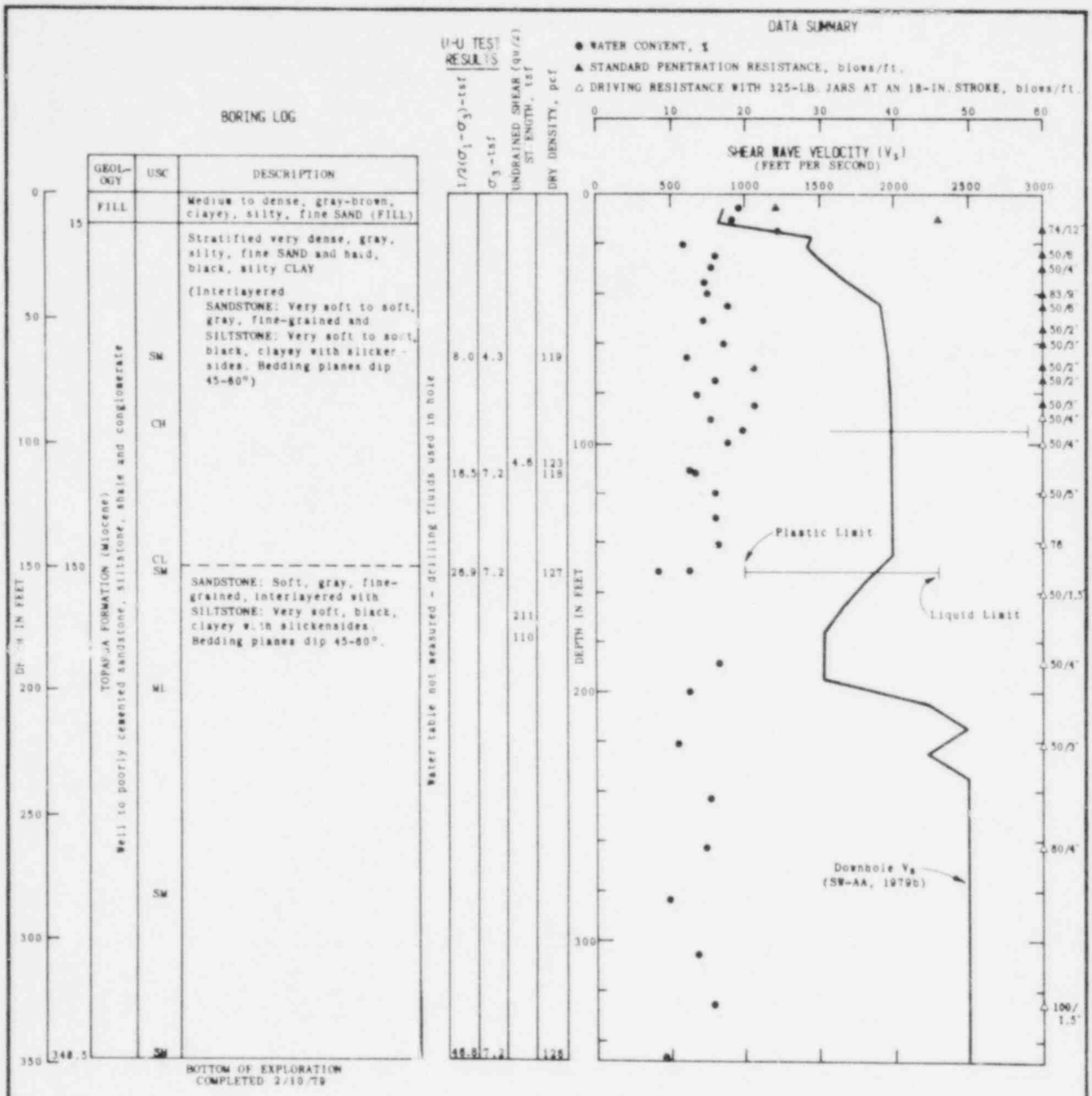
BUILDING: The Los Angeles Water and Power Building (111 N. Hope) is a 15-story high-rise with 2 basements. Foundation level is on the average of 15 feet below grade. The building is founded partially on a cut up to 15 feet deep and partially on a fill up to 15 feet thick. The lowest level accelerograph is located at foundation level (lowest basement).

NOTES: 1) Soil properties are based on triaxial shear data (assumed C-U tests) reported in the foundation investigation for the Los Angeles Water and Power Building.

2) The boring by SW-AA (1979b) was advanced in the lower Fernando Formation rather than the Puente Formation which underlies the Los Angeles Water and Power Building.

SUMMARY LOG
111 N. HOPE ST.
LOS ANGELES, CALIFORNIA

FIG. A-36



BORING

Elevation: 700 feet, MSL (hand leveled referencing 1st floor of bldg.)

Location: 450 feet southeast of the accelerograph at 3838 Lankershim Blvd.

Data Source: SW-AA (1979b)

Equipment: Failing 1500 rotary drill; sampling with a 2" O.D. split spoon drive barrel, Pitcher sampler and an NX core barrel

VELOCITIES

Source: SW-AA (1979b)

Location: Downhole testing performed in above boring

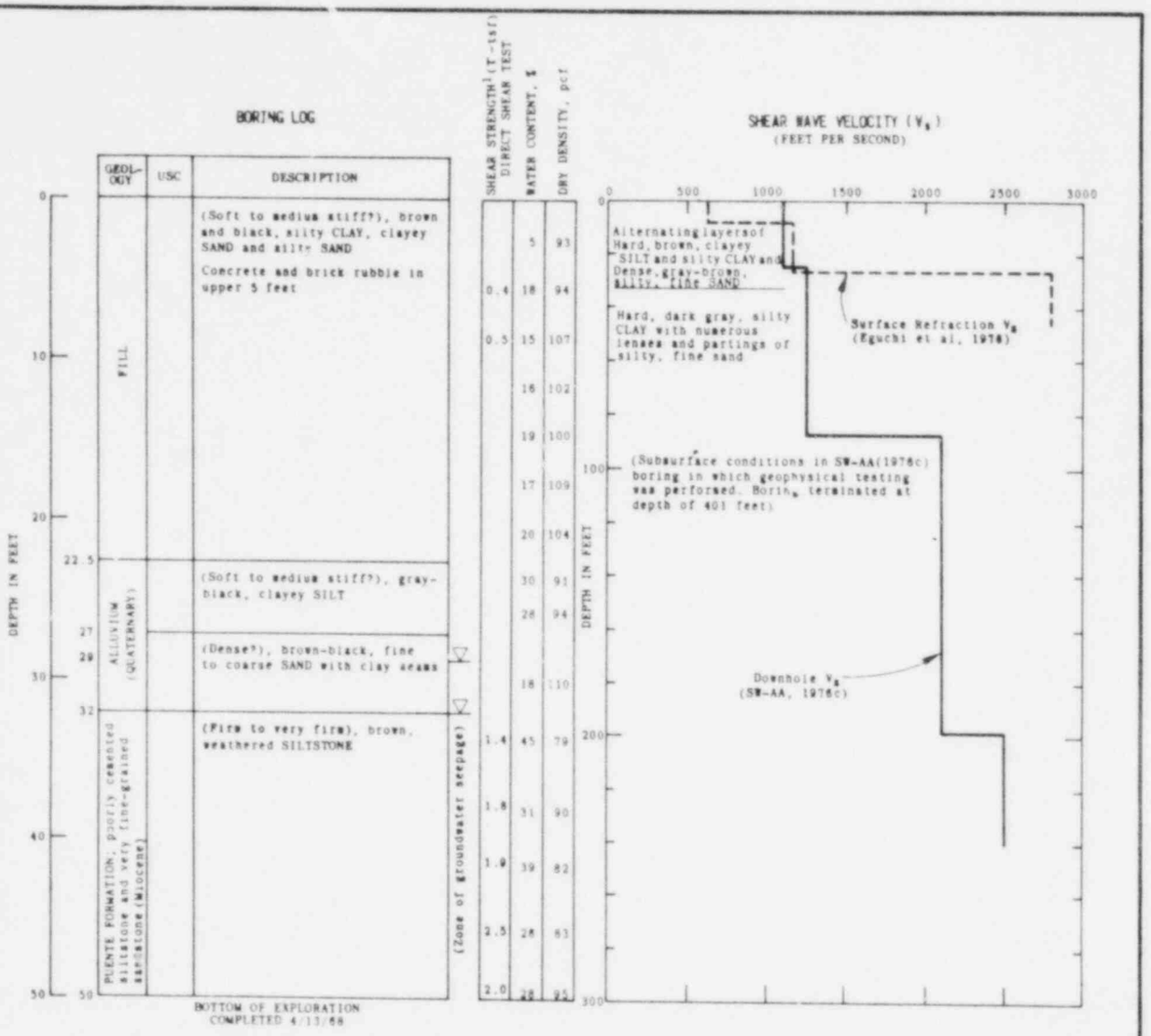
Date: May 24 and 25, 1979

REPORT: SW-AA (1977b, 1979b)

BUILDING: The Sheraton-Universal Motel (3838 Lankershim Blvd.) is a 20-story high-rise with a basement. The lowest level accelerograph is located in the basement, approximately 13 feet below grade.

SUMMARY LOG
3838 LANKERSHIM BLVD.
LOS ANGELES, CALIFORNIA

FIG. A-37



BORING
Elevation: Approximately 220 feet, MSL (USGS Topographic Quad.)
Location: 616 S. Normandie
Data Source: Converse, Davis and Associates
Foundation Investigation for Wilshire Christian Towers
Boring B-1 . Report

VELOCITIES
Source: SW-AA (1976c) Wilshire Blvd. Sites – Eguchi, et al. (1976)
Location: Alexandria and Wilshire Blvd. 700 Feet East of 616 S. Normandie – Site No. 33 - Normandie & 6th Street 600 Feet North of 616 S. Normandie Ave.
Date: October 1975 – August 1975

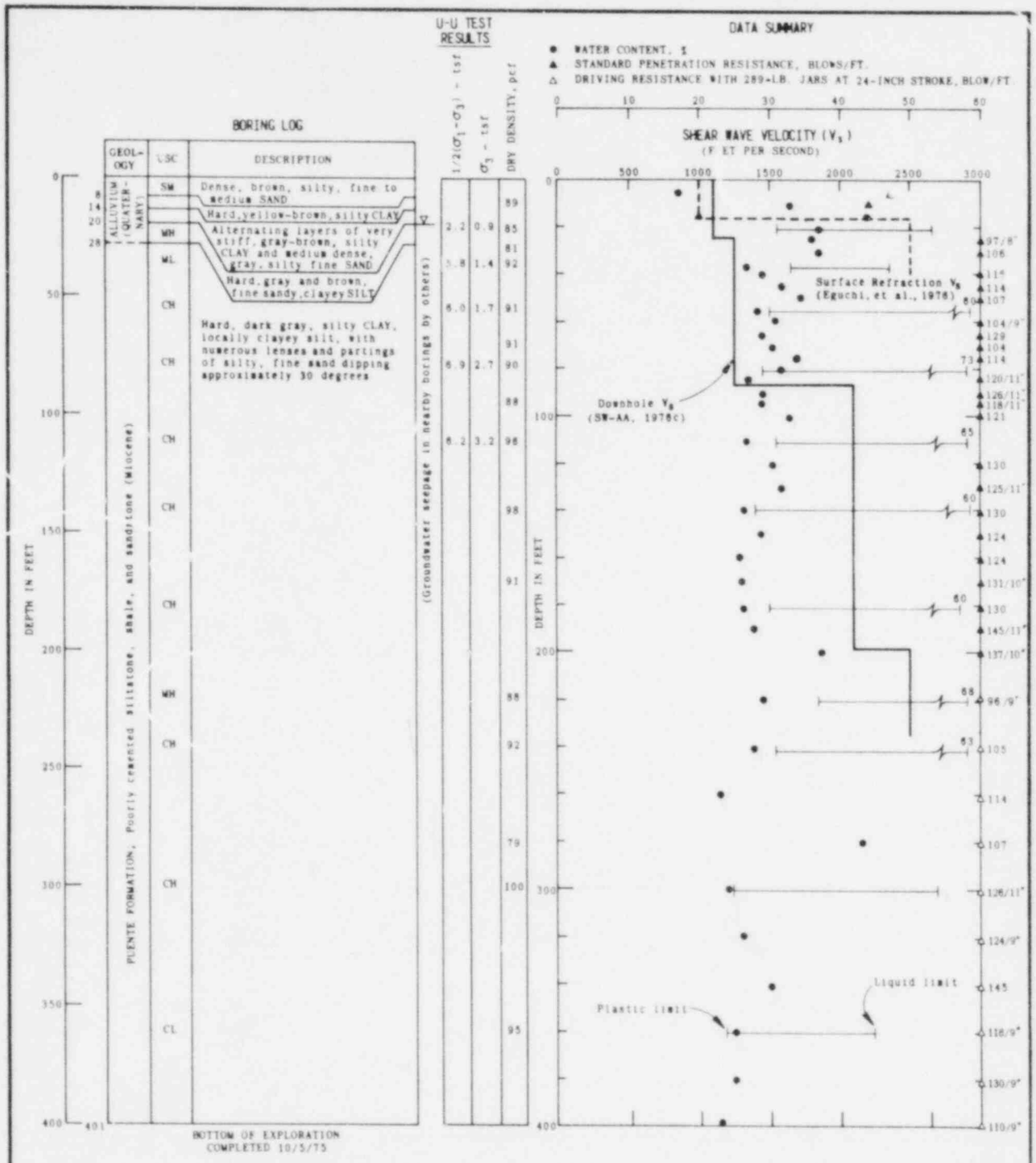
REPORT SW-AA (1976b)

BUILDING The Wilshire Christian Manor (616 S. Normandie) is a 17-story high-rise with one basement. The lowest level accelerograph is in the basement, about 10 - 15 feet below grade.

NOTES: 1) Shear strengths from direct shear tests run at overburden pressures (assumed). Denoted on log that samples below 30 feet sheared at reduced normal load.

SUMMARY LOG
616 S. NORMANDIE AVE.
LOS ANGELES, CALIFORNIA

FIG. A-38



BORING

Elevation: 213 feet, MSL

Location: Wilshire & Alexandria (600 feet Southwest of 3407 W. Sixth Street)

Data Source: SW-AA (1976c) Wilshire Blvd. Sites

Equipment: Failing 1500 Rotary Drill: Sampling with a 2" O.D. SPT Split Spoon and a Pitcher Barrel

VELOCITIES

a) Data Source: SW-AA (1976c) Wilshire Blvd. Sites

Location: Survey perfo[illegible] 4 in above boring

Date: October 1975

b) Data Source: Eguchi et al. (1 76)

Location: Site No. 32 - Ambassador Hotel 1400 feet South of 3407 W. Sixth Street

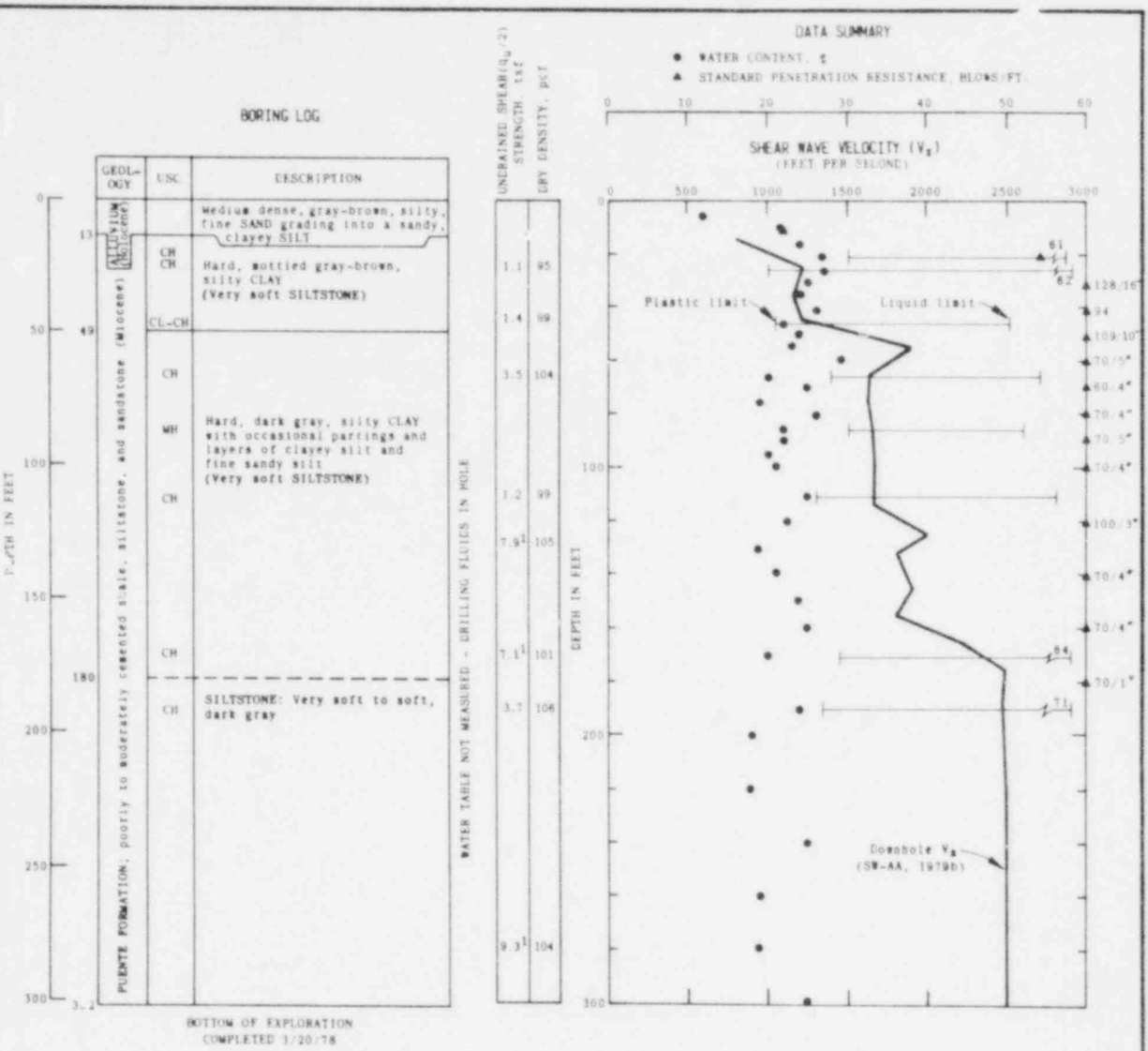
Date: August 1[illegible]

REPORT SW-AA (1976c)

BUILDING The Mutual Bldg. (3407 W. Sixth Street) is an 8-story high-rise founded at grade. The lowest level accelerograph is at grade level.

SUMMARY LOG
3407 W. SIXTH ST.
LOS ANGELES, CALIFORNIA

FIG. A-39



BORING

Elevation: 382 feet, MSL

Location: 250 feet northwest of the accelerograph at 4867 Sunset Blvd.

Data Source: SW-AA (1979b)

Equipment: Failing 1500 rotary drill; sampling with a SPT split spoon and a pitcher barrel

VELOCITIES

Data Source: SW-AA (1979b)

Location: Testing performed in above boring

Date: March 29, 1978

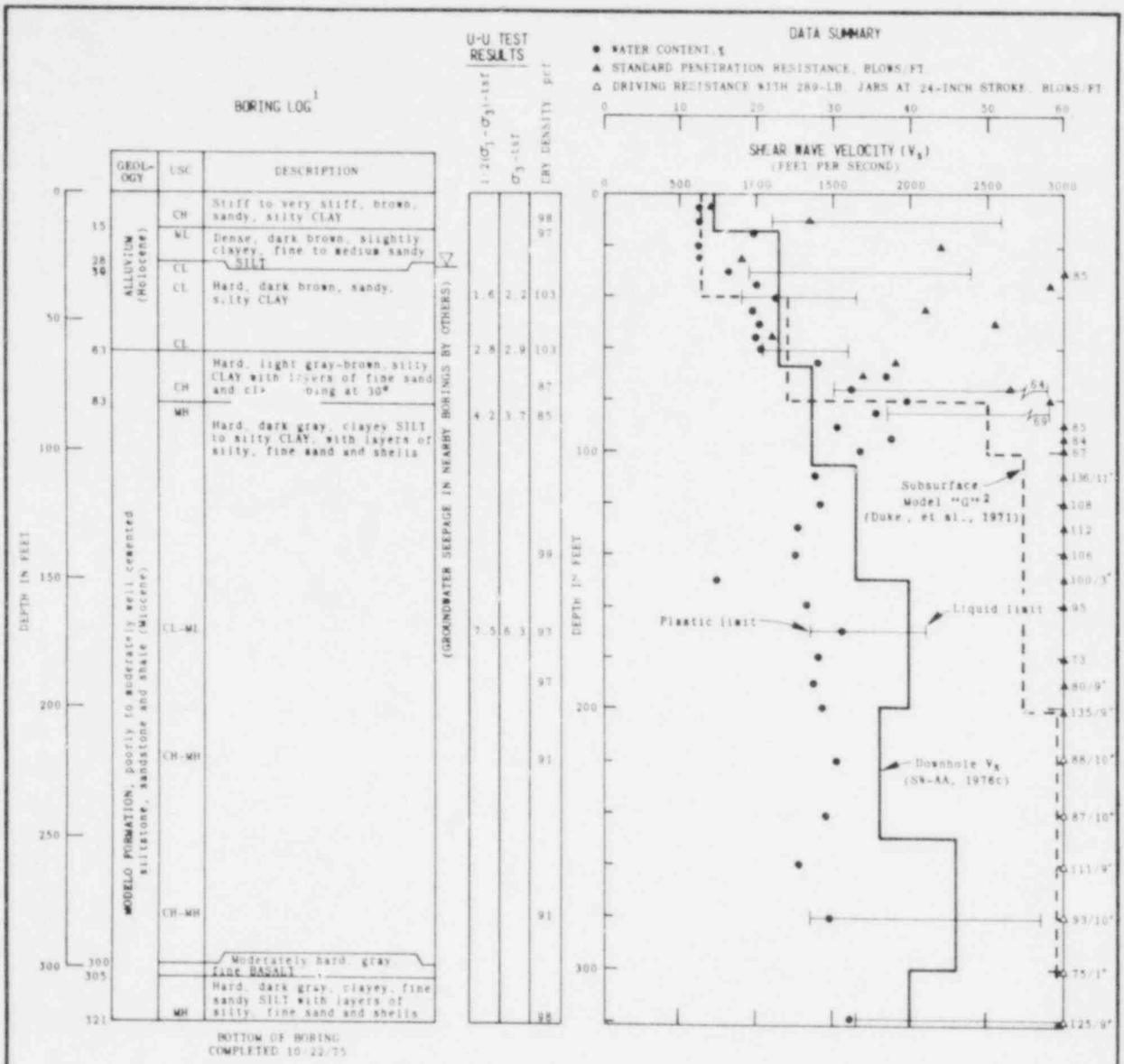
REPORT: SW-AA (1977b, 1979b)

BUILDING: The Kaiser Foundation Hospital (4867 Sunset Blvd.) is an 8-story structure with one deep basement (extends 16 feet below grade). The lowest level accelerograph is located in the basement.

NOTES: 1) Shear strengths are atypically high for material and are generally associated with brittle failure. This occurrence may be partially due to the sampling technique.

SUMMARY LOG
4867 SUNSET BLVD.
LOS ANGELES, CALIFORNIA

FIG. A-40



BORING

Elevation: 717.5 feet, MSL

Location: Dickens Street and Sepulveda Blvd. (3,700 feet west of 14724 Ventura Blvd.)

Data Source: SW-AA (1976c) Ventura Blvd. sites

Equipment: Failing 1500 rotary drill; sampling with a 2" O.D. SPT split spoon sampler and a pitcher barrel

VELOCITIES

Data Source: SW-AA (1976c) Ventura Blvd. sites - Duke et al (1971)

Location: Survey performed in above boring - Subsurface model "G" developed for 15431 Ventura Blvd. (approximately 4400 feet west of 14724 Ventural Blvd.)[2]

Date: October 1975 - August 1971

REPORT: SW-AA (1976c)

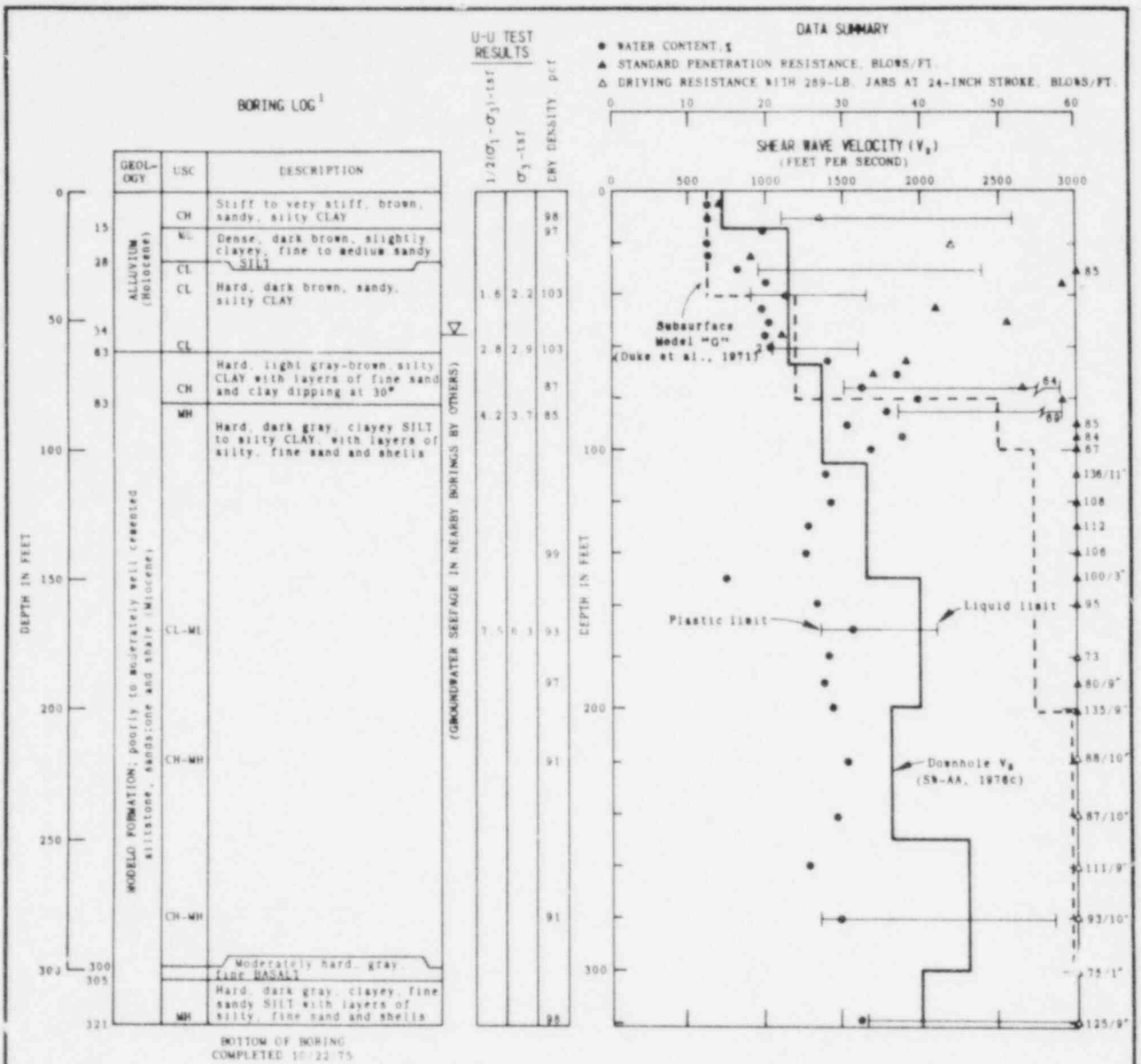
BUILDING: The Certified Life Buildings (14724 Ventura Blvd.) is a 14-story high-rise founded at grade on a pile foundation (41-foot piles). The lowest level accelerograph is located on the ground floor.

NOTES: 1) Borings of Converse Foundation Engineers at 14800 Ventura Blvd. (Ventura and Keater) indicate 70 to 80 feet of alluvium (clays and silts) overlying the Modelo Formation.

2) Velocities to 50 feet were measured at Libbit and Addison Street in Encino (Site 11 - approximately 10,900 feet northwest of 14724 Ventura Blvd.). Velocities below 50 feet were estimated from site geology.

SUMMARY LOG
14724 VENTURA BLVD.
LOS ANGELES, CALIFORNIA

FIG. A-41



BORING

Elevation: 713.5 feet, MSL

Location: Dickens Street and Sepulveda Boulevard (250 feet Southwest of 15250 Ventura Boulevard)

Data Source: SW-AA (1976c) Ventura Boulevard Sites

Equipment: Failing 1500 rotary drill; sampling with a 2" O.D. SPT split spoon sampler and a pitcher barrel

VELOCITIES

Data Source: SW-AA (1976c) Ventura Boulevard Sites - Duke, et al (1971)

Location: Survey performed in above boring - Subsurface model "G" developed for 1541 Ventura Blvd. (approximately 1400 feet west of 15250 Ventura Blvd.)[2]

Date: October 1975 - August 1971

REPORT SW-AA (1976c)

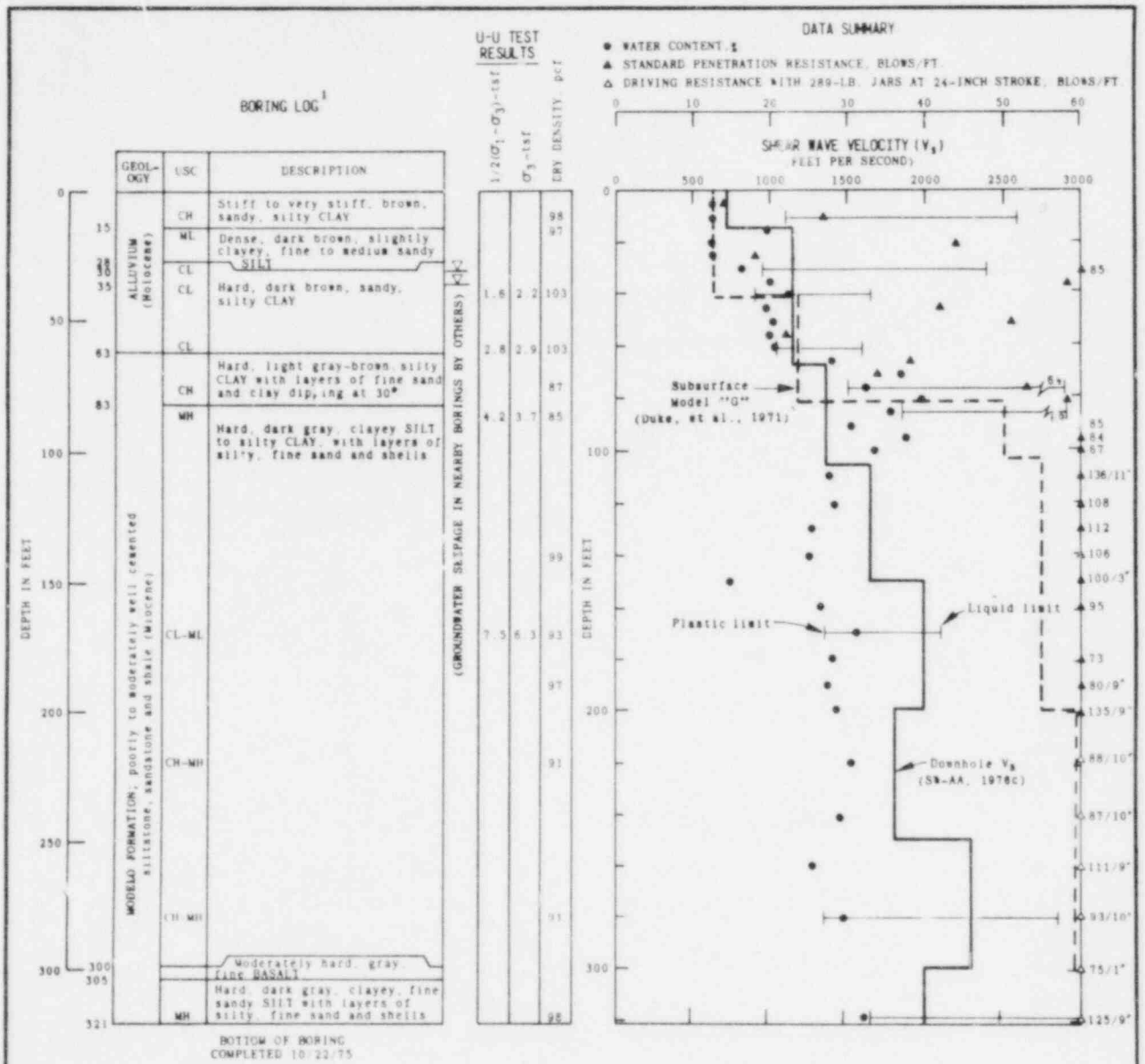
BUILDING The Bank ... California Building (15250 Ventura Boulevard) is a 12-story high-rise founded at grade on a pile foundation (35-50 foot piles). The lowest level accelerograph is located in a partial basement which extends about 10 feet below ground level.

NOTES: 1) Borings of LeRoy Crandall and Associates for the Union Bank (15233 Ventura Boulevard) encountered 63 feet of alluvium overlying the Modelo Formation. Water was encountered at a depth of about 45 feet (February 21, 1964).

2) Velocities to 50 feet were measured at Libbit and Addison Street in Encino (Site 11 - approximately 8100' N.W. of 15250 Ventura Blvd.). Velocities below 50 feet were estimated from site geology.

SUMMARY LOG
15250 VENTURA BLVD.
LOS ANGELES, CALIFORNIA

FIG. A-42



BORING

Elevation: 713.5 feet, MSL

Location: Dickens Street and Sepulveda Boulevard (4200 feet East of 15910 Ventura Boulevard)

Data Source: SW-AA (1976c) Ventura Boulevard sites

Equipment: Failing 1500 rotary drill; sampling with a 2" O.D. SPT split spoon sampler and a pitcher barrel

VELOCITIES

Data Source: SW-AA (1976c) Ventura Boulevard sites - Duke et al (1971)

Location: Survey performed in above boring - Subsurface model "G" developed for 15433 Ventura Blvd. (approximately 3100 feet east of 15910 Ventura Blvd.)[2]

Date: October 1975 - August 1971

REPORT SW-AA (1976c)

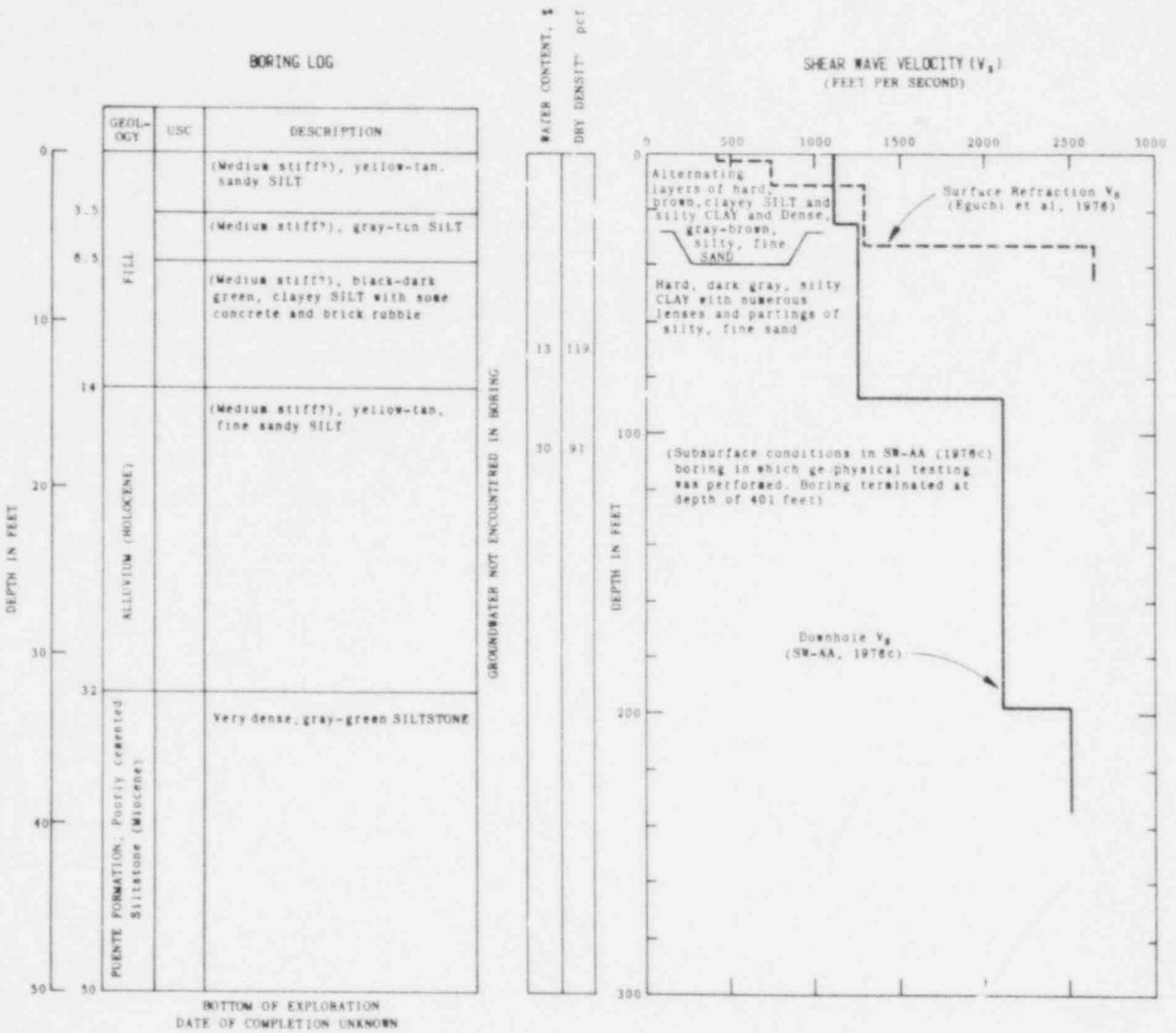
BUILDING The KB Valley Center Building (15910 Ventura Boulevard) is a 16-story high-rise with one basement (13 feet below grade). The building is supported on piles 54 feet long. The lowest level accelerograph is located in the basement.

NOTES: 1) Borings by R. T. Frankian and Associates drilled at 15910 Ventura Blvd. terminated at 71 feet and did not encounter the Modelo Formation.

2) Velocities to 50 feet were measured at Libbit and Addison Street in Encino (Site 11 - approximately 3500 feet northwest of 15910 Ventura Blvd.). Velocities below 50 feet were estimated from site geology.

SUMMARY LOG
15910 VENTURA BLVD.
LOS ANGELES, CALIFORNIA

FIG. A-43



BORING

Elevation: Approximately 296 feet, MSL (USGS topographic quad.)

Location: 2500 Wilshire Boulevard

Data Source: R.T. Frankian and Associates
Soils Exploration for Wilshire-Coronado Building
Boring B-4 in report

VELOCITIES

Source: SW-AA (1976c) Wilshire Boulevard sites - Eguchi et al (1976)

Location: 5000 feet West of 2500 Wilshire Blvd. - Site Number 31, MacArthur Park 700 feet East of 2500 Wilshire Blvd.

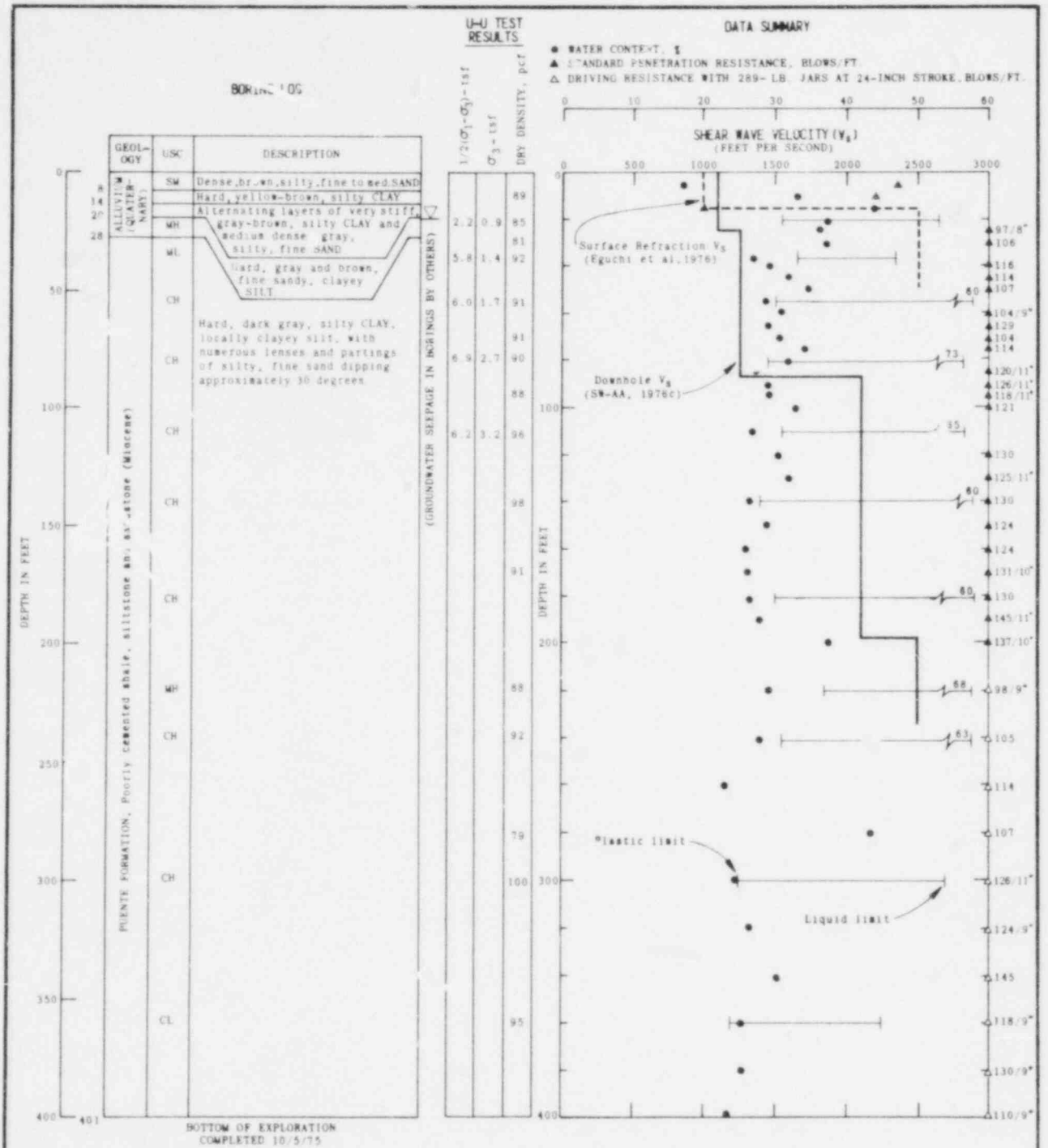
Date: October 1975 - July 1975

REPORT SW-AA (1976b)

BUILDING The Wilshire-Coronado Buildi[illegible] 7500 Wilshire Boulevard) is a 13-story hig[illegible]e with one basement. The lowest level ac[illegible] seismograph is in the basement, about 10-15 f[illegible]et below grade.

SUMMARY LOG
2500 WILSHIRE BLVD.
LOS ANGELES, CALIFORNIA

FIG. A-44



BORING

Elevation: 213 feet, MSL
Location: Wilshire and Alexandria (500 feet Northwest of 3345 Wilshire Boulevard)
Data Source: SW-AA (1976c) Wilshire Boulevard site
Equipment: Failing 1500 Rotary drill; sampling with a 2" O.D. SPT split spoon and a Pitcher barrel

VELOCITIES

a) Source: SW-AA (1976c) Wilshire Boulevard sites
Location: Survey performed in above boring
Date: October 1975

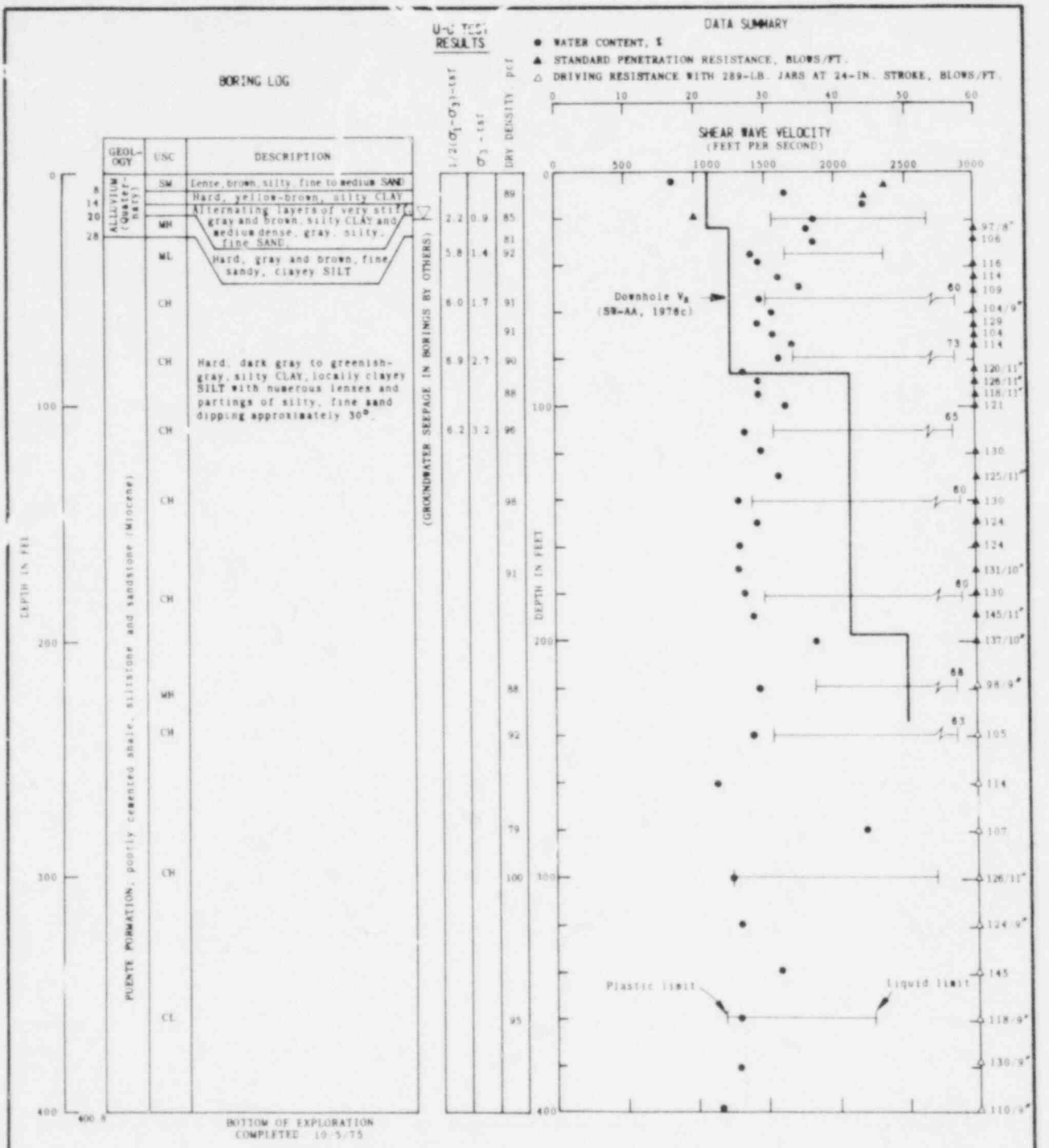
b) Source: Eguchi et al (1976)
Location: Site Number 32; Ambassador Hotel, 700 feet South of 3345 Wilshire Boulevard
Date: August 1975

REPORT SW-AA (1976c)

BUILDING The Wilshire Square Building (3345 Wilshire) is a 12-story high rise with 3 levels of basement parking (base is about 25 feet below grade). The lowest level accelerograph is located in the "A" basement, 2 floors above foundation level.

SUMMARY LOG
3345 WILSHIRE BLVD.
LOS ANGELES, CALIFORNIA

FIG. A-45



BORING

Elevation: 213 feet, MSL

Location: Alexandria and Wilshire Blvd. 300 feet NE of 3411 Wilshire Blvd.

Data Source: SW-AA (1976c) Wilshire Blvd. Sites

Equipment: Failing 1500 rotary drill sampling with a 2" O.D. split spoon and a Pitcher barrel

VELOCITIES

Data Source: SW-AA (1976c) Wilshire Blvd. sites

Location: Survey performed in above boring

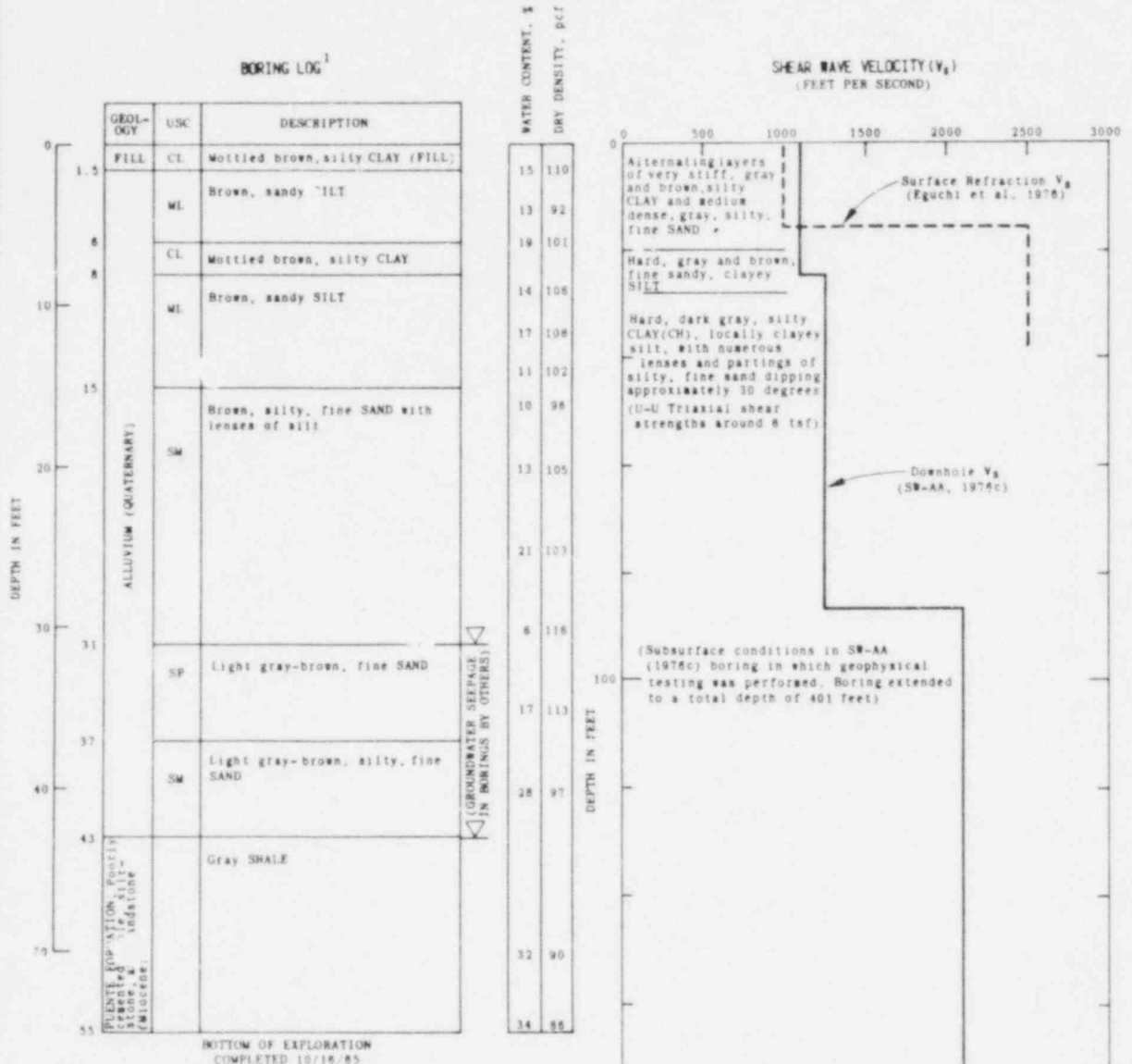
Date: October 1975

REPORT SW-AA (1976b)

BUILDING The Equitable Life Assurance Plaza Bldg. (3411 Wilshire) is a 31-story high-rise with 5 basements. The lowest level accelerograph is located at the foundation level (60-70 feet below grade).

SUMMARY LOG
3411 WILSHIRE BLVD.
LOS ANGELES, CALIFORNIA

FIG. A-46



BORING

Elevation: 209.1 feet, MSL
Location: 3470 Wilshire Blvd.
Data Source: LeRoy Crandall and Associates Foundation Investigation for 3470 Wilshire Boulevard Building Boring B-5 in report
Equipment: Bucket auger

VELOCITIES

a) Source: SW-AA (1976c) Wilshire Boulevard sites
Location: Wilshire and Alexandria (1100 feet Northeast of 3470 Wilshire Blvd.
Date: October 1975

b) Source: Eguchi et al (1976)
Location: Site Number 12 Ambassador Hotel 1200 feet East of 3470 Wilshire Blvd.
Date: August 1975

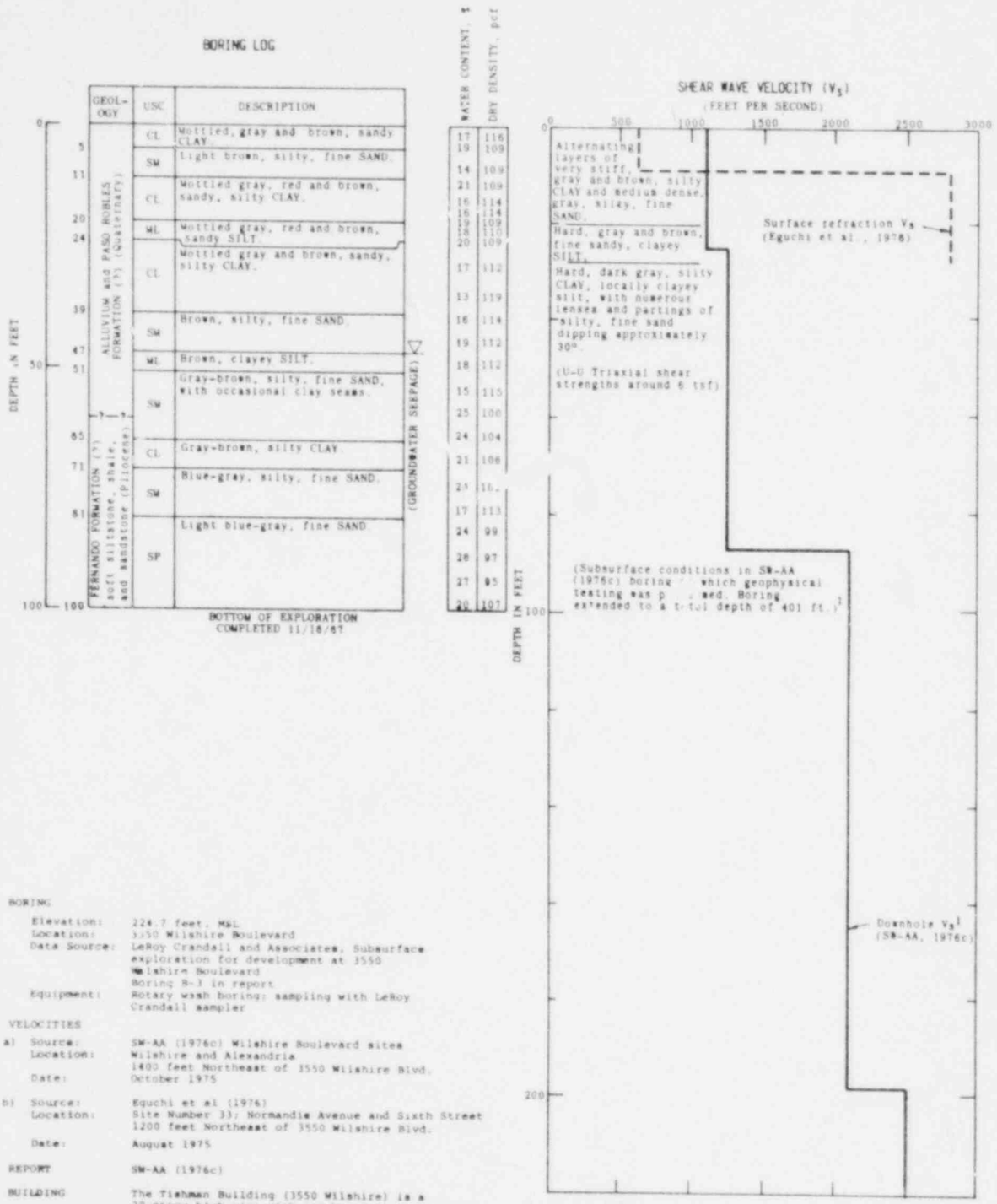
REPORT SW-AA (1976c)

BUILDING The Pacific Telephone Building (3470 Wilshire Boulevard) is a 12-story high rise, with one basement, which extends about 10 feet below grade. The lowest level accelerograph is located in the basement.

NOTES: 1) The Foundation Investigation report mentions that the alluvial soils are moderately firm to firm (medium stiff or medium dense) and that the shale is very firm. From direct shear data on overburden soils ϕ=16°; d=0.28 taf (ϕ=17°; c=0.29 taf) Direct shear data on the shale indicates ϕ=26°; d=0.65 taf (ϕ=29°; c= 0.74 taf).

SUMMARY LOG
3470 WILSHIRE BLVD.
LOS ANGELES, CALIFORNIA

FIG A-47



BORING

Elevation:	224.7 feet, MSL
Location:	3550 Wilshire Boulevard
Data Source:	LeRoy Crandall and Associates, Subsurface exploration for development at 3550 Wilshire Boulevard Boring B-3 in report
Equipment:	Rotary wash boring; sampling with LeRoy Crandall sampler

VELOCITIES

a) Source: SW-AA (1976c) Wilshire Boulevard sites
Location: Wilshire and Alexandria 1400 feet Northeast of 3550 Wilshire Blvd.
Date: October 1975

b) Source: Eguchi et al (1976)
Location: Site Number 33; Normandie Avenue and Sixth Street 1200 feet Northeast of 3550 Wilshire Blvd.
Date: August 1975

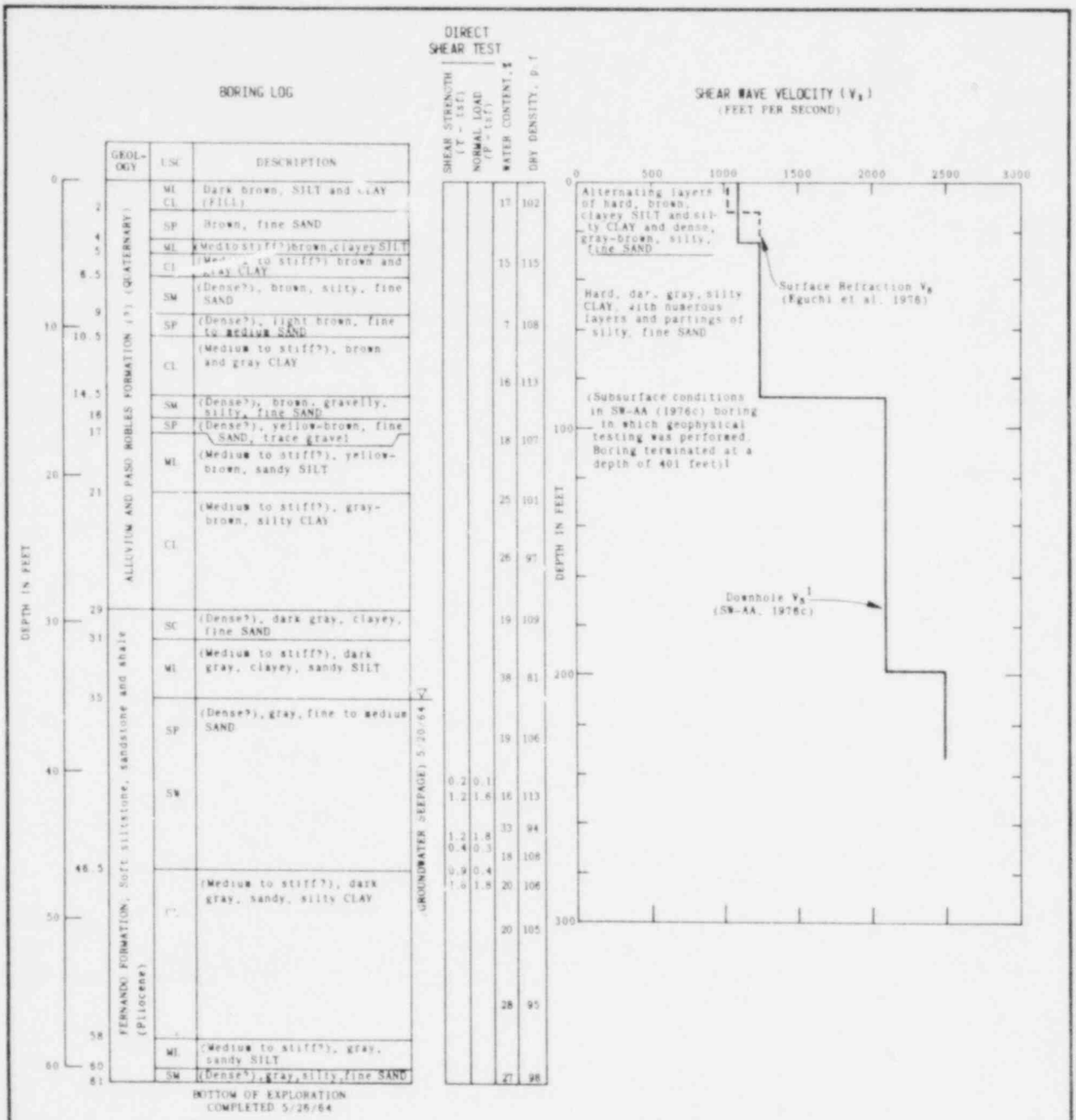
REPORT: SW-AA (1976c)

BUILDING: The Tishman Building (3550 Wilshire) is a 20-story high-rise with one basement, which extends about 10 feet below grade. The lowest level accelerograph is located in the basement.

NOTES: 1) The boring by SW-AA (1976c) was advanced in the Puente Fm. rather than the Fernando Fm. which underlies 3550 Wilshire.

SUMMARY LOG
3550 WILSHIRE BLVD.
LOS ANGELES, CALIFORNIA

FIG. A-48



BORING

Elevation: 208.8 feet, MSL
Location: 3710 Wilshire Boulevard
Data Source: LeRoy Crandall and Associates Foundation Investigation for Beneficial Life Building (3710 Wilshire) Boring B-5 in report
Equipment: Bucket auger 0-38 feet; 6 inch diameter rotary wash 38-61 feet

VELOCITIES

a) Source: SW-AA (1976c) Wilshire Boulevard sites
Location: Alexandria and Wilshire Boulevard 3000 feet East of 3710 Wilshire Boulevard
Date: October 1975

b) Source: Eguchi et al (1976)
Location: Site Number 41 - 3710 Wilshire, 300 feet South of 3710 Wilshire Blvd. building
Date: August 1975

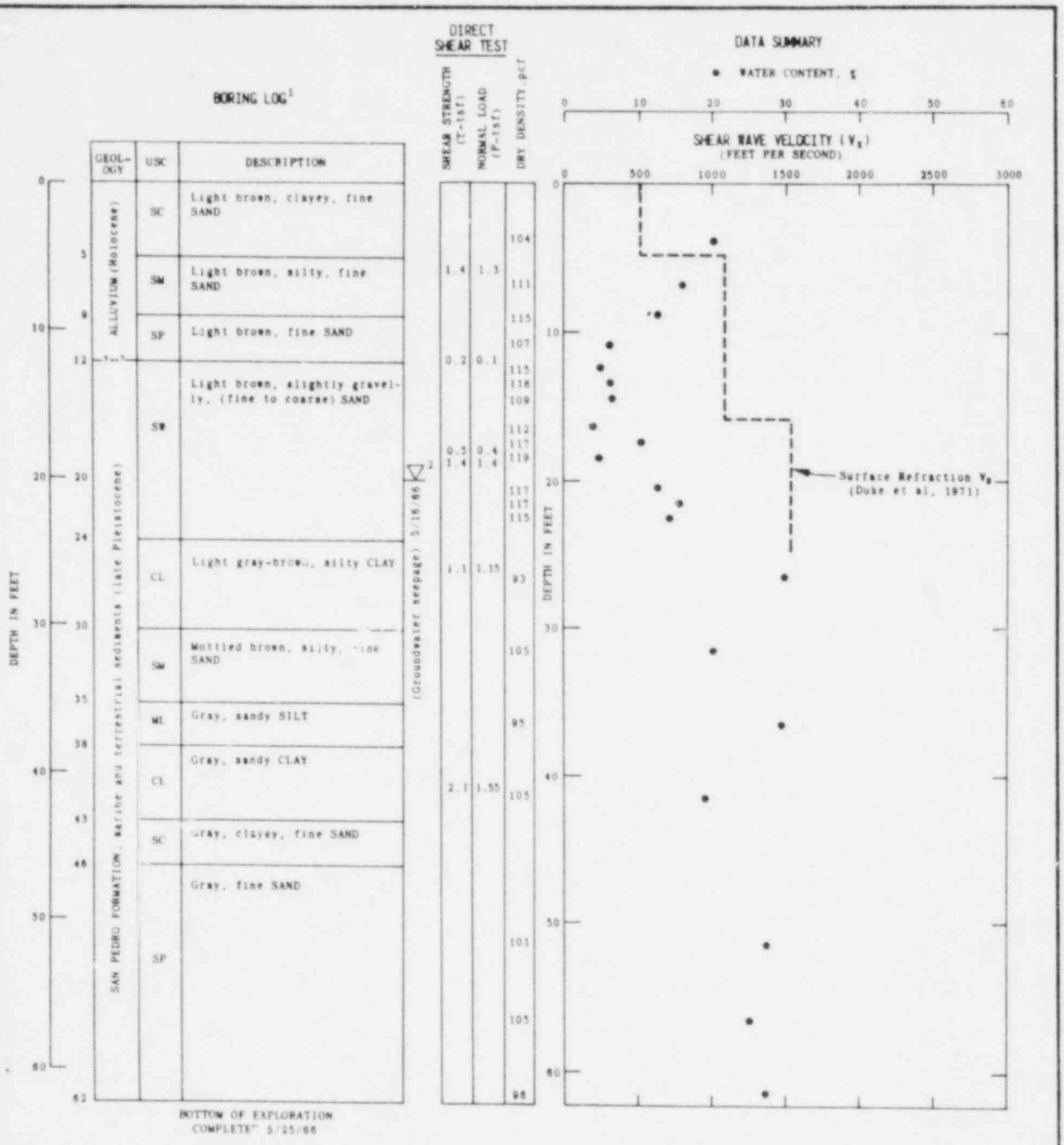
REPORT SW-AA (1976b)

BUILDING The Beneficial Plaza Building (3710 Wilshire Boulevard) is an 11-story structure with three basements, the lowest of which is about 35 feet below grade. The lowest level accelerograph is located at the foundation level.

NOTES: 1) The boring by SW-AA (1976c) was advanced in Puente Fm. rather than the Fernando Fm. which underlies Wilshire Blvd.

SUMMARY LOG
3710 WILSHIRE BLVD.
LOS ANGELES, CALIFORNIA

FIG. A-49



BORING

Elevation: Approximately 205 feet, MSL (USGS topographic quad.)

Location: 25 feet East of 4680 Wilshire Boulevard Building

Data Source: LeRoy Crandall & Associates
Soil investigation for 4680 Wilshire Boulevard Building addition
Boring B-1 in report

Equipment: Bucket auger drill to 23 feet; 6 inch diameter rotary wash 23 to 62 feet

VELOCITIES

Source: Duke et al (1971)

Location: Site Number 16, 4600 Wilshire Boulevard
300 feet North of 4680 Wilshire Boulevard

Date: August 25, 1971

REPORT: SW-AA (1976b)

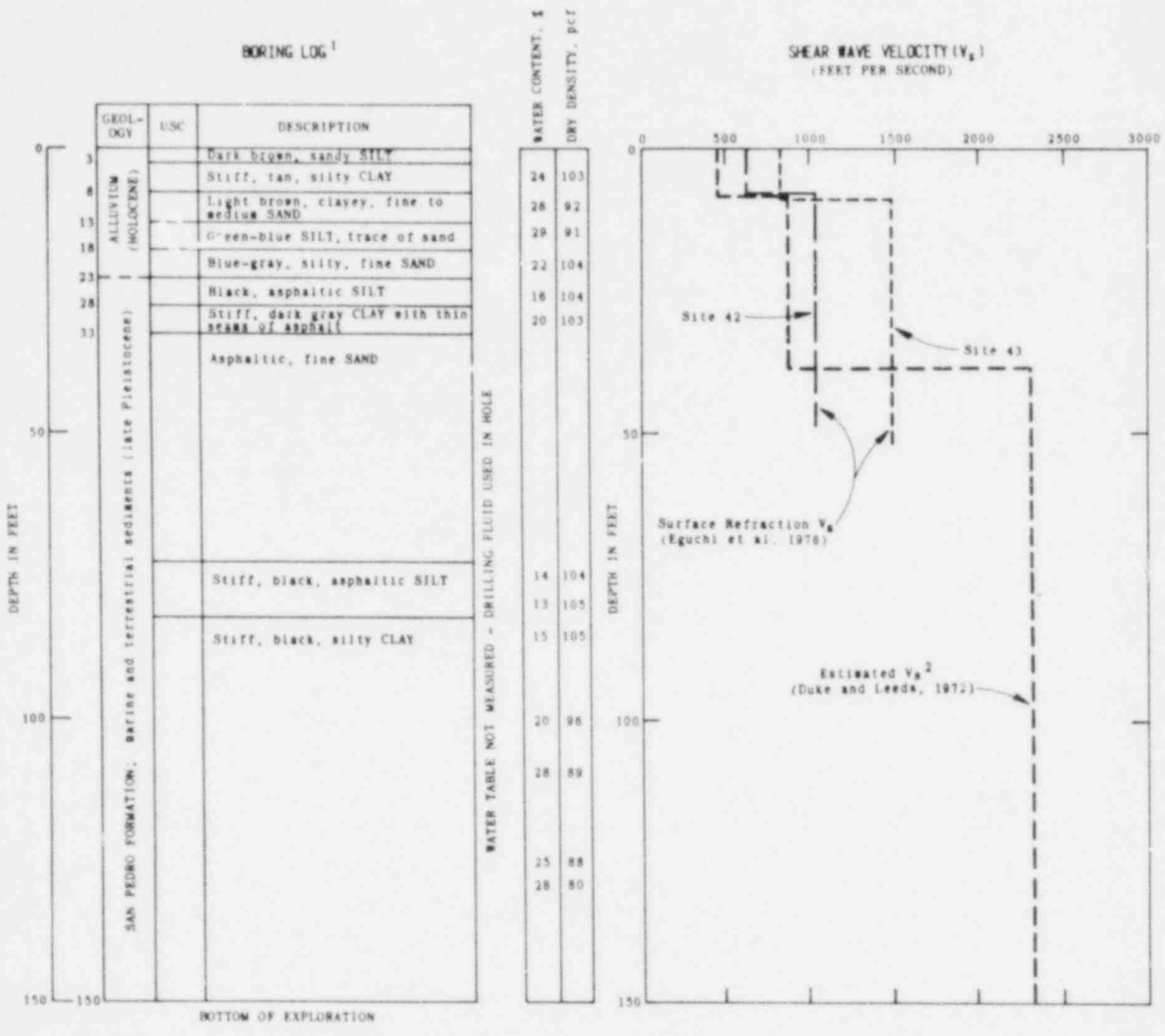
BUILDING: The Farmers Insurance Building (4680 Wilshire Boulevard) is a 7-story structure with one basement. The lowest level accelerograph is in the basement (about 10 feet below grade).

NOTES: 1) The Pico (Fernando) Fm. may be at a depth of 100 feet based on Duke & Leeds (1972) site 8 - Hancock Park, 5801 Wilshire (7600 feet west of 4680 Wilshire).

2) Groundwater table at 155 feet based on LACFCD data (Duke, et al, 1971).

SUMMARY LOG
4680 WILSHIRE BLVD.
LOS ANGELES, CALIFORNIA

FIG. A-50



BORING

Elevation: 170 feet, MSL

Location: 5900 Wilshire Boulevard.

Data Source: L.T. Evans, Inc. Foundation Investigation for 5900 Wilshire Building Boring B-2 in report

VELOCITIES

a) Source: Eguchi et al (1976)

Location: Site Number 42 - Wilshire & Spaulding 500 feet East of 5900 Wilshire Boulevard

Date: August 1975

b) Source: Eguchi et al (1976)

Location: Site Number 43 - Wilshire & McCarthy Vista 2000 feet west of 5900 Wilshire Blvd.

Date: August 1975

c) Source: Duke and Leeds (1972)

Location: Site No. 8 - Hancock Park (5801 Wilshire) 500 feet Northeast of 5900 Wilshire Boulevard

Date: November 1, 1962

REPORT: SW-AA (1976b)

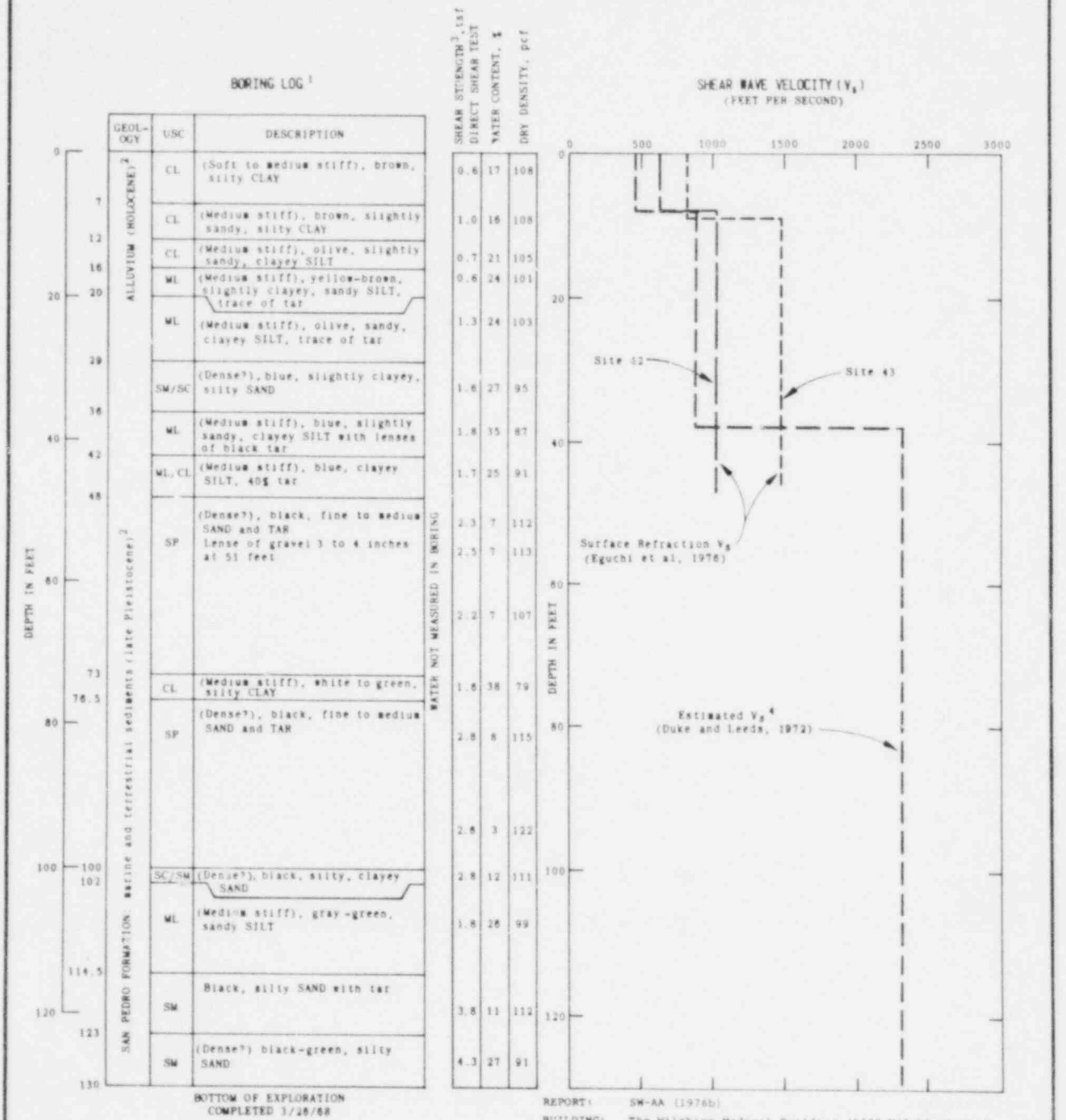
BUILDING: The Mutual Benefit Building (5900 Wilshire) is a 31-story high-rise with 3 basements (foundation level is about 35-40 feet below grade). The lowest level accelerograph is located in the 2nd basement.

NOTES: 1) The Pico (Fernando) Fm. may be at a depth of 100 feet based on Duke & Leeds (1972) Site 8 - Hancock Park (500 feet Northeast of 5900 Wilshire). That is, sand and tan shale from 100 to 200 ft. and shale below 200 ft.

2) Velocities estimated based on site geology.

SUMMARY LOG
5900 WILSHIRE BLVD.
LOS ANGELES, CALIFORNIA

FIG. A-51



REPORT: SW-AA (1976b)

BUILDING: The Wilshire Medical Building (6200 Wilshire) is a 16-story high-rise essentially founded at grade. The lowest level accelerograph is at the ground floor level.

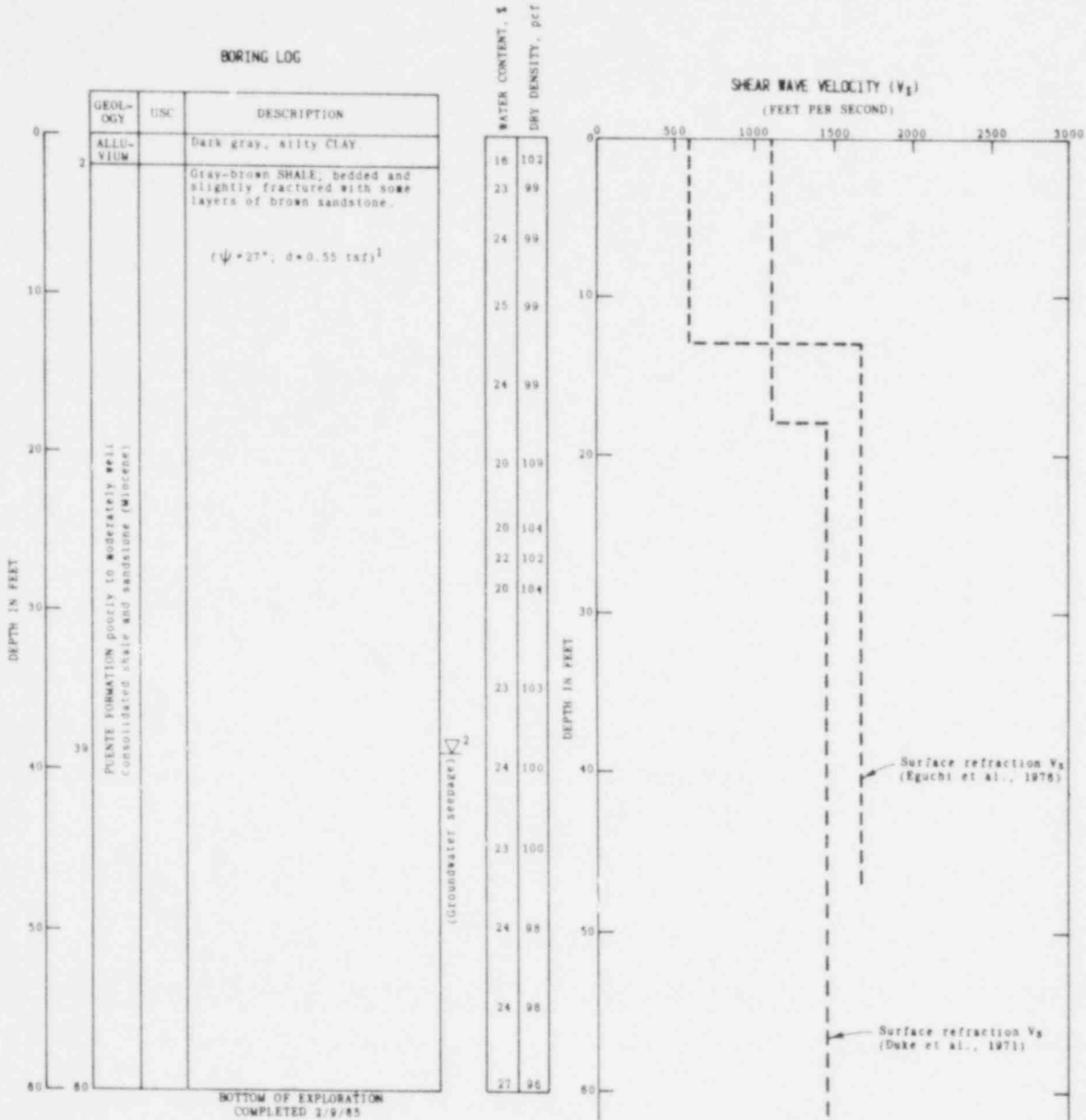
NOTES:
1) The Pico (Fernando) Fm. may be at a depth of 100 feet based on Duke & Leeds (1972) Site 8 - Hancock Park (1600 ft. east of 6200 Wilshire). That is, sand and tan shale from 100 to 200 ft. and shale below 200 ft.
2) Contact between the alluvium and the San Pedro Fm. is between 16 and 36 feet based on interpretation of boring log descriptions.
3) S. strength values assumed to correspond to Direct Sh. ar tests run at overburden pressures.
4) Velocities estimated based on site geology.

BORING
Elevation: pproximately 157 feet, MSL (USGS topographic quad.)
Location: 6200 Wilshire Blvd. (Wilshire Medical Bldg.)
Data Source: Nikola Soils Engineers
Foundation investigation for Wilshire Medical Building
Job No. 43-68 LA, dated April 1968
Boring B-2 in report

VELOCITIES
a)Source: Eguchi et al (1976)
Location: Site Number 42 - Wilshire & Spaulding
1800 feet East of 6200 Wilshire
Date: August 1975
b)Source: Eguchi et al (1976)
Location: Site Number 43 - Wilshire & McCarthy Vista
500 feet West of 6200 Wilshire
Date: August 1975
c)Source: Duke and Leeds (1972)
Location: Site No. 8 - Hancock Park (5801 Wilshire)
1600 feet east of 6200 Wilshire
Date: November 1, 1962

SUMMARY LOG
6200 WILSHIRE BLVD.
LOS ANGELES, CALIFORNIA

FIG. A-52



BORING

Elevation: 388.2 Feet, MSL
Location: 2011 Zonal Avenue
Data Source: LeRoy Crandall and Associates Foundation investigation for Medical Research Building
Boring B-2 of report
Equipment: Bucket auger

VELOCITIES

a) Source: Duke et al (1971)
Location: Site Number 17; Hazard Park 1100 feet Northeast of 2011 Zonal
Date: August 13, 1971

b) Source: Eguchi et al (1976)
Location: Site Number 49; Zonal Street and San Pablo St. 400 feet South&east of 2011 Zonal
Date: August 1975

REPORT: SW-AA (1976b)

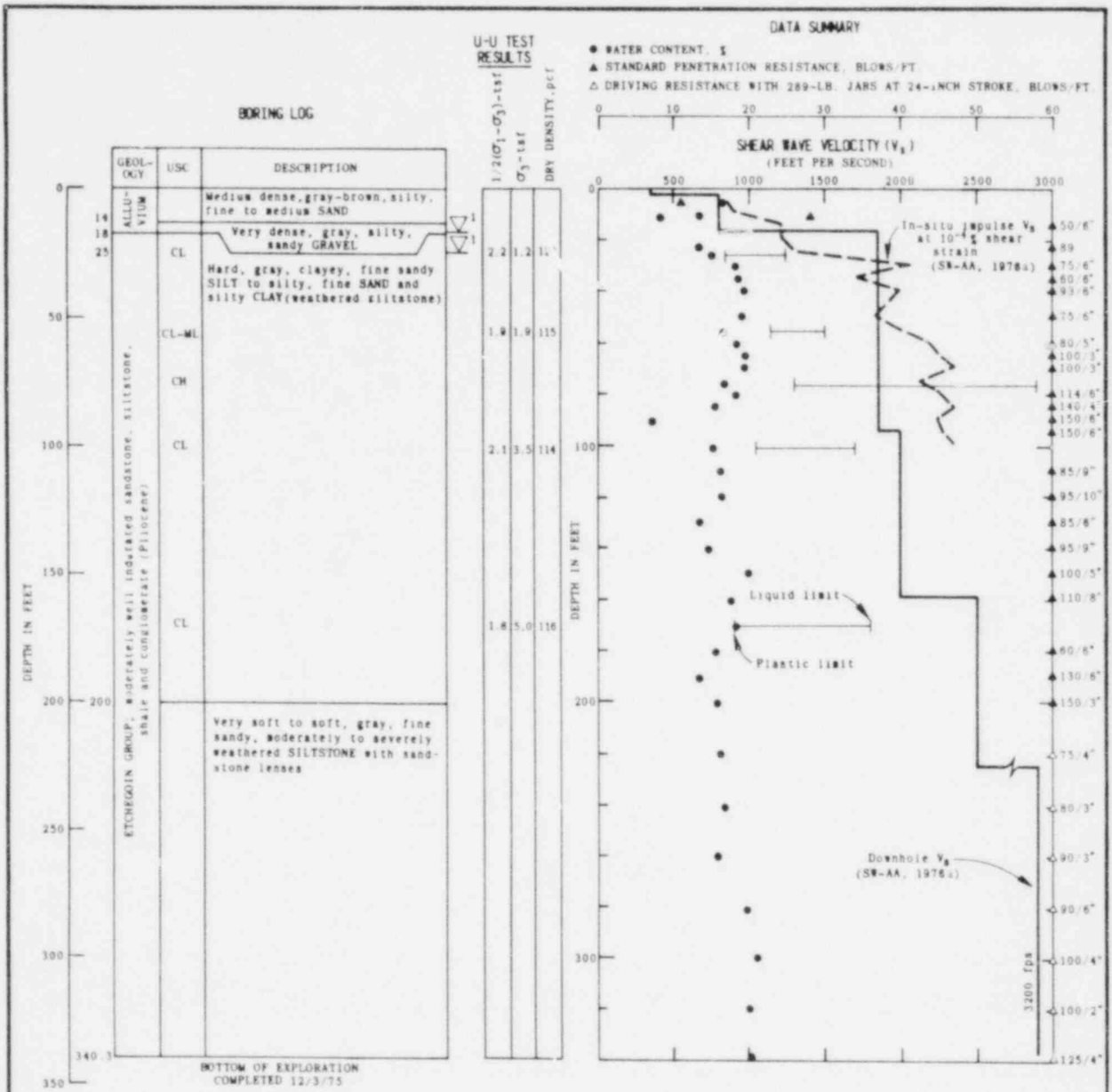
BUILDING: The Hoffman Medical Research Center (2011 Zonal) is a 9-story structure with a day-light basement. The building is located partially on a cut up to 26 feet deep and partially on a fill up to 16 feet thick. The lowest level accelerograph is located in the basement, over the area of fill.

Notes: 1) Soil properties are from direct shear tests performed by LeRoy Crandall in their foundation investigation report for the Medical Research Building.

2) Groundwater seepage observed in the boring (B-2) at a depth of 39 feet. Duke, et al. (1971) indicate the water table at a depth of 16 feet.

SUMMARY LOG
2011 ZONAL AVE.
LOS ANGELES, CALIFORNIA

FIG. A-53



BORING

Elevation: 1000 feet, MSL (USGS Topographic quad.)

Location: 30 feet East of the accelerograph station

Data Source: SW-AA (1976a)

Equipment: Failing 1500 Rotary drill; sampling with a 2" O.D. SPT split spoon sampler and a Pitcher barrel

VELOCITIES

Source: SW-AA (1976a)

Location: Downhole and in-situ impulse tests performed in above boring

Date: December 1975

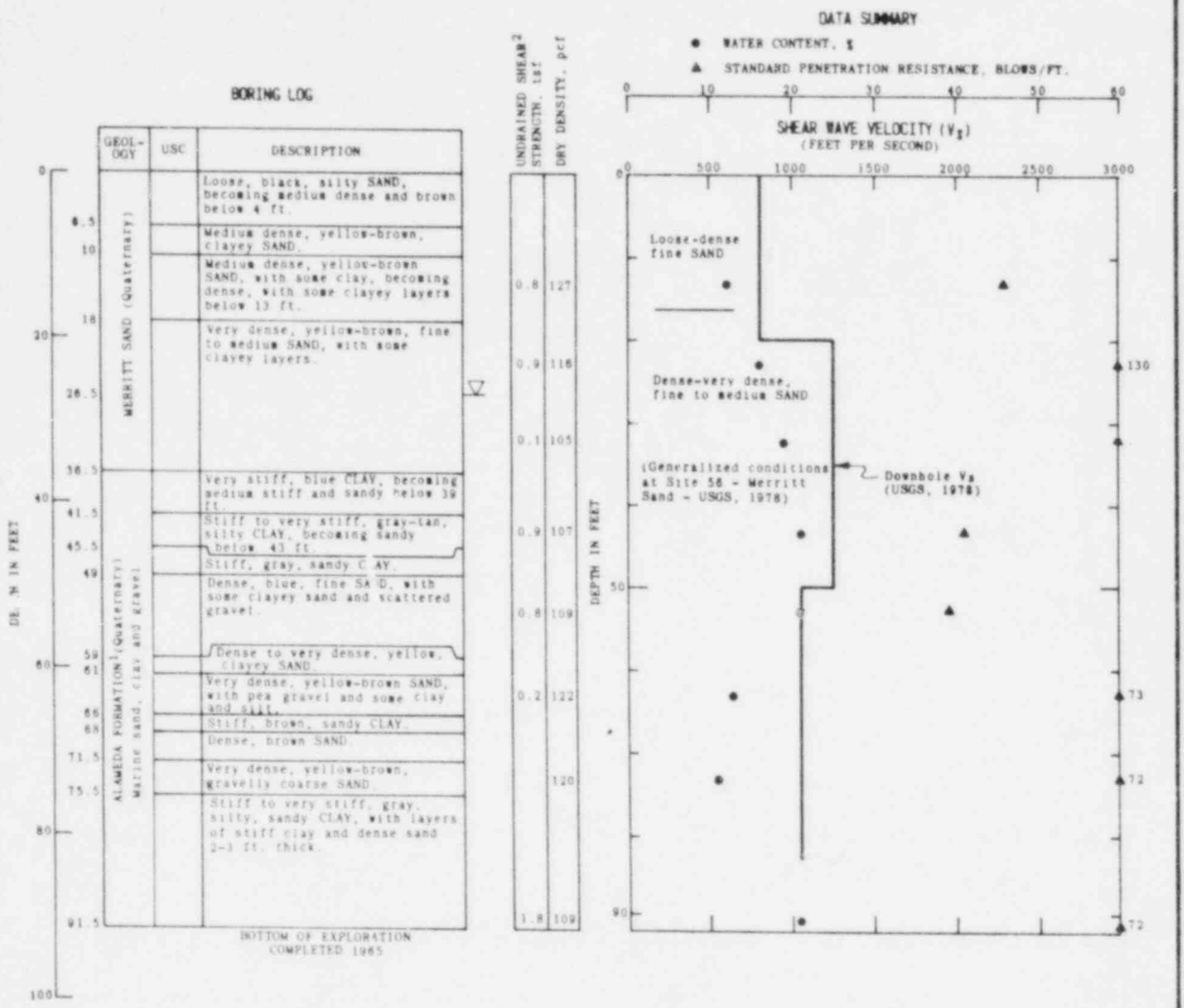
REPORT SW-AA (1976a)

BUILDING The accelerograph was located in a one-story barn. The instrument was removed in September 1972.

NOTE: 1) Position of the water table is based on the water level observed in an adjacent stream (18 feet) and compressional wave velocity measurements (25 feet).

SUMMARY LOG
MELENDY RANCH BARN
CALIFORNIA

FIG. A-54



BORING

Elevation: 36 feet

Location: City Hall

Data Source: 1965 Woodward-Clyde-Sherard & Assoc. Soils exploration for Oakland City Hall Elevators. Boring 2 in report, reprinted in Woodward - Lundgren & Assoc. (1973).

VELOCITIES

Source: USGS (1977, 1978)

Location: Site 56, Merritt Sand (MER, MS)
2500 feet northwest of Oakland City Hall.

Date: May 3, 1976

REPORT SW-AA (1977b)

BUILDING The Oakland City Hall (1421 Washington Street) is a 15-story structure with a basement. The lowest level accelerograph is in the basement, about 10 feet below grade.

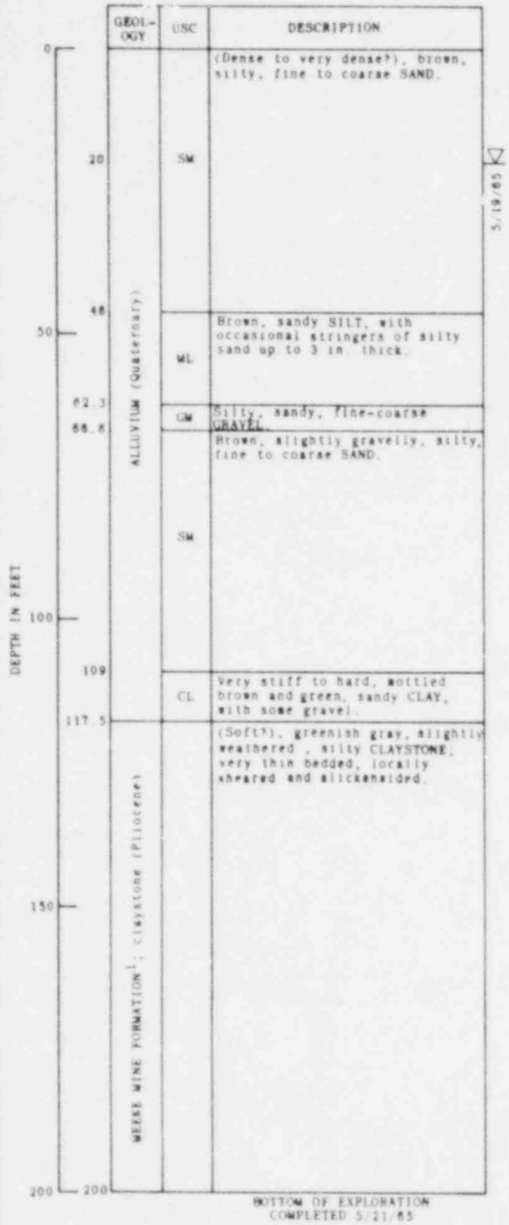
NOTES: 1) The upper section of the Alameda Formation consists of sandy, silty clay. The lower part consists of continental and marine sand, clay and gravel. Maximum known thickness, 1,650 feet. (Woodward-Lundgren and Associates, 1973).

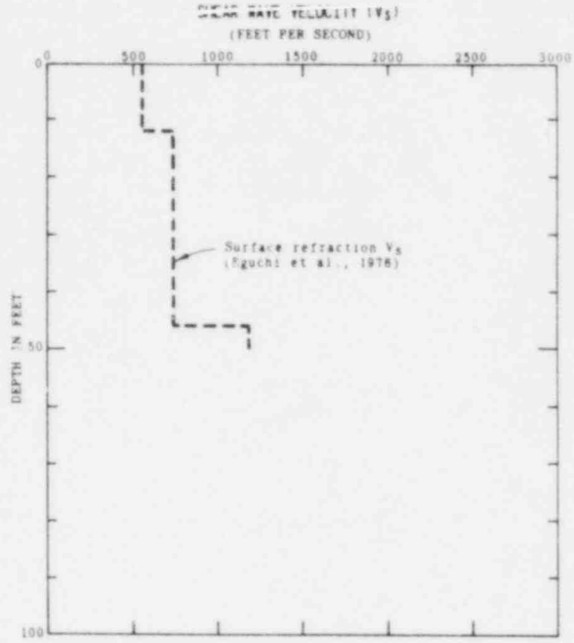
2) Shear strengths are assumed to correspond to U-U tests run at overburden pressure.

SUMMARY LOG
CITY HALL
OAKLAND, CALIFORNIA

FIG. A-55

BORING LOG





BORING

Elevation:	Approximately 3140 feet MSL (USGS topographic quad.)
Location:	300 feet East of original accelerograph station
Data Source:	California Department of Water Resources Boring DH-5 at Oso Pumping Plant
Equipment:	Failing 1500 Rotary drill; sampling with drive tubes and a Pitcher barrel

VELOCITIES

Source:	Eguchi et al (1976)
Location:	Site Number 60; Oso Pumping Plant 1500 feet East of original accelerograph station
Date:	September 1975

REPORT: SM-AA (1976b)

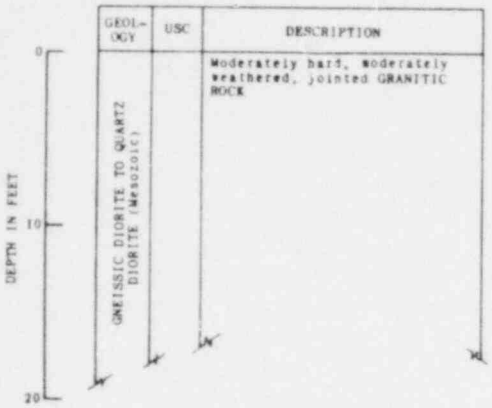
BUILDING: The original accelerograph station was housed in a small instrument shelter located at grade. The station has been relocated to the Valve Gallery.

NOTE: 1) The Meeks Mine Formation may be several thousand feet thick.

SUMMARY LOG
OSO PUMPING PLANT
CALIFORNIA

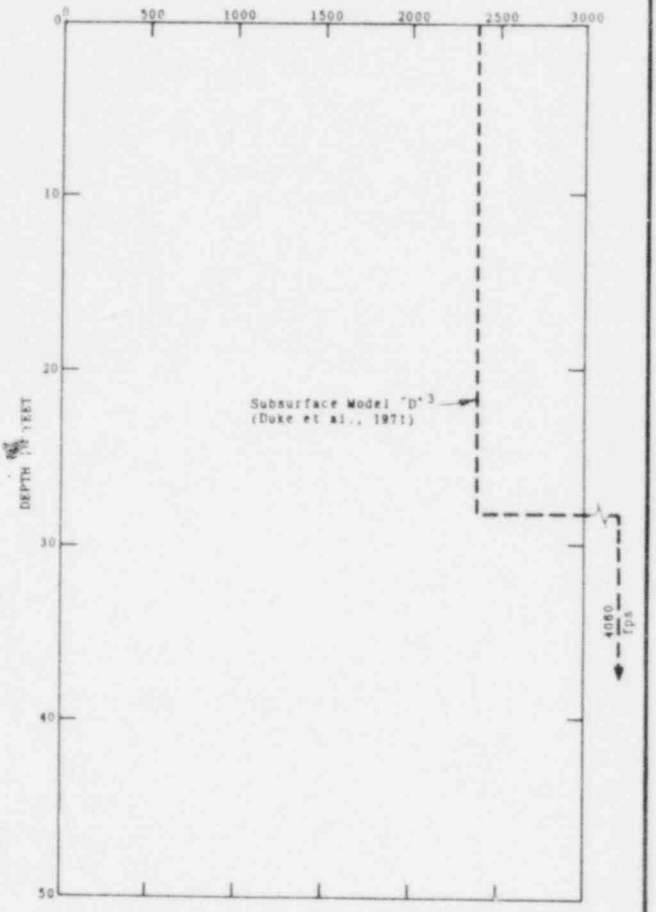
FIG. A-56

LOG [1,2]



SHEAR WAVE VELOCITY (V_S)

(FEET PER SECOND)



VELOCITIES

Source: Duke et al (1971)

Location: Subsurface model "D" developed for Pacoima Dam[3].

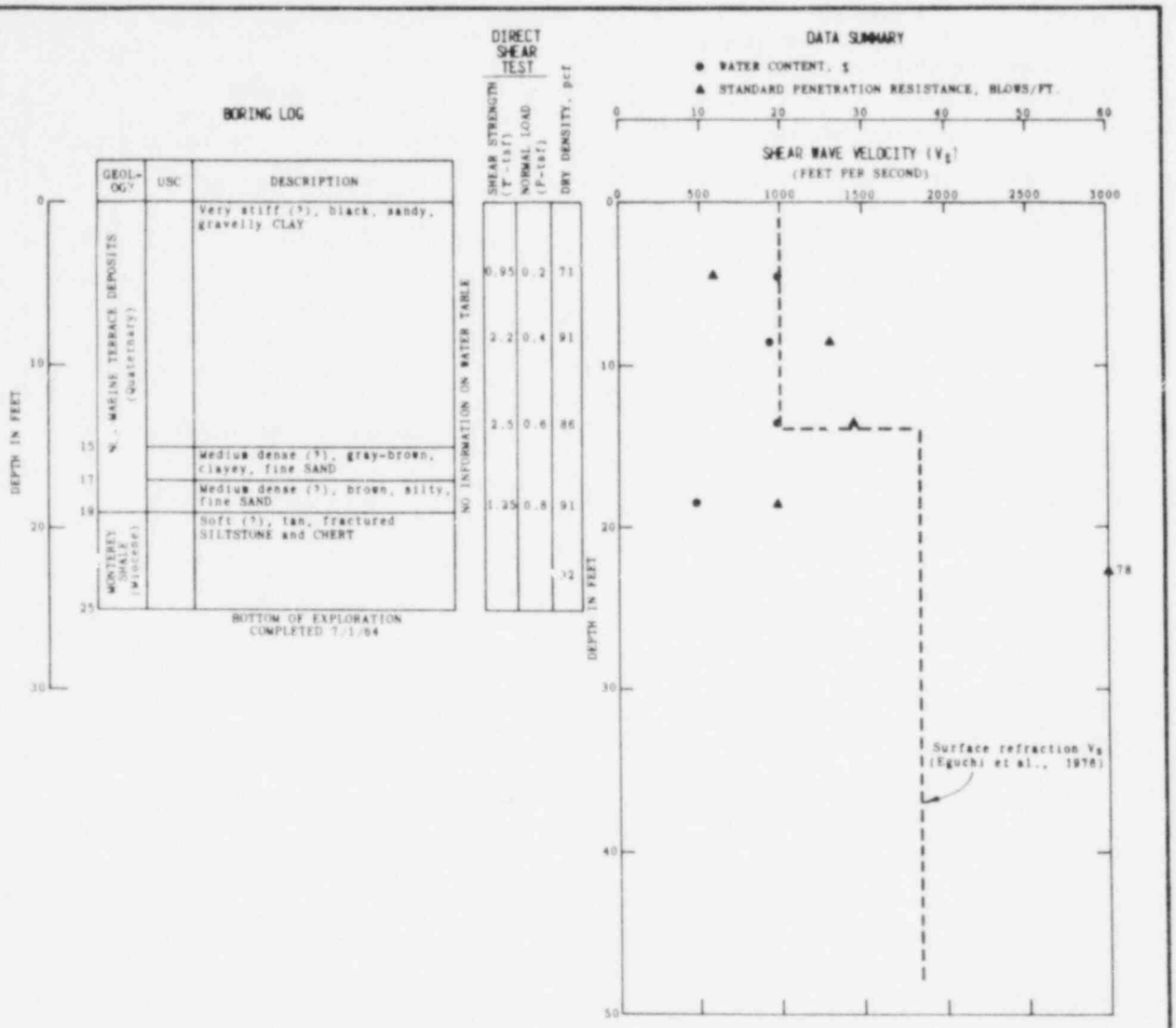
REPORT: SW-AA (1977b)

BUILDING: The accelerograph is housed in a small instrument shelter located directly on rock, on the left abutment of the dam.

NOTES:
1) No borings were made at the site. The materials indicated on the log were observed during our site reconnaissance. (SW-AA, 1977b).
2) Surface elevation of the accelerograph station (USGS Number 279) is approximately 2060 feet, MSL.
3) Compressional wave velocities (V_p) at Pacoima Dam were measured by Woodward-Lundgren Associates using both cross hole and surface refraction techniques. Shear wave velocities (V_s) were estimated from the V_p values by Duke, et al[3] (1971).

SUMMARY LOG
PACOIMA DAM
CALIFORNIA

FIG. A-57



BORING

Elevation: Approximately 230 feet, MSL (USGS topographic quad.)

Location: About 180 feet South of 2516 Via Tejon

Data Source: Mauraeth & Howe foundation investigation for Via Campesina, Palos Verdes Estates, dated July 15, 1964 Boring B-2 in report

Equipment: Bucket Auger

VELOCITIES

Source: Eguchi et al (1976)

Location: Site No. 57; Malaga Lane, within 300 feet of 2516 Via Tejon

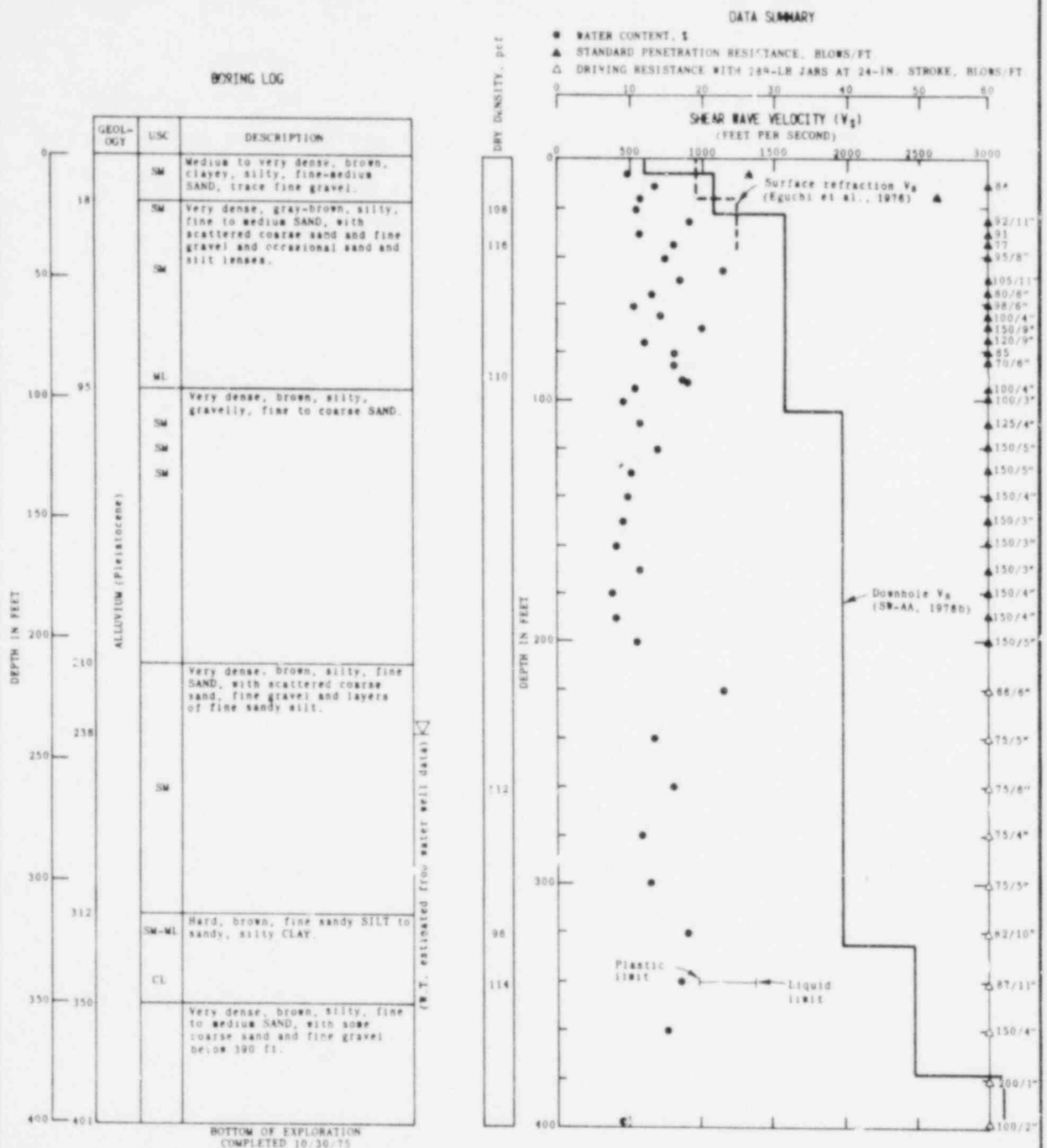
Date: September 1975

REPORT SW-AA (1977b)

BUILDING The 2516 Via Tejon Building is a 1-story structure with the 1st floor partially embedded in a hillside. The accelerograph is located on the first floor at grade level.

SUMMARY LOG
2516 VIA TEJON
PALOS VERDES ESTATES, CALIFORNIA

FIG. A-58



BORING

Elevation: 758.6 feet, MSL

Location: 200 feet Southwest of Millikan Library

Data Source: SW-AA (1976a)

Equipment: Failing 1500 Rotary drill; sampling with a 2" O.D. SPT split spoon sampler and a Pitcher barrel

VELOCITIES

a) Source: SW-AA (1976a)

Location: Survey performed in above boring

Date: November 1975

b) Source: Eguchi et al (1976)

Location: Site Number 52, California Institute of Technology Millikan Library (100 feet West of Millikan Library)

Date: August 1975

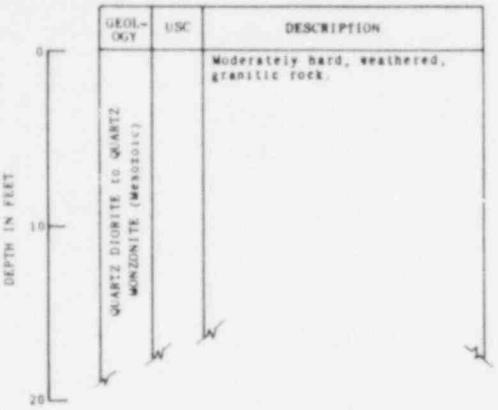
REPORT: SW-AA (1976a)

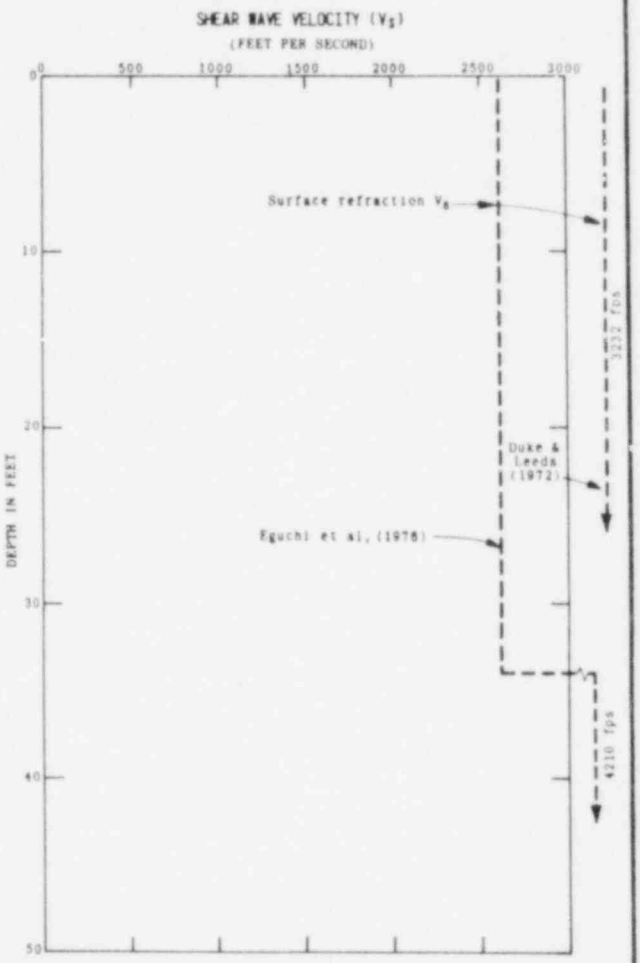
BUILDING: The Millikan Library Building is a 9-story high rise with one basement which extends 12 feet below grade. The lowest level accelerograph is located in the basement.

SUMMARY LOG
CIT MILLIKAN LIBRARY
PASADENA, CALIFORNIA

FIG. A-59

LOG [1,2]





VELOCITIES

a) Source: Eguchi et al (1976)

Location: Site No. 53; 220 N. San Rafael Boulevard. Approximately 1500 feet south of old Seismic Laboratory

Date: August 1975

b) Source: Duke and Leeds (1972)

Location: Site No. 36; 220 N. San Rafael Boulevard approximately 1500 feet south of old Seismic Lab.

Date: November 1962

REPORT: SW-AA (1977b)

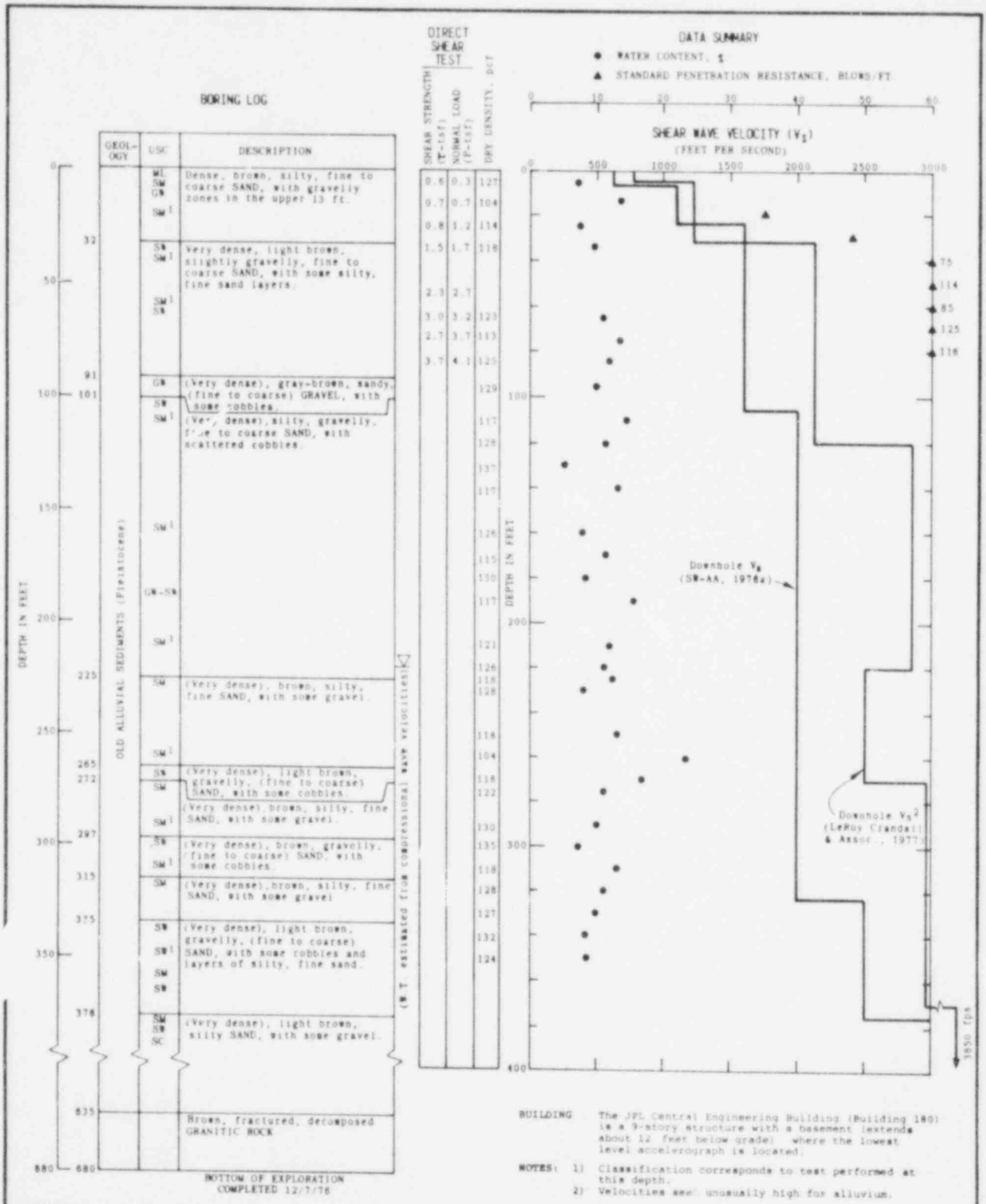
BUILDING: Although the station has been discontinued, the accelerograph at the CIT old Seismic Lab (295 North San Rafael Blvd.) was located in the basement (10 feet below grade) of a 3-story structure.

NOTES: 1) No borings were made at the site. The materials indicated on the log were observed during our site reconnaissance (SW-AA, 1977b).

2) Surface elevation of the old Seismic Laboratory is approximately 960 feet, MSL (USGS topographic quad.).

SUMMARY LOG
CIT OLD SEISMIC LAB
PASADENA, CALIFORNIA

FIG. A-60



BUILDING The JPL Central Engineering Building (Building 180) is a 9-story structure with a basement (extends about 12 feet below grade) where the lowest level accelerograph is located.

NOTES: 1) Classification corresponds to test performed at this depth.
2) Velocities seem unusually high for alluvium.

BORING

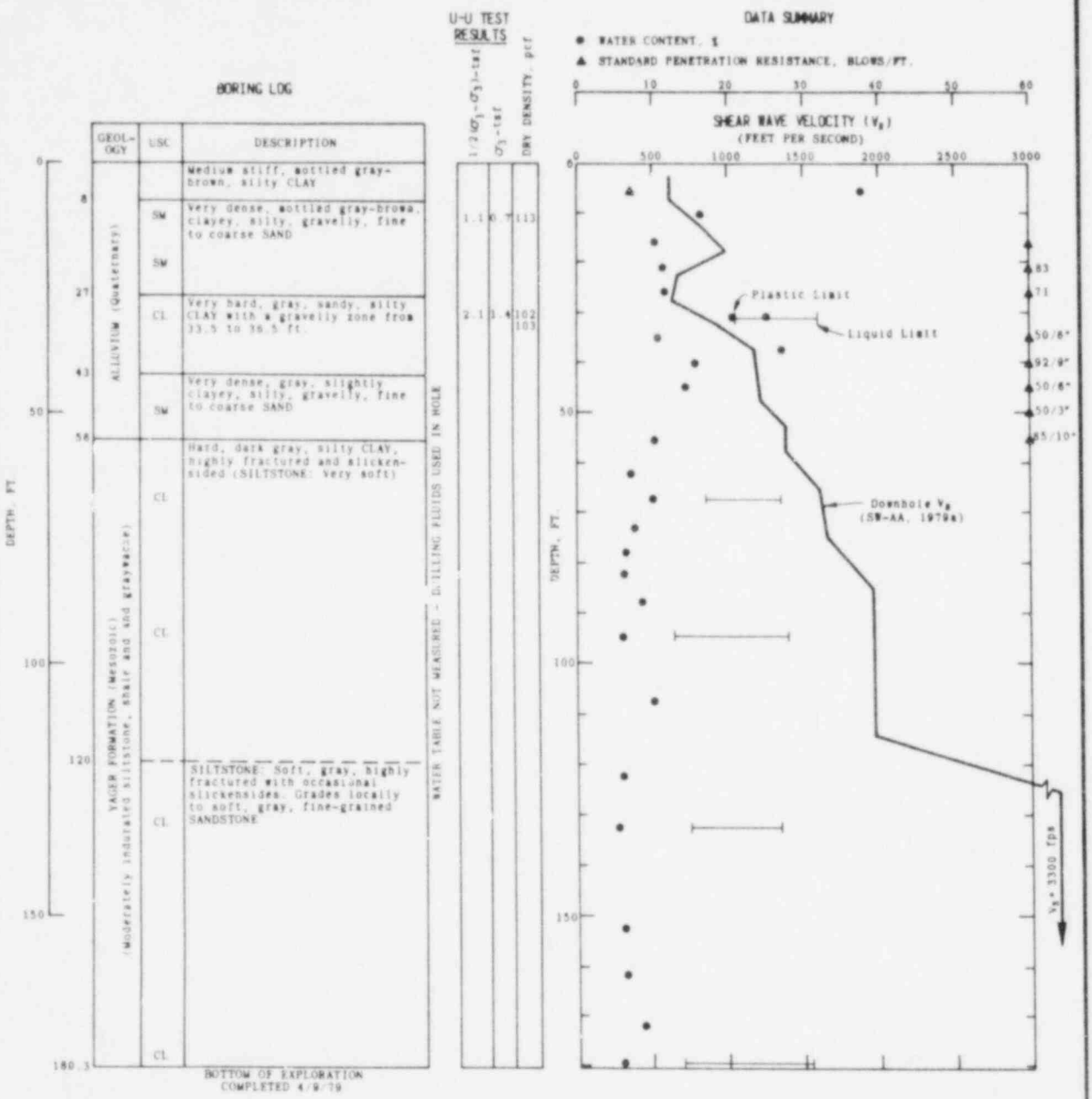
Elevation:	1149.6 feet, MSL
Location:	190 feet South of Central Engineering Bldg. (Bldg. 180).
Data Source:	LeRoy Crandall and Associates (1977)
Equipment:	Rotary wash boring, sampling with a SPT split spoon, LeRoy Crandall sampler and NX core barrel.

VELOCITIES

a) Source:	LeRoy Crandall and Associates (1977)
Location:	Survey performed in above boring (Max. Depth 414 ft.)
Date:	December 1976
b) Source:	SW-AA (1976a)
Location:	CIT Millikan Library(old Alluvium) (5 mi. Southeast of JPL)
Date:	Nov. 1975
REPORT	SW-AA (1977b)

SUMMARY LOG
4800 OAK GROVE (JPL)
PASADENA, CALIFORNIA

FIG. A-61



BORING

Elevation: 185 ft. MSL (interpolated from USGS topo quad.).

Location: 65 ft. NE of the instrument shelter and 110 ft. N. of the General Store.

Data Source: SW-AA (1979a)

Equipment: Failing 1500 Rotary drill, sampling with an SPT drive barrel, shelby tubes, a pitcher barrel and an NX core barrel (2 runs).

VELOCITIES

Source: SW-AA (1979a)

Location: Downhole testing performed in above boring.

Date: June 2, 1979

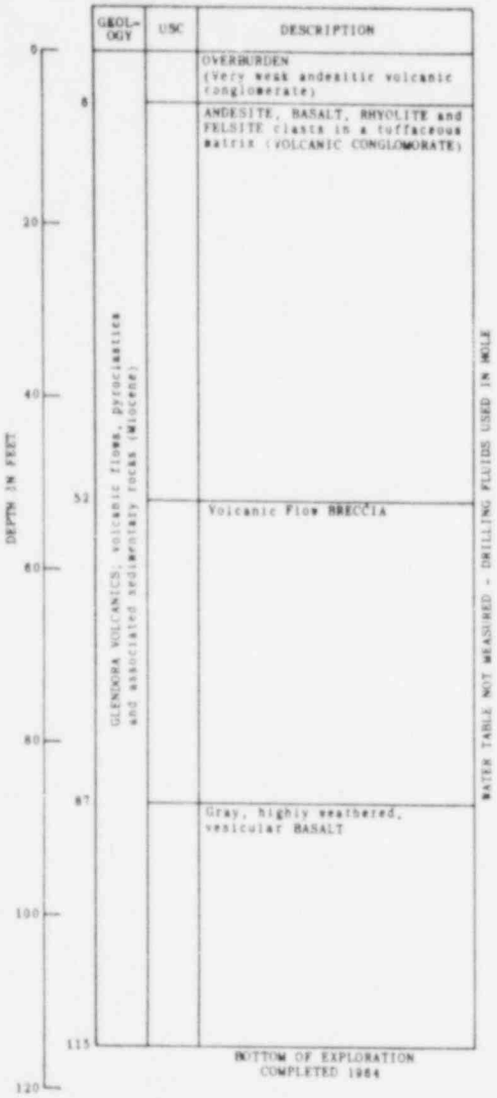
REPORT: SW-AA (1979a)

BUILDING: The accelerograph is located in a free field instrument shelter, founded at grade.

SUMMARY LOG
GENERAL STORE
PETROLIA, CALIFORNIA

FIG. A-62

BORING LOG



BORING

Elevation: Approximately 950 feet MSL (USGS topographic quad.)

Location: Within 20 feet of accelerograph station

Data Source: Los Angeles County Flood Control District
Boring 64-16, Puddingstone Dam Number 1

Equipment: Rotary with NX coring

VELOCITIES Not Available

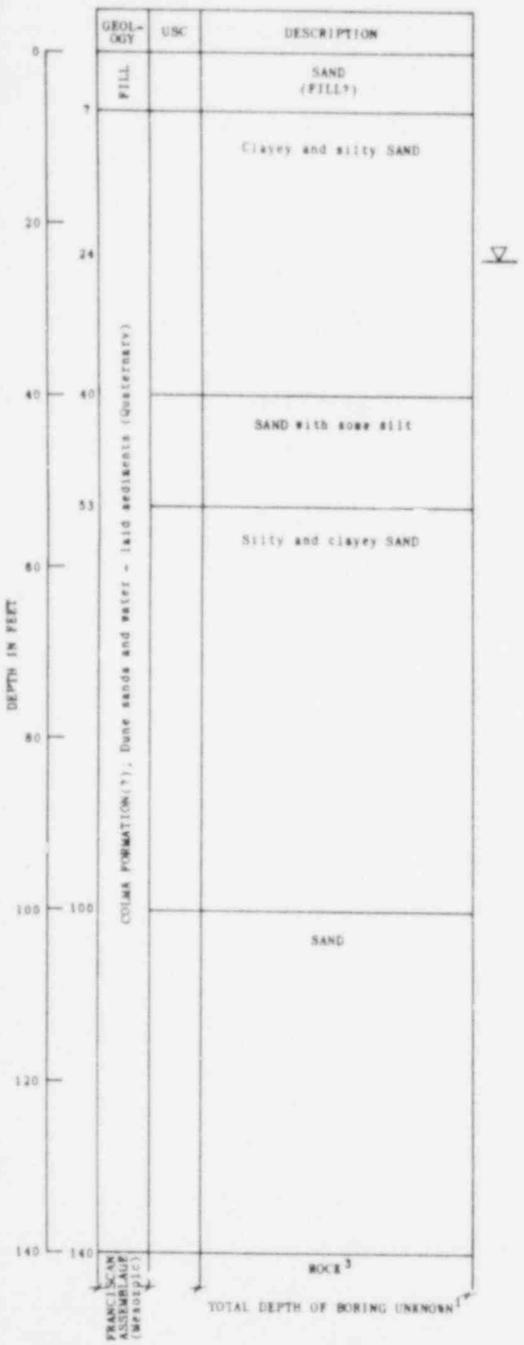
REPORT SW-AA (1977b)

BUILDING Accelerograph is housed in instrument shelter founded on grade on the left abutment of the dam.

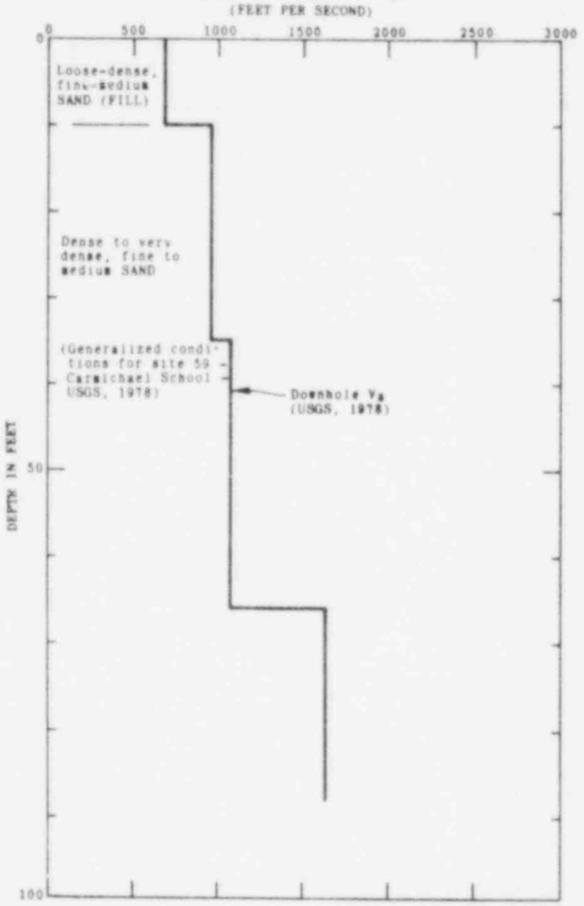
SUMMARY LOG
PUDDINGSTONE RESERVOIR
CALIFORNIA

FIG. A-53

BORING LOG[1]



SHEAR WAVE VELOCITY (V_s)
(FEET PER SECOND)



NOTES:
1) Source of boring information not identified in Seed and Idriss (1969)
2) About 10 feet of fill underlies the site (USGS, unpub.).
3) Bedrock is at Elevation -100 ft. (depth of 135 ft.) based on Schlocker (1974). Depth to bedrock is quite variable in the site area.

BORING
Elevation: Approximately 35 feet MSL (USGS Topographic Quad.)
Data Source: Seed and Idriss (1969)[1]

VELOCITIES
Source: USGS (1977, 1978)
Location: Site 59, Carmichael School (CAR)
5300 feet south-southwest of Alexander Building.
Date: May 5, 1976

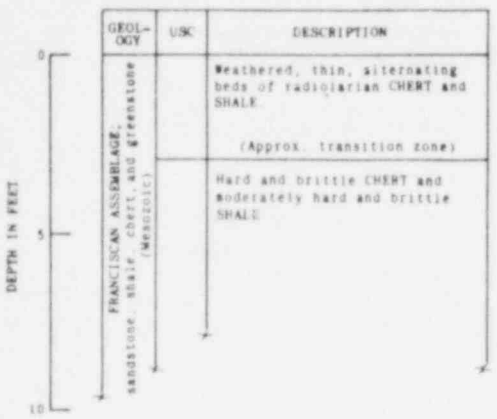
REPORT: SM-AA (1977b)

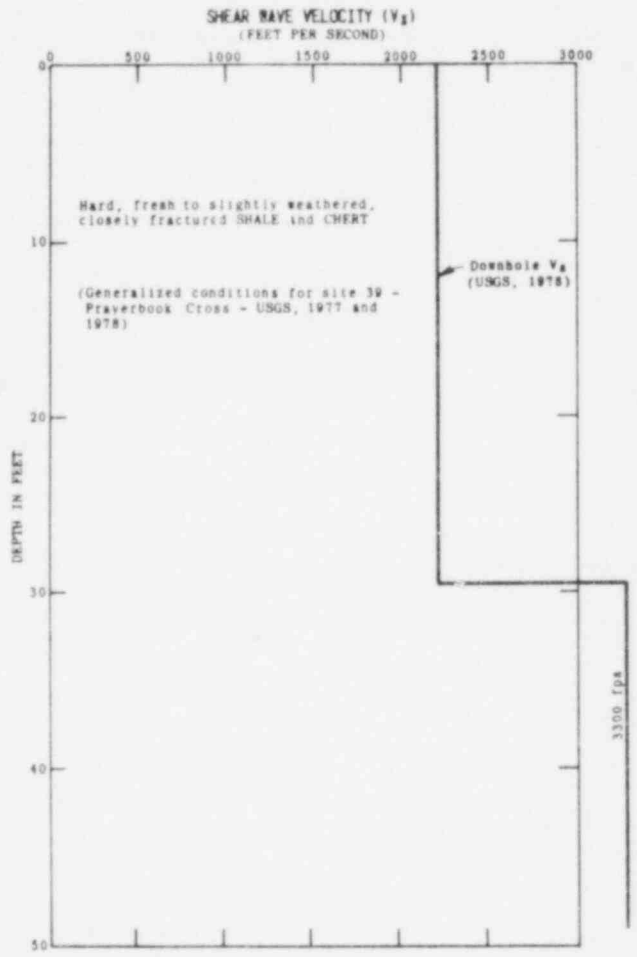
BUILDING: The Alexander Building (155 Montgomery) is a 16-story high-rise with a basement. The lowest level accelerograph is in the basement, about 10 feet below grade.

SUMMARY LOG
ALEXANDER BUILDING
SAN FRANCISCO, CALIFORNIA

FIG. A-64

LOG [1]





VELOCITIES

Source: USGS (1977 & 1978)

Location: Site 39, Prayerbook Cross (PBX) (site of Golden Gate Park accelerograph station)

Date: March 31, 1976

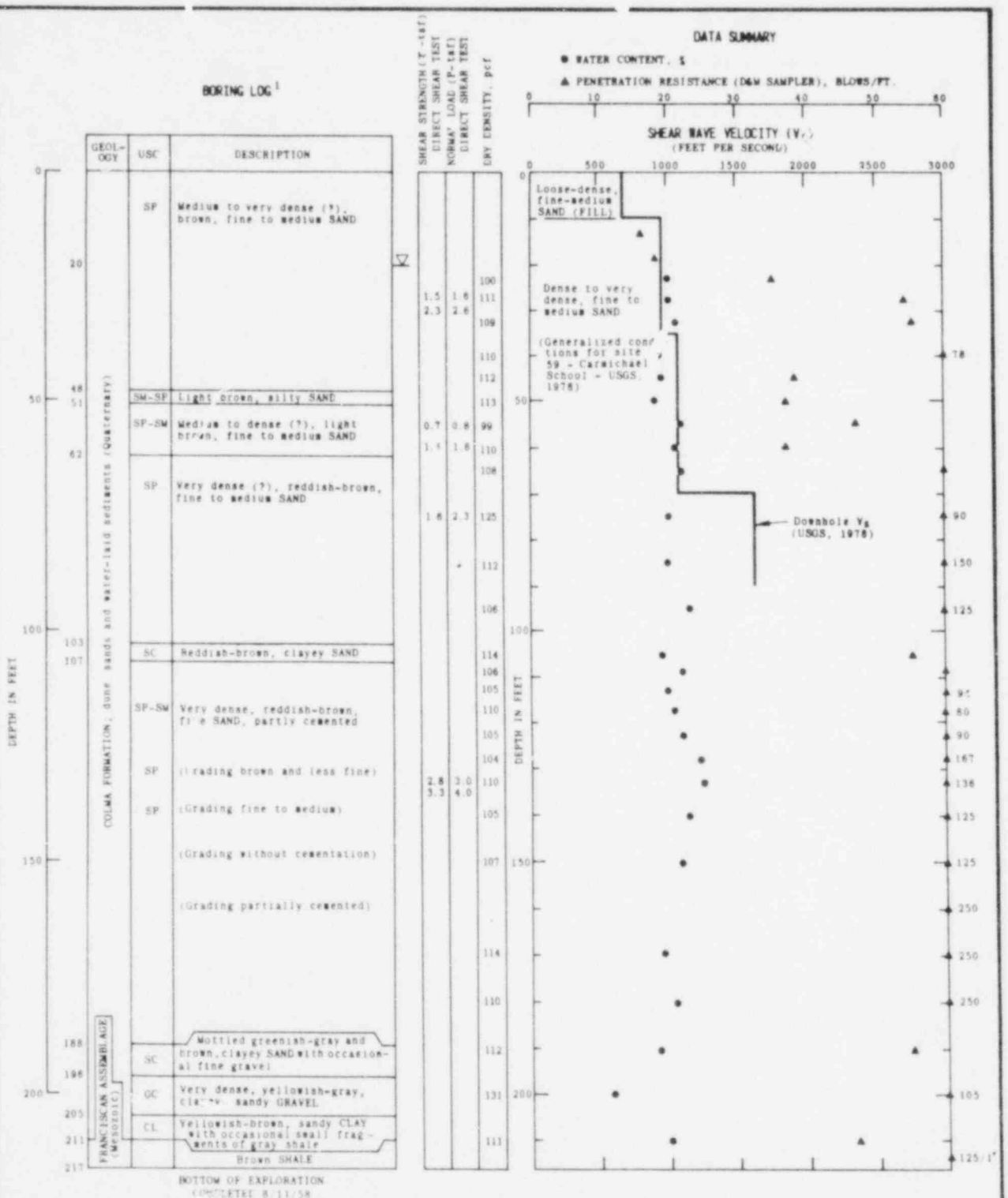
REPORT SW-AA (1977b)

BUILDING The accelerograph is housed in a small building founded at grade at the base of Prayerbook Cross.

NOTE: 1) No borings were made at the site. The materials indicated on the log were observed during our site reconnaissance. (SW-AA, 1977b).

SUMMARY LOG
GOLDEN GATE PARK
SAN FRANCISCO, CALIFORNIA

FIG. A-65



BORING

Elevation: 67.6 feet

Location: East side of Polk Street, between Turk Street and Golden Gate Avenue. Approximately 300 feet North of State Building.

Data Source: Dames & Moore, 1958 Foundation Investigation for Federal Building Boring No. 4 in report (reprinted in Woodward - Lundgren & Assoc., 1973).

VELOCITIES

Source: USGS (1977 and 1978)

Location: Site 59, Carmichael School (CAR) 4000 feet southeast of State Building.

Date: May 6, 1976

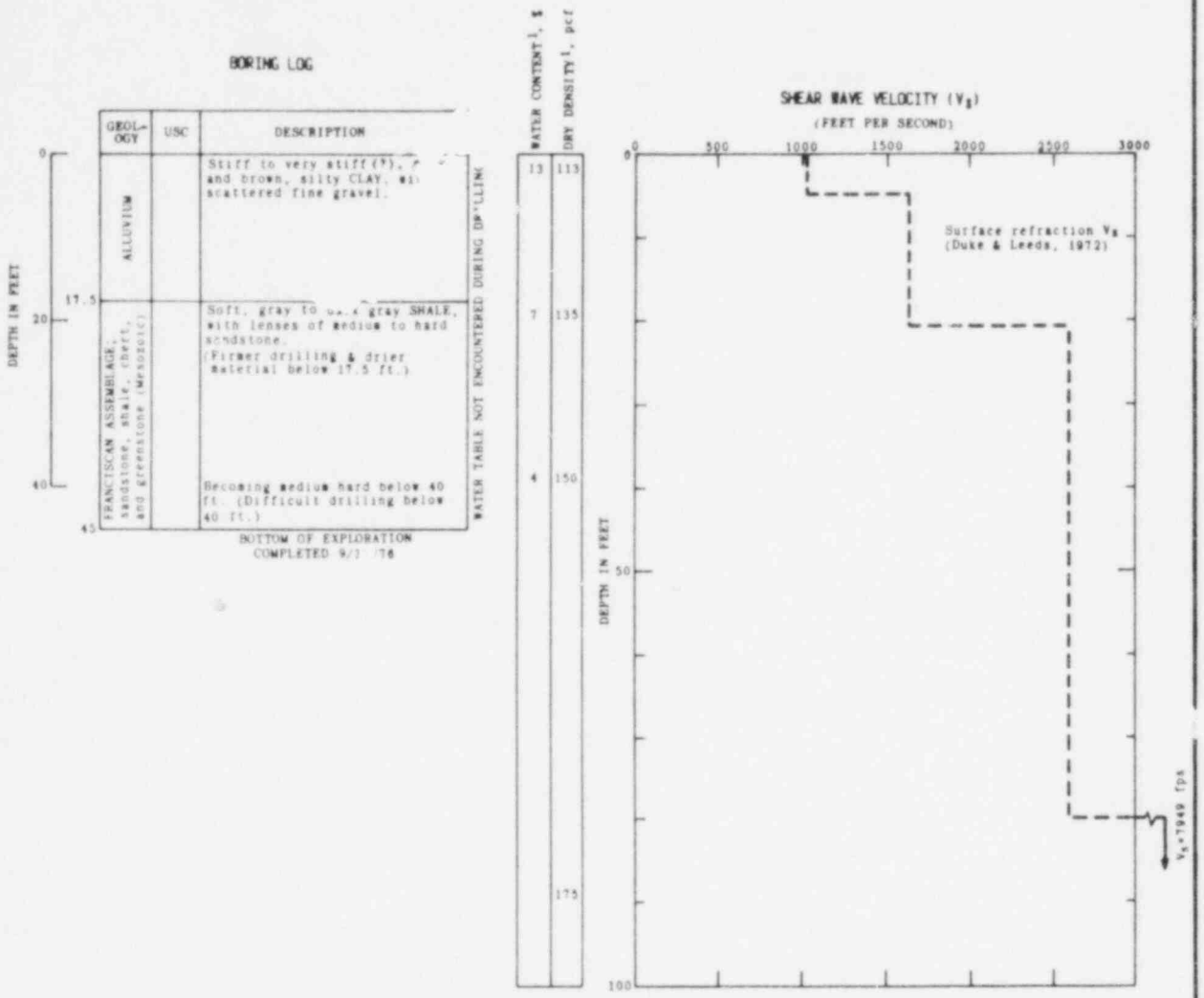
REPORT SW-AA (1977b)

BUILDING The State Bldg. (350 McAllister) is a 7-story structure with a basement (extends about 10 feet below grade) where the accelerograph was located.

NOTE: 1) Depth to bedrock in the vicinity of the State Bldg. is quite variable (Schlocker, 1974).

SUMMARY LOG
STATE BUILDING
SAN FRANCISCO, CALIFORNIA

FIG. A-66



BORING

Elevation: Approximately 260 feet, MSL (USGS topographic quad.)

Location: Adjacent to Northeast corner of City Recreation Building

Data Source: SW-AA (1977b)

Equipment: Mobile B-40 solid stem auger; hole logged by observing drill action and cutting returns.

VELOCITIES

Source: Duke and Leeds (1972)

Location: Site 62 Municipal Recreation Building (City Rec.)

Date: November 1, 1962

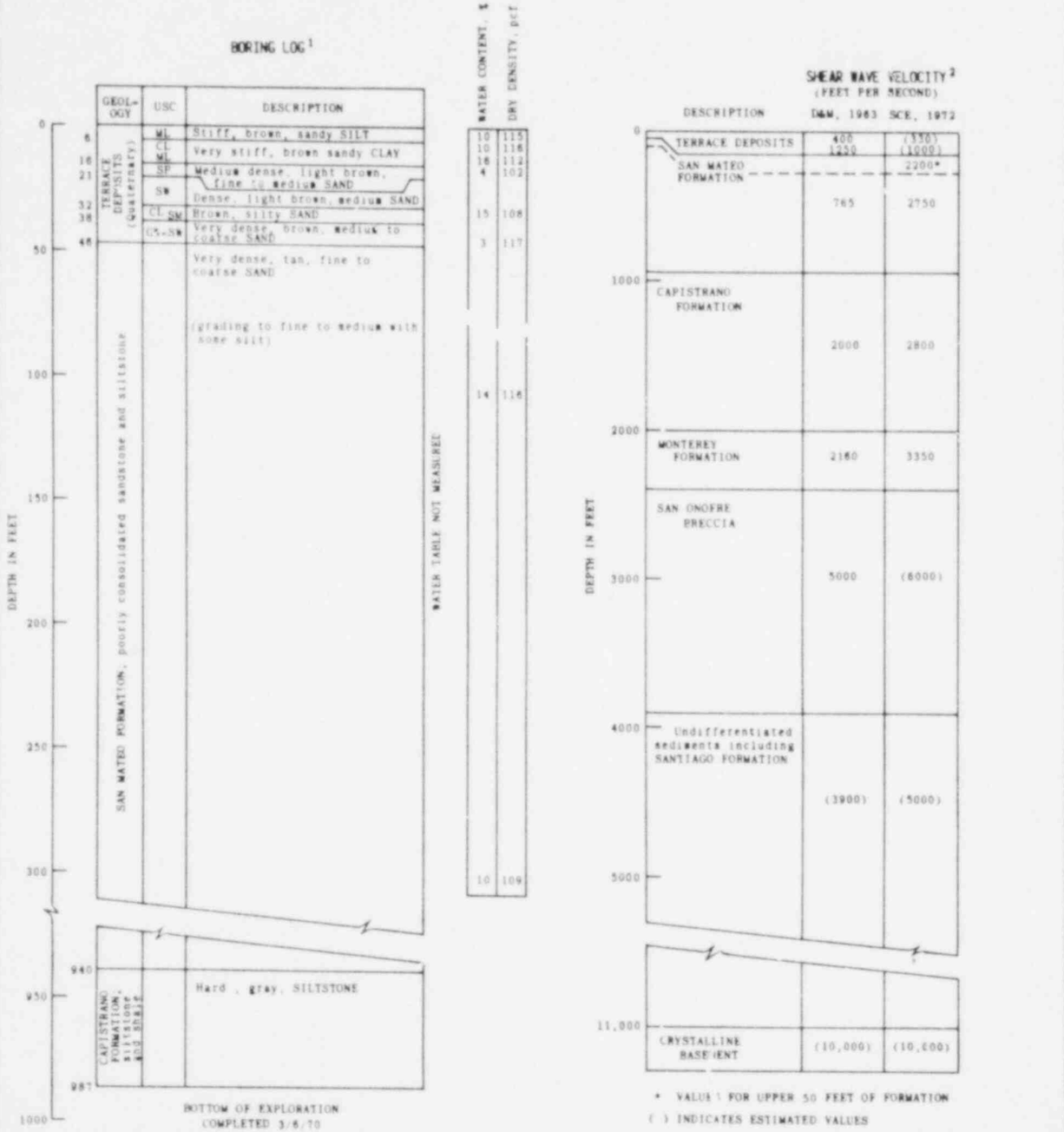
REPORT SW-AA (1977b)

BUILDING The City Recreation Building (864 Santa Rosa) is a 2-story structure with a daylight basement (extends about 2 feet below grade) where the accelerograph is located.

NOTE: 1) Soil properties from Duke and Leeds (1972).

SUMMARY LOG
CITY RECREATION BUILDING
SAN LUIS OBISPO, CALIFORNIA

FIG. A-67



BORING

Elevation: 189 feet, MLLW
Location: 1,000 feet southeast of accelerograph station
Data Source: Southern California Edison (1972) Boring B-1 in report
Equipment: Rotary wash boring; Sampling with a pitcher barrel and a Dames & Moore sampler

VELOCITIES

Data Source:	Dames & Moore (D&M, 1963)	- Southern California Edison (SCE, 1972)
Method:	Surface refraction	- Downhole (?) surface refraction
Dates:	1963	- 1970 (?)
Location:	Vicinity of plant site	- Vicinity of plant site

REPORT: SM-AA (1977b)

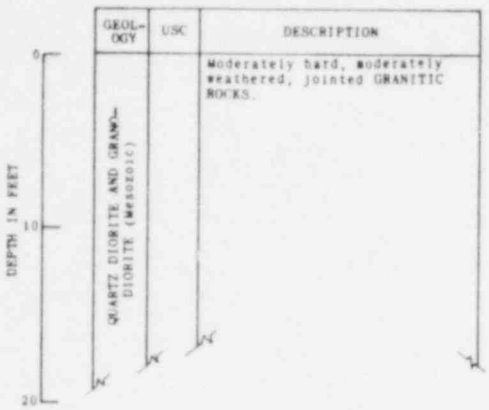
BUILDING: At the time of the San Fernando Earthquake, the accelerograph was housed in a one-story warehouse founded at grade (see note 1).

NOTES:
1) The plant site has been excavated to a level of about 25 to 50 feet below the top of the San Mateo Formation.
2) Unless indicated otherwise, values were either measured directly or calculated from compressional wave velocity measurements.
3) Shear wave velocities in the of order of 1,500-2,000 fps for the upper San Mateo Formation may be more representative than the values given in the above table.

SUMMARY LOG
NUCLEAR POWER PLANT
SAN ONOFRE, CALIFORNIA

FIG. A-68

LOG[1,2]



VELOCITIES: Not available within vicin y of the site

REPORT: SW-AA (1977b)

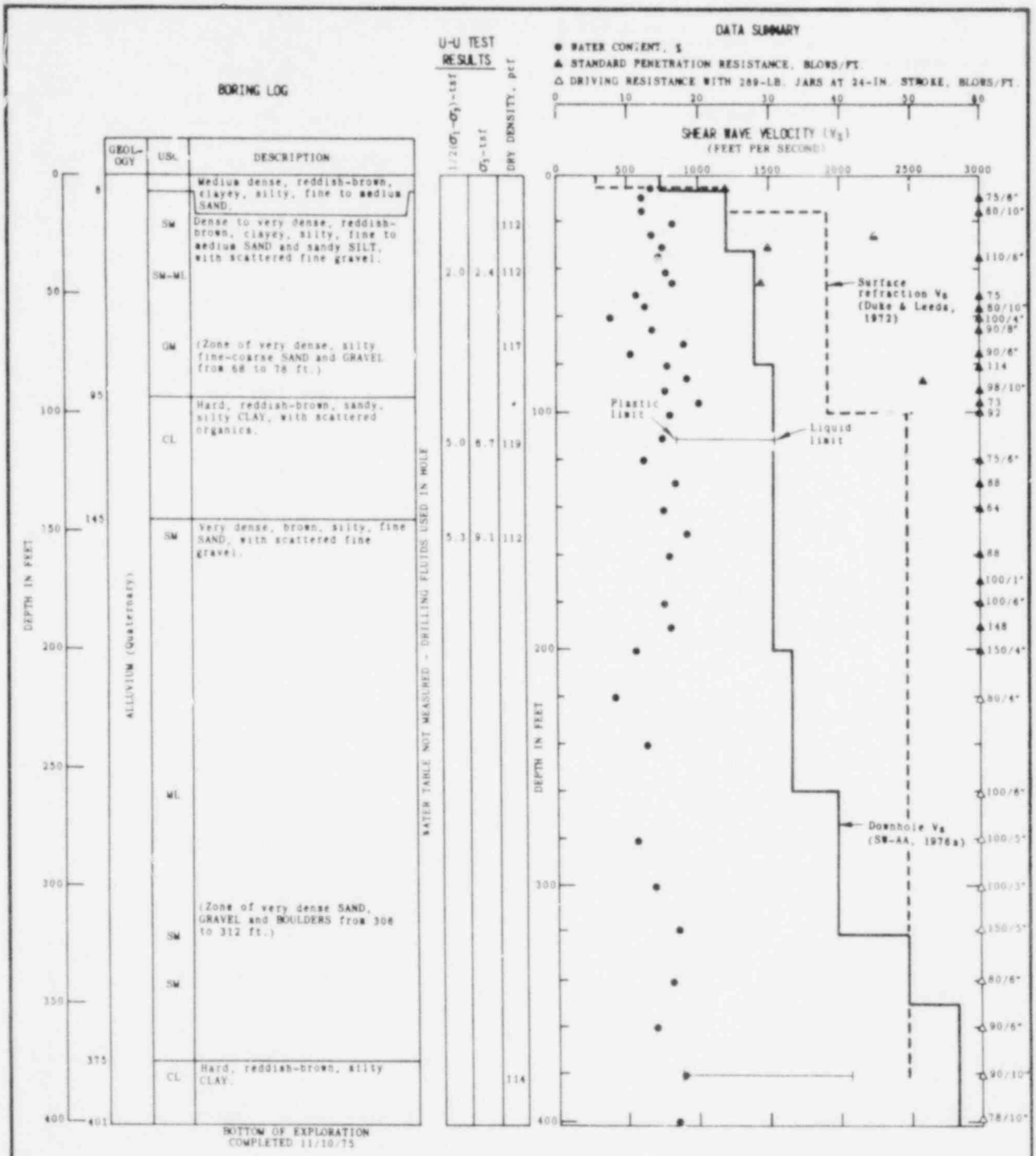
BUILDING: The accelerograph is housed a small instrument shelter located directly ck on the right abutment of the dam.

NOTES: 1) No borings were made at the site. The materials indicated on the log were observed during our site reconnaissance. (SW-AA, 1977b)

2) Surface elevation of the accelerograph station (USGS Number 104) is approximately 1410 feet MSL.

SUMMARY LOG
SANTA ANITA DAM
CALIFORNIA

FIG. A-69



BORING

Elevation: 85.2 feet, MSL

Location: 450 feet North of County Courthouse

Data Source: SW-AA (1976a)

Equipment: Failing 1500 Rotary drill; sampling with a 2"O.D. SPT split spoon sampler and a oitcher barrel

VELOCITIES

a) Source: SW-AA (1976a)

Location: Downhole survey performed in above boring

Date: December 1975

b) Source: Duke & Leeds (1972)[1]

Location: Site 59; Santa Barbara County Courthouse (within about 300 feet of courthouse)

Date: November 1962

REPORT: SW-AA (1976a)

BUILDING: The Santa Barbara County Courthouse is a 2-story structure with one basement (extends about 10 feet below grade) where the accelerograph is located.

NOTE: 1) Duke & Leeds made velocity measurements to a depth of about 40 feet. Below this depth, the velocities were estimated from site geology.

SUMMARY LOG
COUNTY COURTHOUSE
SANTA BARBARA, CALIFORNIA

FIG. A-70

BORING LOG

BORING

Elevation: 868 feet ±

Location: 60 feet Southwest of Outlet Works Accelerograph Station

Data Source: United Water Conservation District, Santa Paula Drawing Number SD105-0 "Foundation-Location and Logs of Drill Holes" prepared by Bechtel Corporation, dated January 27, 1954
Boring Number 33

VELOCITIES: Not Available

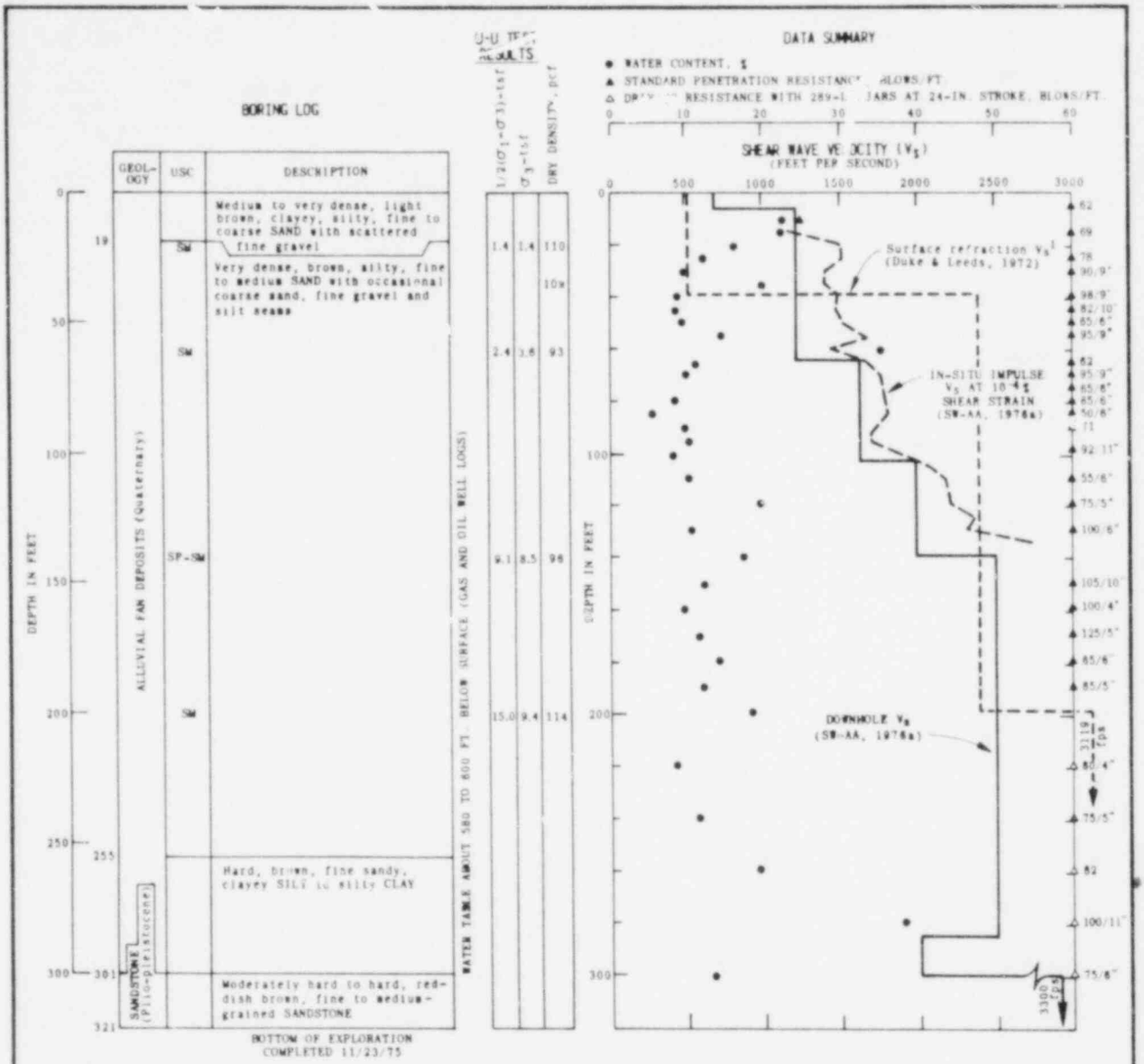
REPORT: SW-AA (1977b)

BUILDING: The Outlet Works control house is a one-story structure with a concrete stilling well foundation extending about 10 feet below grade, which adjoins the outlet pipes from the dam. The accelerograph was located at grade level.

NOTE: 1) The USGS has removed the accelerograph from the Outlet Works control house and relocated the instrument in a garage near the west abutment of the dam. The USGS made this move since they felt that the earthquake movements recorded on the instrument at the control house location may have been affected by the large diameter outlet pipes in the vicinity of the station.

SUMMARY LOG
SANTA FELICIA DAM
CALIFORNIA

FIG A-71



BORING

Elevation: 915 feet, MSL

Location: 300 feet east of Accelerograph (School Tunnel)

Data Source: SW-AA (1976a)

Equipment: Failing 1500 Rotary Drill; sampling with a 2" O.D. SPT split spoon sampler and a Pitcher barrel

VELOCITY

a) Data Source: SW-AA (1976a)

Location: Downhole and in-situ impulse test performed in above boring

Date: December 1975

b) Data Source: Duke & Leeds (1972)

Location: Site No. 55 - Taft, Lincoln Junior High School

Date: November 1962

REPORT: SW-AA (1976a)

BUILDING: The accelerograph at Lincoln School is located in an underground tunnel between two buildings (instrument approximately 5-10 feet below grade).

NOTES: 1) Duke & Leeds made velocity measurements to a depth of about 40 feet. Below this depth velocities were estimated from site geology.

SUMMARY LOG
LINCOLN SCHOOL TUNNEL
TAFT, CALIFORNIA

FIG. A-72

BORING LOG[1]

BORING

Elevation: Approximately 5930 feet, M&L (USGS topographic quad.)

Location: 15 feet from accelerograph station

Data Source: SW-AA (1977b)

Equipment: Mobile B-61 hollow stem auger
Augered 0-39 feet sampling only cutting returns.
Switched to rotary below 39 feet and sampled cutting returns and attempted 2-MX cores between 40 and 49 feet.

VELOCITIES: Not Available

REPORT: SW-AA (1977b)

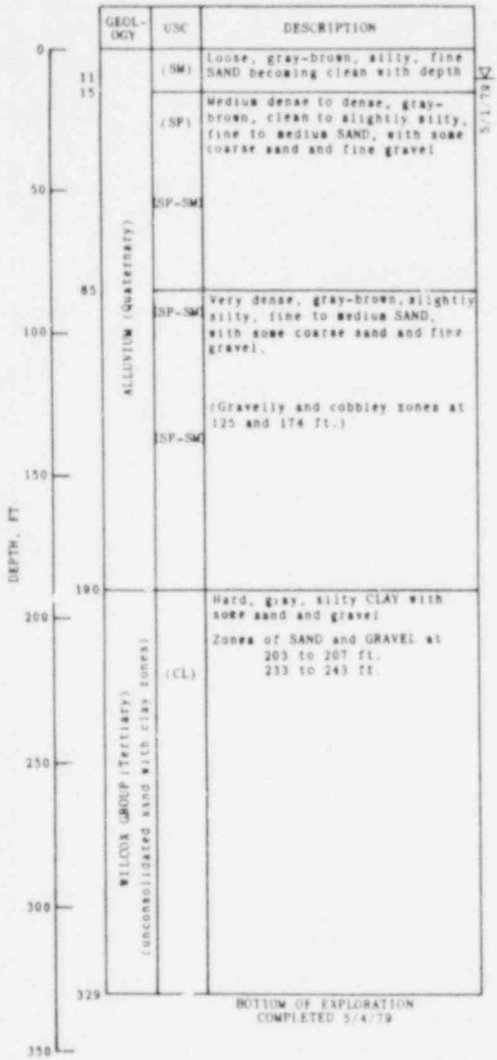
BUILDING: Although the station has been discontinued, the accelerograph at the United California Bank Building (6074 Park Drive) was located in the daylight basement (grade level) of a one story structure.

NOTE: 1) Bedrock was not encountered within the depth of the boring.

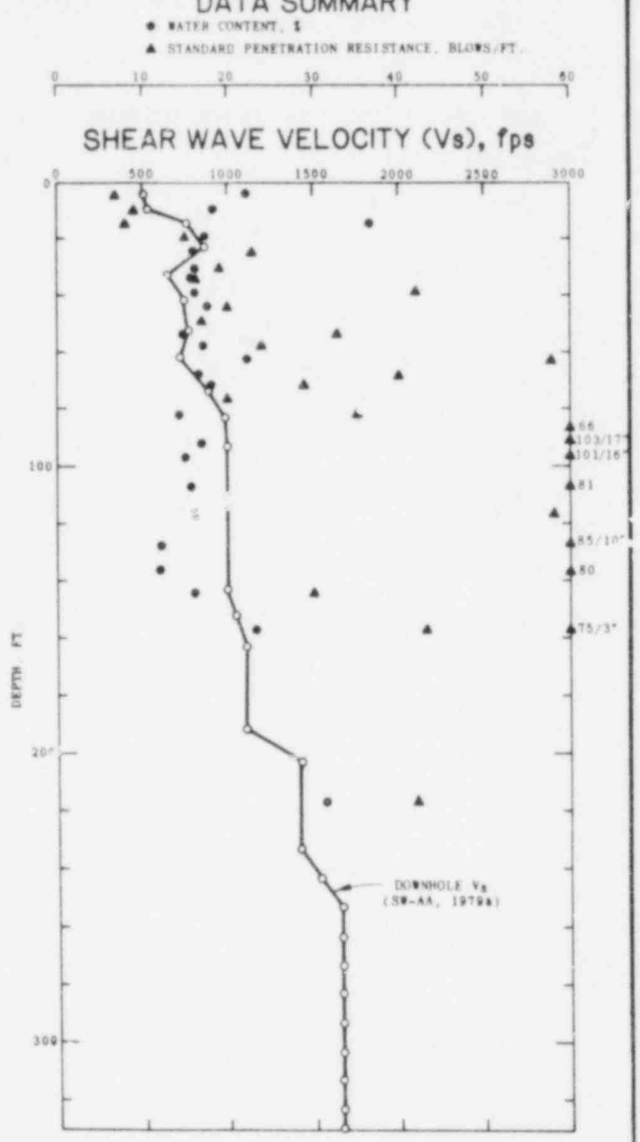
SUMMARY LOG
6074 PARK DRIVE
WRIGHTWOOD, CALIFORNIA

FIG. A-73

BORING LOG



DATA SUMMARY



BORING

Elevation: 297 feet, MSL (hand leveled from nearby benchmark)

Location: 600 feet Southwest of the Rectifier/Control Building.

Data Source: SW-AA (1979a)

Equipment: CME 55 and Mobile B-80; auger ed to 29 feet then rotary drilled with CME to 176 ft. hole below 176 ft. rotary drilled with Mobile B-80. All sampling with SPT split spoon.

VELOCITIES

Source: SW-AA (1979a)

Location: Downhole testing performed in above boring

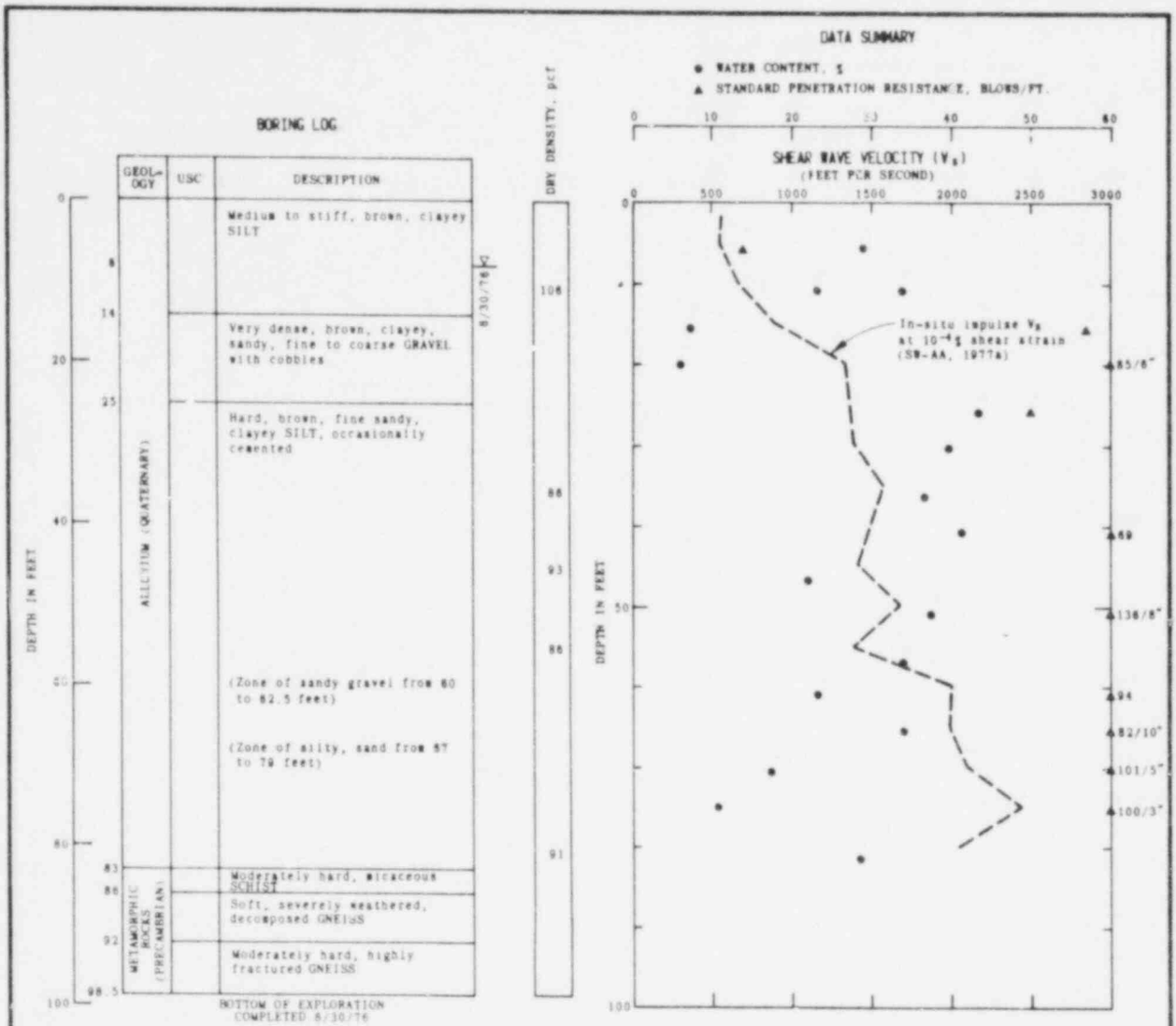
Date: June 5, 1979

REPORT: SW-AA (1979a)

BUILDING: The Rectifier/Control Building, which contains the accelerograph at the Noranda Aluminum Plant, is a one-story concrete block structure founded at grade (no basement).

SUMMARY LOG
NORANDA ALUMINUM PLANT
NEW MADRID, MISSOURI

FIG. A-74



BORING

Elevation: Approximately 4860. MSL (USGS topographic quad.)

Location: 50 feet North of Roberts Hall

Data Source: SW-AA (1977a)

Equipment: Failing 1500 Rotary drill; sampling with a SPT split spoon sampler, Shelby tubes, Pitcher barrel and an NX core barrel

VELOCITIES

Source: SW-AA (1977a)

Location: In-situ impulse test performed in above boring

Date: September, 1976

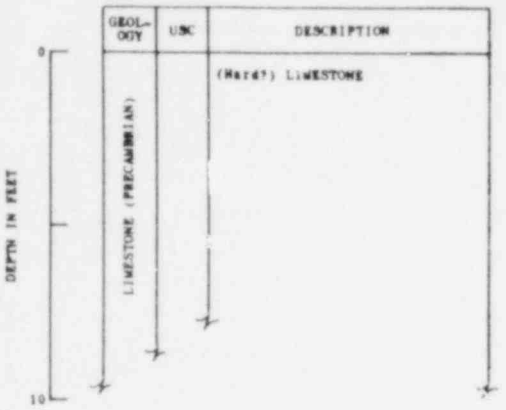
REPORT: SW-AA (1977a)

BUILDING: Roberts Hall is a 3-story structure with a daylight basement (extends about 6 feet below grade) where the accelerograph is located.

SUMMARY LOG
MSU ROBERTS HALL
BOZEMAN, MONTANA

FIG. A-75

LOG [1,2]



VELOCITIES: Not available within vicinity of site

REPORT: SW-AA (1977a)

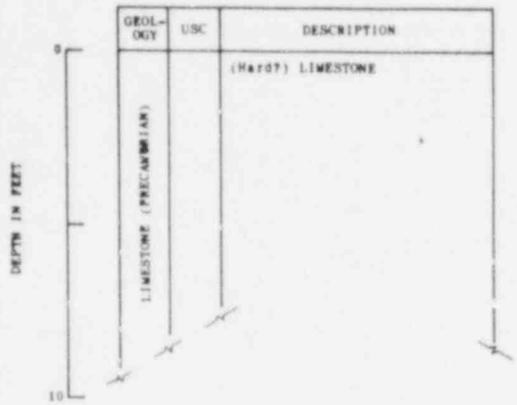
BUILDING: The Science and Library Building at Carroll College is a 4-story structure with a daylight basement (extends about 5 feet below grade.) The accelerograph was originally located in the basement of the Administration Building. On July 16, 1958, it was moved to the first floor of the Science & Library Building.

NOTES: 1) No borings were made at the site. Materials indicated on the log were observed during our site reconnaissance. (SW-AA, 1977a).

2) Site elevation approximately 4000 feet, MSL (USGS topographic quad.)

SUMMARY LOG
CARROLL COLLEGE
HELENA, MONTANA

LOG[1,2]



VELOCITIES: Not available within vicinity of the site

REPORT: SW-AA (1977a)

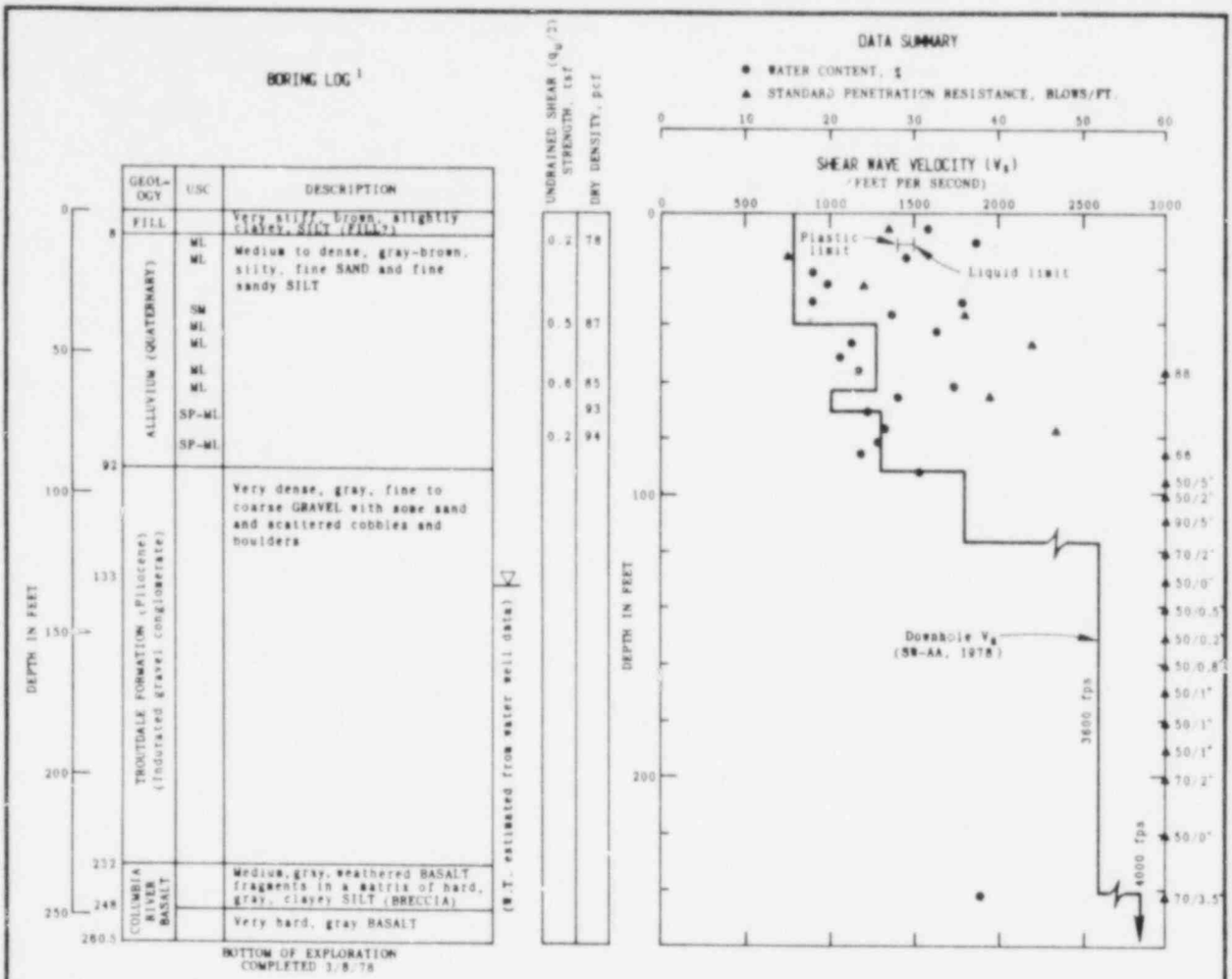
BUILDING: Although the station has been discontinued, the accelerograph at the Federal Building was located in the partial basement (5 to 10 feet below grade) of a 4-story structure.

NOTES: 1) No borings were made at this site. Materials indicated on the log were observed during our site reconnaissance. (SW-AA, 1977a).

2) Site Elevation approximately 4000 feet, MSL (USGS topographic quad.).

SUMMARY LOG
FEDERAL BUILDING
HELENA, MONTANA

FIG. A-77



BORING

Elevation: 133 feet MSL (hand leveled from nearby survey elevations)

Location: 300 feet Northeast of Cramer Hall

Data Source: SW-AA (1978)

Equipment: Failing 1500 Rotary Drill; sampling with a SPT split spoon and a Pitcher barrel

VELOCITIES

Source: SW-AA (1978)

Location: Downhole Testing performed in above boring

Date: May 1978

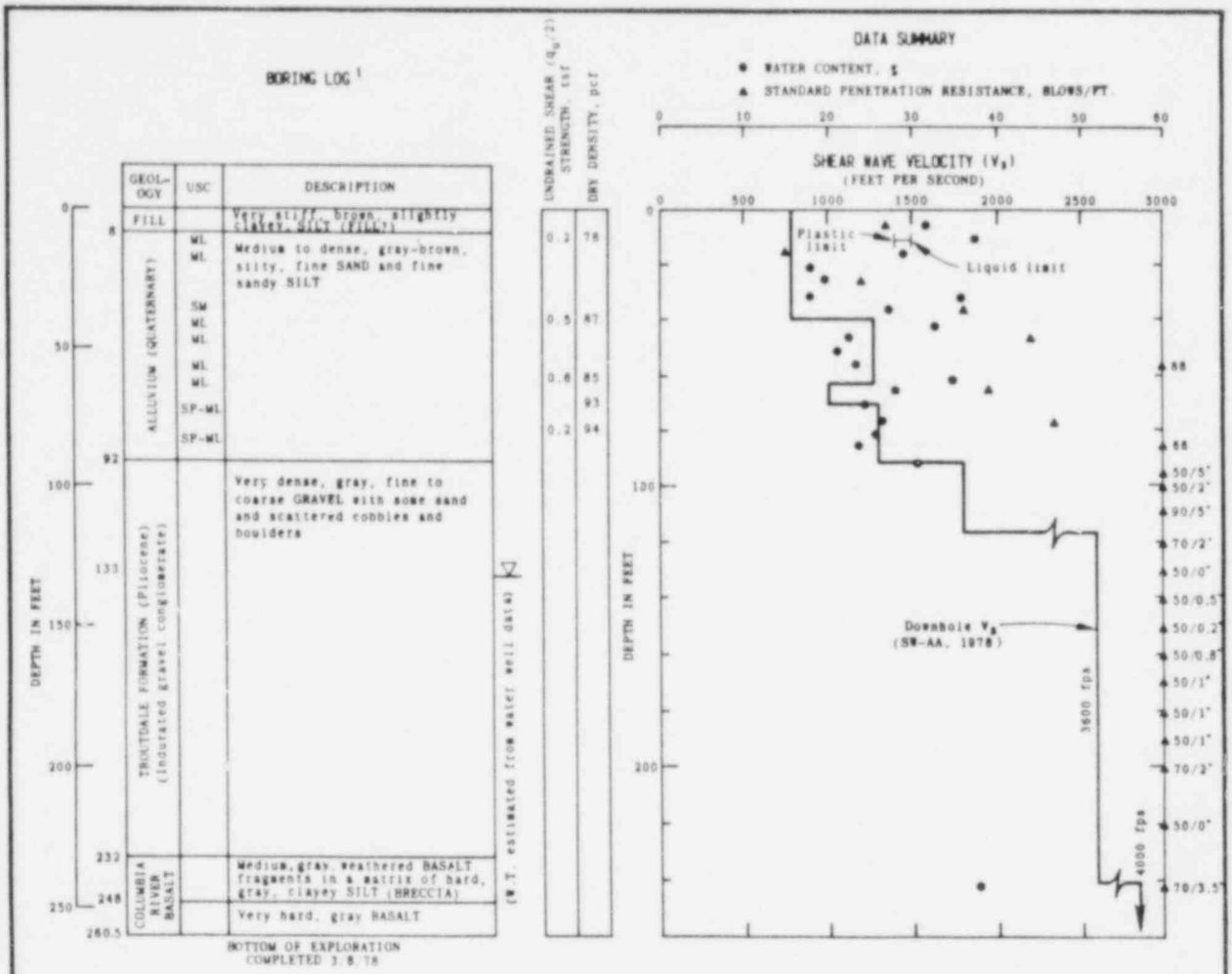
REPORT SW-AA (1978)

BUILDING Cramer Hall is a four story structure with a daylight basement (ground floor) and subbasement. The accelerograph is located in the subbasement which extends approximately 20 feet below grade (Elevation 126.2 feet MSL).

NOTES: 1) Other borings drilled closer to Cramer Hall indicate that the alluvium is about 100 feet thick near the building.

SUMMARY LOG
PSU CRAMER HALL
PORTLAND, OREGON

FIG A-78



BORING

Elevation: 133 feet MSL (hand leveled from nearby survey elevations)

Location: 900 feet Southwest of State Office Building.

Data Source: SW-AA (1978)

Equipment: Failing 1500 Rotary Drill; sampling with a SPT split spoon and a Pitcher barrel

VELOCITIES

Source: SW-AA (1978)

Location: Downhole Testing performed in above boring

Date: May 1978

REPORT: SW-AA (1978)

BUILDING: The State Office Building (1400 S. W. Fifth Avenue) is an 11 story structure with the first floor (also called the ground floor or basement level) located partially below grade. Although the station has been discontinued, the accelerograph was originally located on the first floor about 15 feet below grade.

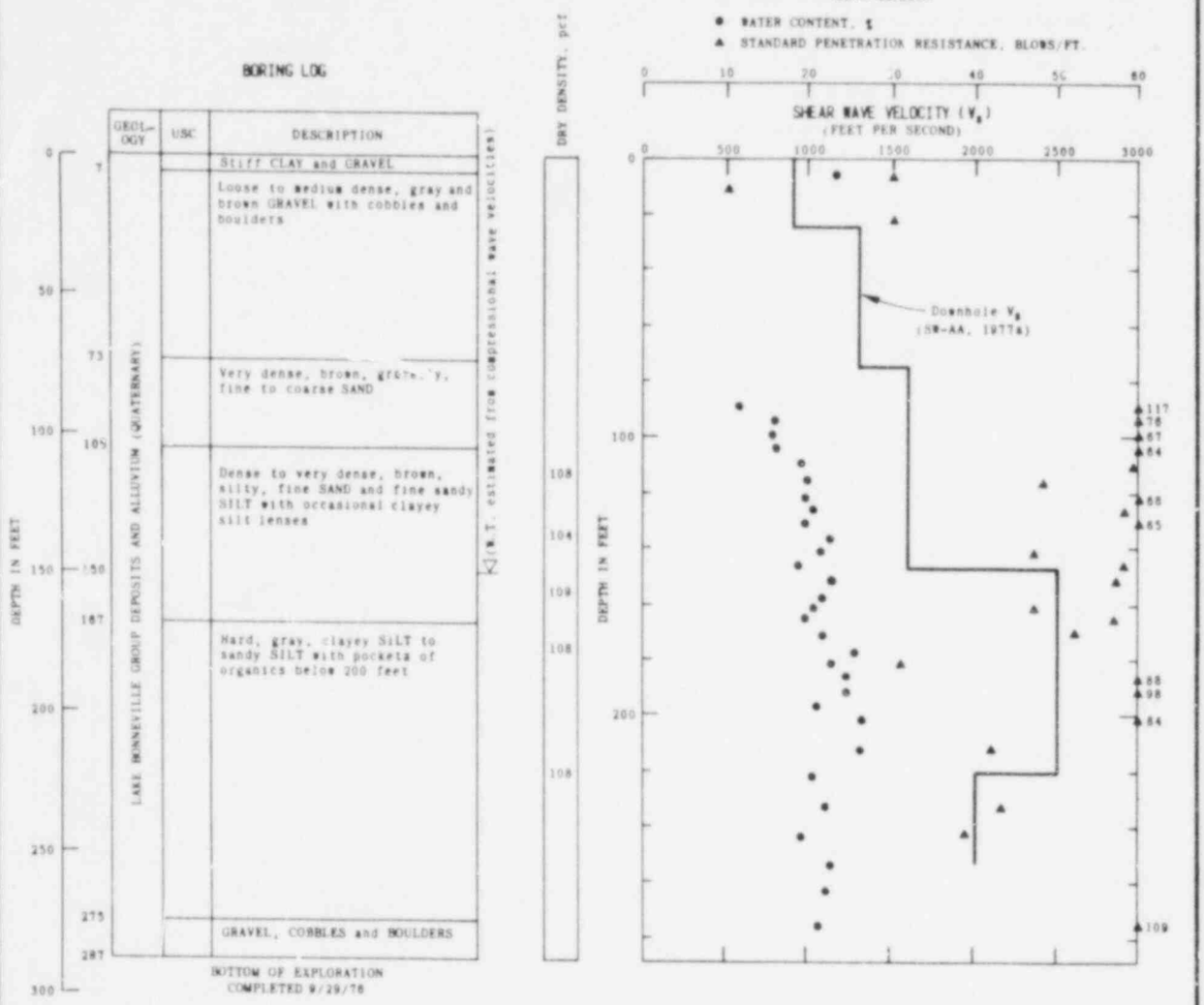
NOTES: 1) Other borings drilled closer to the State Office Building indicate that the alluvium is about 65 feet thick near the building.

SUMMARY LOG

STATE OFFICE BUILDING

PORTLAND, OREGON

FIG. A-79



BORING

Elevation: Approximately 4780 feet, MSL (GS Topographic quad.)

Location: 30 feet East of Old Main Building

Data Source: SW-AA (1977a).

Equipment: Failing 1500 Rotary drill; sampling with a SPT split spoon sampler, Shelby tubes, a pitcher barrel and an NX core barrel

VELOCITIES

Source: SW-AA (1977a)

Location: Downhole survey performed in above boring

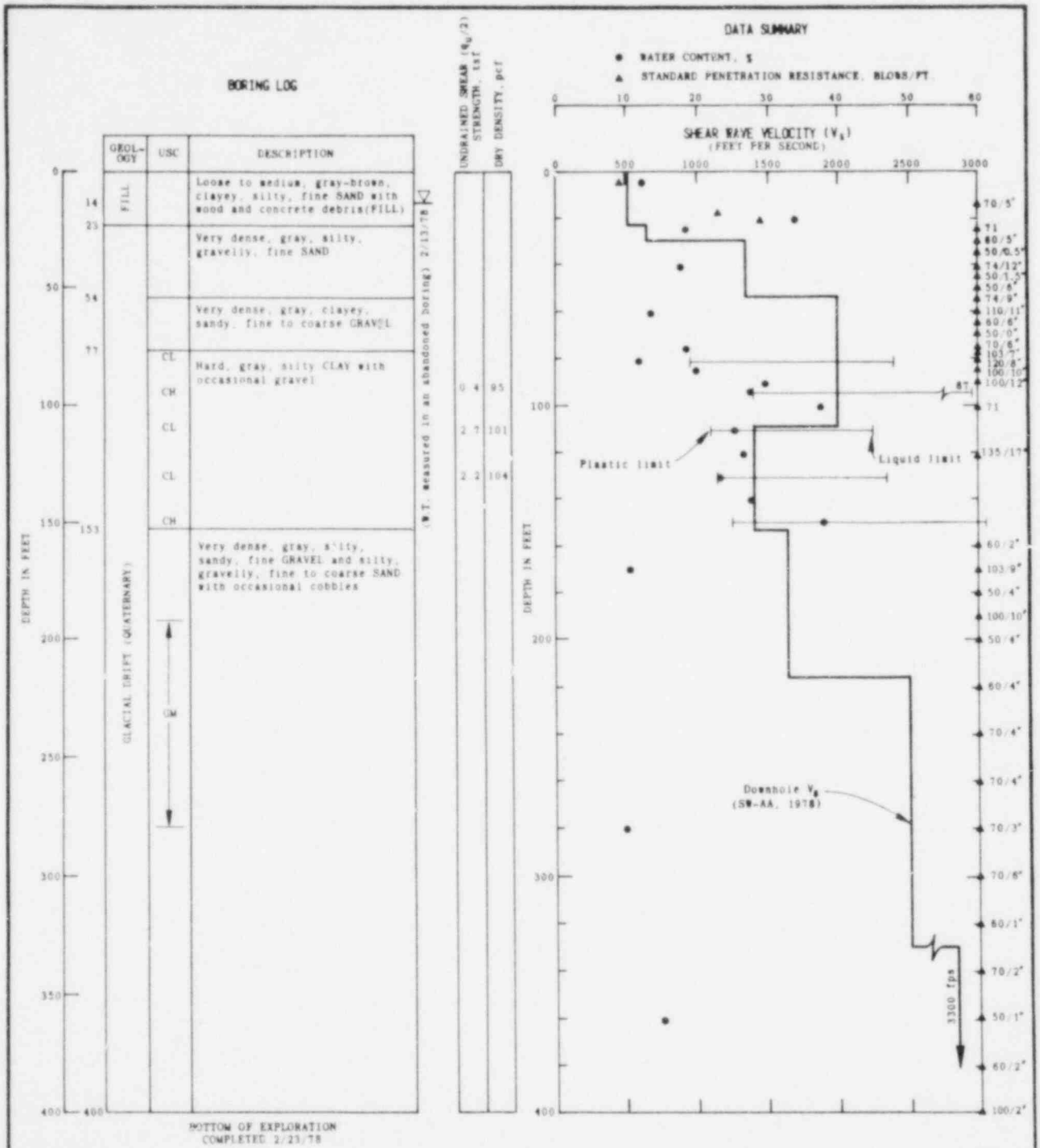
Date: Oct, 1976

REPORT: SW-AA (1977a).

BUILDING: The Old Main Building is a 2 to 3 story structure with a daylight basement, extending approximately 4 feet below grade, where the accelerograph is located.

SUMMARY LOG
USU OLD MAIN BUILDING
LOGAN, UTAH

FIG. A-80



BORING

Elevation: 14.5 feet, MSL (interpolated from survey data)

Location: 100 feet Southeast of the Federal Office Building

Data Source: SW-AA (1978)

Equipment: Failing 1500 Rotary Drill; sampling with a SPT Split Spoon and a Pitcher Barrel

VELOCITIES

Data Source: SW-AA (1978)

Location: Testing performed in above boring

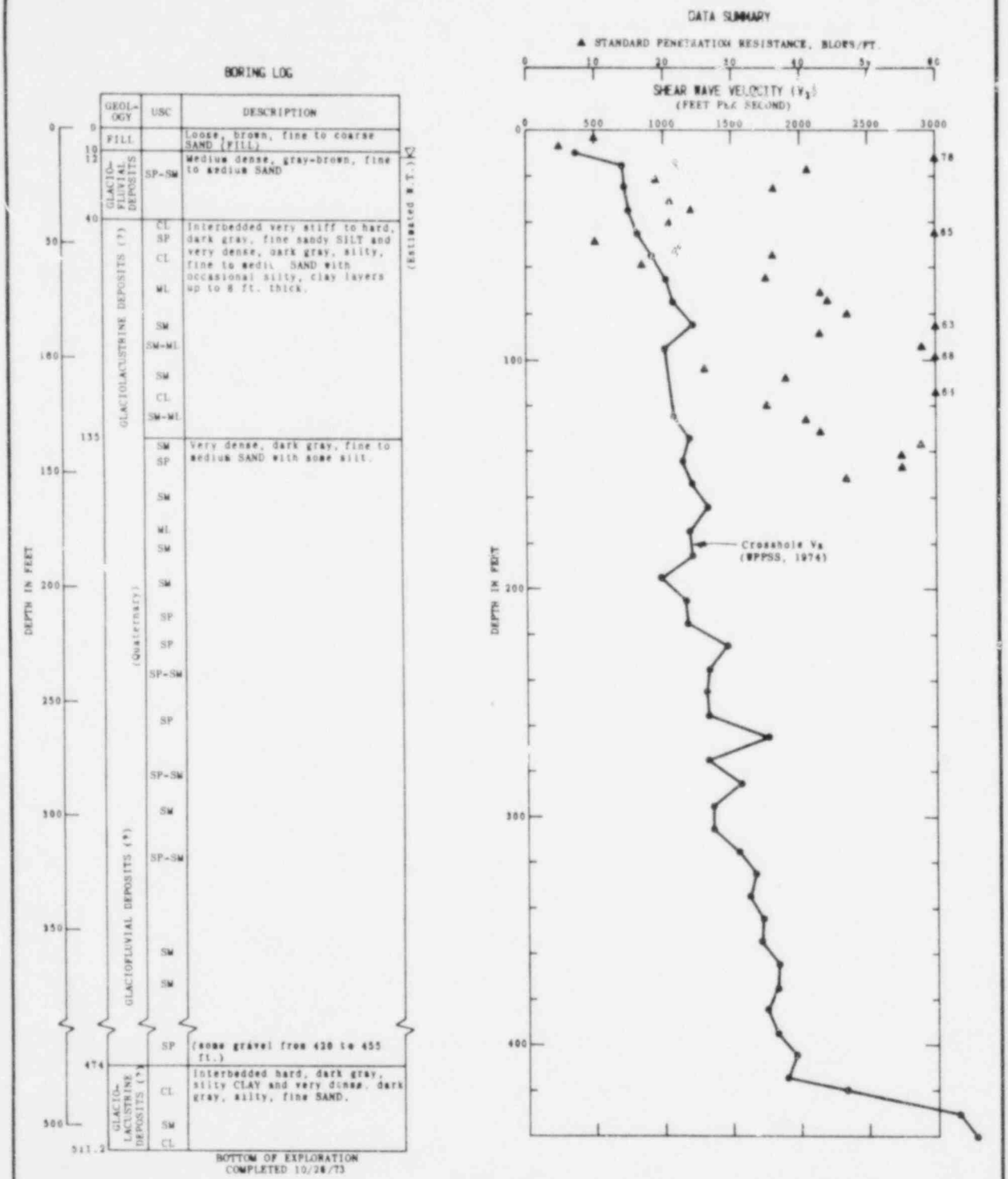
Date: May 1978

REPORT SW-AA (1978)

BUILDING The Federal Office Building (909 - 1st Ave.) is a multistory (1-9) structure with a daylight basement and sub-basement. The accelerograph is located in the sub-basement (about 15 feet below grade).

SUMMARY LOG
FEDERAL OFFICE BLDG.
SEATTLE, WASHINGTON

FIG. A-82



BORING

Elevation:	12 feet MSL
Location:	Within 30 feet of accelerograph.
Data Source:	WPPSS (1974)
Equipment:	Rotary drill; SPT Sampling (only)

VELOCITIES

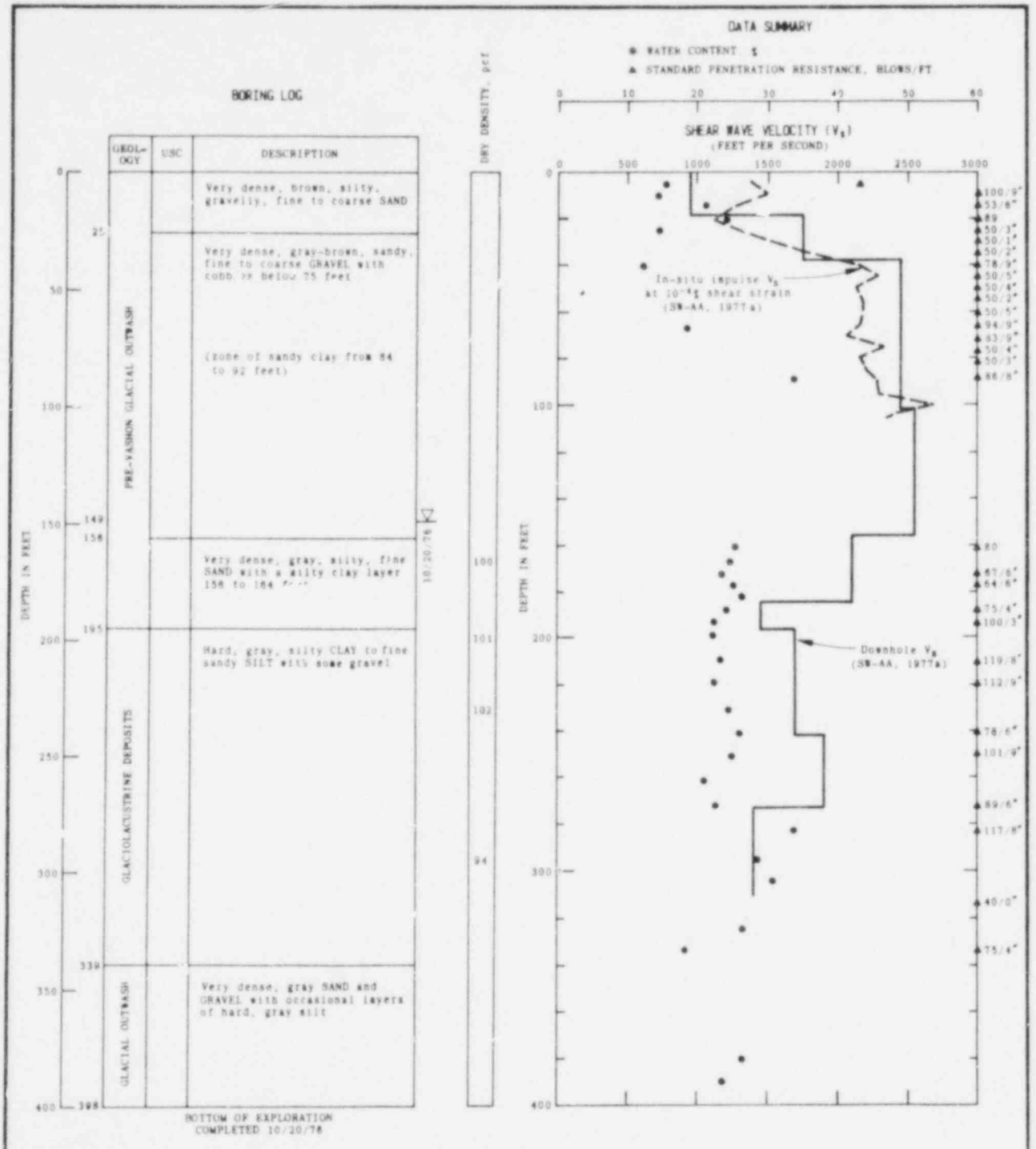
Data Source:	WPPSS (1974)
Location:	Cross hole testing in above borings to 440 foot depth.
Date:	1973-1974

REPORT: SW-AA (1978)

BUILDING: The accelerograph is housed in a small shed in the highway dept. parking lot (315 State Ave.)

SUMMARY LOG
HIGHWAY TEST LAB
OLYMPIA, WASHINGTON

FIG. A-81



BORING

Elevation: Approximately 260 feet, MSL (USGS topographic quad)

Location: 120 feet West of County-City Building

Data Source: SW-AA (1977a)

Equipment: Failing 1500 Rotary drill; sampling with a SPT split spoon sampler, a Pitcher barrel and an NX core barrel

VELOCITIES

Source: SW-AA (1977a)

Location: Downhole and in-situ impulse testing performed in above boring

Date: October 1976

REPORT: SW-AA (1977a)

BUILDING: The County-City Building is a 10-story high-rise with a penthouse and a basement. The accelerograph is located in the basement, about 10-15 feet below grade.

SUMMARY LOG
COUNTY-CITY BUILDING
TACOMA, WASHINGTON

FIG. A-83

REFERENCES

REFERENCES

CAMPBELL, K. W., AND DUKE, C. M. (1976)
"Correlations Among Seismic Velocity, Depth and Geology in the Los Angeles Area," UCLA-ENG-7662, Univ. of Calif., School of Eng. and Applied Sci., Los Angeles, Calif.

CRANDALL, LEROY & ASSOCIATES (1966)
"Report of Foundation Investigation, Proposed Costa Mesa Towers, 19th Street at Meyers Place, Costa Mesa, California." Rept. A-66331, Dec. 7.

_____ (1977)
"Report of Subsurface Investigation, Overall Investigation of Geology, Soils and Seismic Hazard, Seismic Safety Plan, Jet Propulsion Laboratory Site, Pasadena, California," Rept. to the Jet Propulsion Lab. (unpub.).

DAMES AND MOORE (1958)
"Foundation Investigation, Proposed Courthouse and Office Building, San Francisco, California," Rept. to the General Services Adm., Sept. 29 (unpub.).

_____ (1962)
"Seismic Survey, Area of Arts Building, University of California, Santa Barbara," Rept. to the Univ. of Calif., Job No. 234-088-02 (unpub.).

_____ (1963)
"Third Preliminary Report, Aseismic Investigation, Proposed Nuclear Power Plant, Camp Pendleton, California," Rept. to Southern Calif. Edison Company.

DIBBLEE, T. W., JR. (1962)
"Displacements on the San Andreas Rift Zone and Related Structures in Carrizo Plain and Vicinity," Geology of Carrizo Plains and San Andreas Fault." O. Hackel, Ed., San Joaquin Geol. Soc. and Pacific Sec. AAPG-SEPM Guidebook, pp. 5-12, pl. 1.

DUKE, C. M., AND LEEDS, D. J. (1972)
"Site Characteristics of Southern California Strong-Motion Earthquake Stations," Spec. Pub. 38, Calif. Div. of Mines and Geol., pp. 1-33.

DUKE, C. M., JOHNSON, J. A., KHARRAZ, Y., et al. (1971)
"Subsurface Conditions and Geology in the San Fernando Earthquake Area," UCLA-ENG-7206, Univ. of Calif., School of Eng. and Applied Sci., Los Angeles, Calif.

DUKE, C. M., JOHNSEN, K. E., LARSON, L. E., et al. (1972)
"Effects of Site Classification and Distance on Instrumental Indices in the San Fernando Earthquake," UCLA-ENG-7247, Univ. of Calif., School of Eng. and Applied Sci., Los Angeles, Calif.

EARTHQUAKE ENGINEERING RESEARCH INSTITUTE, AND U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (1971)
"Study of Strong Motion Instrument Locations in Northern California," Cooperative programs rept. to Seismol. Research Group, Earth Sci. Lab., Environmental Research Lab., U.S. Natl. Oceanic and Atmospheric Adm. (unpub.).

EGUCHI, R. T., CAMPBELL, K. W., DUKE, C. M., et al. (1976)
"Shear Velocities and Near Surface Geologies at Accelerograph Sites That Recorded the San Fernando Earthquake," UCLA-ENG-7653, Univ. of Calif., School of Eng. and Appied Sci., Los Angeles, Calif.

EVANS, L. T., INC. (1956)
"Foundation Investigation for University of California, Goleta, California," Rept. to the Univ. of Calif. (unpub.).

HOOTS, H. W., BEAR, T. L., AND KLEINPELL, W. D. (1954)
"Geological Summary of the San Joaquin Valley, California," Geology of Southern California, R. H. Jahns, ed., Bull. 170, Calif. Div. of Mines and Geol., Vol. 1, pp. 113-129, pl. 5 and 6.

HUDSON, D. E., et al. (1969-1975)
"Strong-Motion Earthquake Accelerograms, Digitized and Plotted Data, Vol. 1, Uncorrected Accelerograms," Calif. Inst. of Technology, Earthquake Eng. Research Lab., Pasadena, Calif.

_____ (1971-1975)
"Strong-Motion Earthquake Accelerograms, Digitized and Plotted Data, Vol. 2, Corrected Accelerograms," Calif. Inst. of Technology, Earthquake Eng. Research Lab., Pasadena, Calif.

JENNINGS, C. W. (1958)
"Geologic Map of California, San Luis Obispo Sheet," O. P. Jenkins, ed., Calif. Div. of Mines and Geol., scale 1:250,000.

_____ (1959)
"Geologic Map of California, Santa Maria Sheet," O. P. Jenkins, ed., Calif. Div. of Mines and Geol., scale 1:250,000.

_____ (1973)
"State of California, Preliminary Fault and Geologic Map," Calif. Div. of Mines and Geol., Prelim. Rept. 13, scale 1:750,000.

JENNINGS, C. W., AND STRAND, R. G. (1969)
"Geologic Map of California, Los Angeles Sheet," O. P. Jenkins, ed., Calif. Div. of Mines and Geol., scale 1:250,000.

MALEY, R. P., AND CLOUD, W. K. (1971)
"Strong-Motion Accelerograph Records," Strong-Motion Instrumental Data on the San Fernando Earthquake of February 9, 1971, D. E. Hudson, ed., jointly pub. by the Calif. Inst. of Technology, Pasadena, Calif., and the Natl. Oceanic and Atmospheric Adm., pp. 1-53.

MOHRAZ, B. (1976)
"A Study of Earthquake Response Spectra for Different Geological Conditions," Bull., Seismol. Soc. of America, Vol. 66, No. 3, June, pp. 919-935.

SCHLOCKER, J. (1974)
"Geology of the San Francisco North Quandrangle," Prof. Paper 782, U.S. Geol. Survey, 109 pp.

SCHNABEL, P. B., SEED, H. B., AND LYSMER, J. (1971)
"Modification of Seismograph Records for Effects of Local Soil Conditions," EERC 71-8, Univ. of Calif., Earthquake Eng. Research Center, Berkeley, Calif.

SCHWARZ, S. D., AND MUSSER, J. M. (1972)
"Various Techniques for Making In Situ Shear Wave Velocity Measurements: A Description and Evaluation," Proc., 1st Intl. Conf. on Microzonation for Safer Construction, Research and Application, Seattle, Wash., Vol. 2, pp. 593-608.

SEED, H. B., AND IDRISS, I. M. (1969)
"Influence of Soil Conditions on Ground Motion During Earthquakes," Jour. of the Soil Mech. and Found. Div., ASCE, Vol. 95, No. SM1, Jan., pp. 99-137.

SEED, H. B., UGAS, C., AND LYSMER, J. (1974)
"Site-Dependent Spectra for Earthquake Resistant Design," EERC 74-12, Univ. of Calif., Earthquake Eng. Research Center, Berkeley, Calif., Nov.

SEED, H. B., MURARKA, R., LYSMER, J., AND IDRISS, I. M. (1975)
"Relationships Between Maximum Acceleration, Maximum Velocity, Distance from Source and Local Soil Conditions for Moderately Strong Earthquakes," EERC 75-17, Univ. of Calif., Earthquake Eng. Research Center, Berkeley, Calif., July.

SHANNON & WILSON, INC. (1973)
"Geotechnical Investigation for Central Plant Facilities, Carty West Site, Boardman Nuclear Project, Morrow County, Oregon, Vol. 1, Summary Report, Appendix B, Earthquake and Ground Response Analysis," Rept. to Portland General Electric Company (unpub.).

SHANNON & WILSON, INC., AND AGBABIAN-JACOBSEN ASSOCIATES (SW-AJA) (1972)
"Soil Behavior Under Earthquake Loading Conditions: State of the Art Evaluation of Soil Characteristics for Seismic Response Analyses," Rept. to the U.S. Atomic Energy Comm., Jan.; available from the Natl. Tech. Inf. Service, Springfield, Va, TID-26444.

_____ (1974)
"Soil Behavior Under Earthquake Loading Conditions: In Situ Impulse Test for Determination of Shear Modulus for Seismic Response Analyses, Progress Report," Rept. to the U.S. Atomic Energy Comm., June; available from the Natl. Inf. Service, Springfield, Va., TID-26813.

SHANNON & WILSON, INC., AND AGBABIAN ASSOCIATES (SW-AA) (1975)
"Geotechnical and Strong Motion E[illegible]quake Data from U.S. Accelerograph Stations, Vol. 1, Ferndale, Ch[illegible]me, and El Centro, California," NUREG-0029, Vol. 1, NRC-6, Rept. to the U.S. Nuclear Regulatory Comm., Sept.; available from the Natl. Tech. Inf. Service, Springfield, Va., PB 257 234/5SL.*

_____ (1976a)
"Geotechnical and Strong Motion Earthquake Data from U.S. Accelerograph Stations, Vol. 2, Pasadena (CIT Millikan Library), Santa Barbara (Coun y Courthouse), Taft (Lincoln School Tunnel), and Hollister (Melendy Ranch Barn), California," NUREG-0029, Vol. 2, NRC-6A, Rept. to the U.S. Nuclear Regulatory Comm., June; available from the Natl. Tech. Inf. Service, Springfield, Va., PB 283 187/3SL.*

_____ (1976b)
"Verification of Subsurface Conditions at Selected 'Rock' Accelerograph Stations in California, Vol. 1," NUREG/CR-0055, R6A, Rept. to the U.S. Nuclear Regulatory Comm., June; available from the Natl. Tech. Inf. Service, PB 282 205/4SL.*

_____ (1976c)
"Data from Selected Accelerograph Stations at Wilshire Boulevard, Century City, and Ventura Boulevard, Los Angeles, California," NUREG/CR-0074, NRC-6A, Rept. to the U.S. Nuclear Regulatory Comm., June; available from the Natl. Tech. Inf. Service, Springfield, Va., PB 283 029/7SL.*

_____ (1977a)
"Geotechnical and Strong Motion Earthquake Data from U.S. Accelerograph Stations, Vol. 3, Gilroy, CA (Gavilan College - C6); Logan, UT (Utah State Univ.); Bozeman, MT (Montana State Univ.); Tacoma, WA (County-City Bldg.); Helena, MT (Federal Bldg. and Carroll College)," Rept. to the U.S. Nuclear Regulatory Comm., NUREG/CR-0985, September 1980.**

_____ (1977b)
"Verification of Subsurface Conditions at Selected 'Rock' Accelerograph Stations in California, Vol. 2," Rept. to the U.S. Nuclear Regulatory Comm., NUREG/CR-0055, September 1980.**

_____ (1977c)
"Verification of Subsurface Conditions at Selected 'Rock' Accelerograph Stations in California, Vol. 2, Appendix, Earthquake Records," Rep[illegible] to the U.S. Nuclear Regulatory Comm., NUREG/CR-0055, September 1980.**

_____ (1977d)
"Technical Manual: Operation and Equipment Instructions for In Situ Impulse Test," NUREG/CR-0998, R6, RA, Rept. to the U.S. Nuclear Regulatory Comm., June; available from the Natl. Tech. Inf. Service, Springfield, Va.*

SHANNON & WILSON, INC., AND AGBABIAN ASSOCIATES (1978)
"Geotechnical and Strong Motion Earthqake Data from U.S. Accelerograph Stations, Vol. 4, Anchorage, AK (AMU Gould Hall); Seattle, WA (Federal Office Bldg.); Olympia, WA (Highway Test Lab); and Portland, OR (State Office Bldg. and PSU Cramer Hall)," Rept. to the U.S. Nuclear Regulatory Comm., NUREG/CR-0985, September 1980.**

_____ (1979a)
"Geotechnical and Strong Motion Earthquake Data from U.S. Accelerograph Stations, Vol. 5, Fairbanks, AK (UA Duckering Hall); Petrolia, CA (General Store); Hollister, CA (City Hall); Los Angeles, CA (Hollywood Storage Bldg.); and New Madrid, MO (Noranda Aluminum Plant)," Rept. to the U.S. Nuclear Regulatory Comm., NUREG/CR-0985, September 1980.**

_____ (1979b)
"Verification of Subsurface Conditions at Selected 'Rock' Accelerograph Stations in California, Vol. 3," Rept. to the U.S. Nuclear Regulatory Comm., NUREG/CR-0055, September 1980.**

_____ (1979c)
"Site-Dependent Response at El Centro, California Accelerograph Station Including Soil/Structure Interaction Effects," Rept. to the U.S. Nuclear Regulatory Comm., NUREG/CR-1642, September 1980.**

SMITH, A. R. (1964)
"Geologic Map of California, Bakersfield Sheet," O. P. Jenkins, ed., Calif. Div. of Mines and Geol., scale 1:250,000.

SOUTHERN CALIFORNIA EDISON AND SAN DIEGO GAS AND ELECTRIC COMPANIES (1972)
"Preliminary Safety Analysis Report, San Onofre Nuclear Generating Stations, Units 2 and 3, Amendment 2, Appendix 2E," Docket Nos. 50-361/362.

TRIFUNAC, M. D., AND BRADY, A. G. (1975)
"On the Correlation of Seismic Intensity Scales with the Peaks of Recorded Strong Ground Motion," Bull., Seismol. Soc. of America, Vol. 65, No. 1, Feb., pp. 139-162.

U.S. ARMY CORPS OF ENGINEERS (1957)
"Geology and Soils, Carbon Canyon Dam and Channel, Santa Ana River Basin (and Orange County), California, Appendix 1 to Design Memorandum No. 2, General Design for Carbon Canyon Dam and Channel."

U.S. DEPARTMENT OF COMMERCE (1955)
"United States Earthquakes, 1953," Environmental Sci. Services Adm., Coast and Geodetic Survey.

_____ (1959)
"United States Earthquakes, 1957," Environmental Sci. Services Adm., Coast and Geodetic Survey.

_____ (1965)
"United States Earthquakes, 1963," Environmental Sci. Services Adm., Coast and Geodetic Survey.

U.S. GEOLOGICAL SURVEY (1976)
"Strong-Motion Accelerograph Station List - 1975," Open-File Rept. 76-79.

_____ (1977)
"In-Situ Measurements of Seismic Velocities in the San Francisco Bay Region...Part III," Open-File Rept. 77-850.

_____ (1978)
"Correlations Between Seismic Wave Velocities and Physical Properties of Geologic Materials, San Francisco Bay Region, California," Open-File Rept. 78-1067.

WASHINGTON PUBLIC POWER SUPPLY SYSTEM (1974)
"WPPSS Nuclear Project No. 3, Preliminary Safety Analysis Report," Docket Nos. 50-508/509.

WIGGINS, J. H., COMPANY (1973)
"Site Evaluation and Risk Potential for Earthquake in Structural Design," Rept. to Le Roy Crandall & Associates for the Century Plaza Hotel Site, June 26.

WILSON, S. D., BROWN, F. R., JR., AND SCHWARZ, S. D. (1978)
"In Situ determination of Dynamic Soil Properties," Spec. Tech. Pub. 654, American Society for Testing and Materials.

WOODWARD-LUNDGREN & ASSOCIATES (1973)
"Geotechnical Data Compilation for Selected Strong-Motion Seismograph Sites in California," prepared for the Natl. Oceanic and Atmospheric Adm.

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This report summarizes geotechnical data that was obtained in the investigation of 83 accelerograph stations located in the United States. These stations were studied during the period from 1975 to 1979 and the detailed findings are contained in nine data reports. Summary logs indicating subsurface soil conditions and material properties have been prepared for each of the accelerograph stations. A classification system was devised for grouping the stations as either rock sites, stiff soil sites or deep soil sites. Using this classification system, simple ground motion plots have been prepared which qualitatively indicate the dependency of earthquake motions on local site conditions. This classification system may be used in more elaborate and quantitative studies of the influence of local site conditions upon earthquake ground response. On a practical engineering level, the site classification system and the results of the individual site investigations may be used in selecting earthquake records to establish seismic design criteria. Further research of the subsurface conditions at additional accelerograph stations is needed to increase the data base of earthquake records and recording stations.

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